Research Article
Open Access

# Differences between girls and boys based on basic psychomotor skills

Volume 6 Issue 2 - 2023

Mihajlo Mijanovic
State University of Podgorica, Montenegro

**Correspondence:** Mihajlo Mijanovic, Faculty of Sports and Physical Education, University of Podgorica, Montenegro, Tel +382 68 650 974, Email mihajlo.mijanovi@gmail.com

**Received:** May 01, 2023 | **Published:** May 12, 2023

## Summary

According to the aim of the research and the set hypotheses, the scientific methodology was consistently implemented with the application of adequate classical and neoclassical statistical methods and tests. Following the set hypotheses, the following conclusions can be drawn. The first hypothesis H1 assumes that boys will have better results than girls at the beginning of the school year (first measurement) and that these differences will be statistically significant at the Sig.≤.05 error level. One-factor analysis of variance "Anova" shows that there is a statistically significant difference between boys and girls in favor of boys (Chi-square=29.36, df=8, Sig.<.00). Statistically significant correlation with the discriminative function had variables: (SHR, BAH, SBJ and SAR). Tables 1&2. Differences between girls and boys were not established for the variables: (FTR, PLT, SUP and HIG). That there is a difference at the general level is confirmed by the centroid distance. In accordance with according to the results in Tables 3–6 as well as Graphs 1&2, hypothesis H1 remains valid, the probability of statistical error is less than 1%. The second hypothesis H2 assumes that even at the end of the school year (second measurement) boys will also have better results than their female peers, as well as that the difference will be statistically significant. Comparing the arithmetic means (Tables 1&2), it is evident that in the second measurement the results were better, as if on average the girls were slightly higher. Table 7 shows the results of the one-factor analysis of variance "Anova" and the statistical significance of the differences for each test, including body height. Values in Table 7 column Sig. shows and shows that there is no statistically significant difference between girls and boys in any test. There is a difference between the arithmetic means, but these differences are not large enough to be statistically significant. Discriminative coefficients: Eigen value .071, Shi-sque 6.16, centroid distance (.242:-.286) and finally Sig.=.63 confirm that the differences are not statistically significant. Considering the results of the research, hypothesis H2 can be rejected, noting that girls have improved more.

**Keywords:** psychomotor skills, girls, boys, differences

## Introduction

The terms psychomotor abilities, psychomotor characteristics and psychomotor skills are synonymous. In professional and scientific literature dedicated to the science of sports, Kinesiology is dominated by the term "psychomotor skill". Physiologists, psychologists, psychiatrists, psychotherapists prefer the terms psychomotor ability or psychomotor characteristic. Terms are what they are, it is important to understand what it is about. The phrase "motor skill" is especially present in the kinesiology literature that deals with the measurement, classification and improvement of motor skills. What are psycho motor skills? There are many definitions, all of them are good but also incomplete. Motor abilities are defined as indicators of the level of development of human motor activities. Motor abilities condition the realization of simple and complex movement activities. In a functional sense, they represent the shaped structures of the motor system for managing various movement manifestations. Psychomotor abilities represent the complex possibilities of man for the manifestation of complex movement structures that unite biochemical, functional and mental processes. These processes are limited by the characteristics of the Central Nervous System and the Neuromuscular System. One of the short definitions reads: "Psychomotor skills are the interaction between the perceptive senses and the mind." The state of the perceptive senses and the mind are under control and depend on the state of the CNS.[1] At the top of the CNS pyramid is the cortex (gray mass). Anatomically, it is located before the frontal gyrus. In the simplest terms, psychomotor skills are the causality of mind and body. The separation and separation of these concepts is justified only in the case of studying and explaining the relationships of CNS anatomy, functional physiology, functional psychology and functional motor skills. In the domain of their specialties, the mentioned scientific disciplines shed light on the phenomenon of psychomotor. In certain regions of the brain there are centers responsible for gross and fine motor skills. Some findings have been scientifically confirmed, and some are still at the level of theories and assumptions. Centers located in the prefrontal cortex are responsible for gross motor skills. Center that regulates fine motor skills; manipulation of fingers, hands and feet, as well as centers for coordination and balance are located in the cerebellum. It is difficult to specify the time when the scientific approach to the study of psychomotor skills began. Formal and informal contact with humans and other living beings begins with visual observation. Observation is the oldest scientific method that is still in force today. Observing how a person performs daily rough actions, e.g. how to walk is insufficient if we don't have an idea of how someone performs complex motor skills. The situation is similar when observing other living beings. A visual representation of something is necessary, but also insufficient for making serious conclusions. More objective ideas about a subject (man), object, natural and unnatural phenomenon are obtained by means of adequate tests. This paper is about psychomotor tests applied to children and adults.

The psychomotoric theory[2] is related to the experimental psychology of Hermann von Helmholtz. The theory is based on the works of Bell and Magendi on the structure of the nervous system. Involving the nervous system in perception and behavioral responses. Helmholtz made an invaluable contribution to the study of psychomotor abilities. John Dewey was the first to construct instruments for measuring psychomotor skills. Carl Wernicke was one of the first to use the term psychomotor. The need to measure psychomotor skills is evident, the problem was the measuring instruments that had to be constructed. Wilhelma Wundt, Francis Galton, Clark Wissler and James McKeen Cattell[3] made a special contribution in this direction. Cattell made a special contribution to the construction of intelligence tests, he assumed that mental speed was correlated with intelligence. Working on the problems of the construction of intelligence, mental health and psychomotor tests, Cattell made an outstanding contribution to the development of statistical methods.[4] With the help of Statistics, he made Psychology a serious science. Wilhelm Wundt[5] is considered the father of psychology, he separated psychology as a separate science from medicine and philosophy, he was the first to establish an experimental laboratory. He is particularly responsible for the development and construction of numerous psychological instruments, most of which can be considered psychomotor instruments. Fencis Galton[6] dealt with mental health, he is the founder of Psychometry. Galton collaborated with, worked with and supported Cattell for many years. They were the first to construct numerous instruments for measuring psychomotor abilities, such as an instrument for measuring muscle strength (dynamometers), an instrument for measuring the perception of the limit distance from two points, an instrument for measuring the pain threshold (pressure on a part of the body), an instrument for measuring reaction speed to sound, light, color. Galton was the first to invent a method for measuring fingerprints, which is still used today in forensics as well as a number of other instruments for measuring mental and psychomotor skills. The need for measurement and testing is present in all sciences. Research in medicine, kinesiology, sociology and other natural and social sciences is inconceivable without measurement, standardization, scaling, evaluation and finally statistics. A special contribution in finding valid, reliable (clean) tests as well as the construction of physical measuring instruments was made by: Fleishman,[7] Gilford, Wekseler, Likert Adler, Katel, Jung, Krečmer, etc. With the development of cybernetics, electrical engineering and informatics, current measuring instruments have been digitized, and they themselves have become more precise and reliable. Recognizing (detecting) the problem is often a very difficult task. Solving the problem is impossible without determining the cause of the problem. Paradigm, diagnosing a disease is not easy, but it is much more difficult to determine the causes of the disease. The consequences can be the same, but the causes can be very different. Treatment of diseases with the same drugs whose causes are different is impossible, that is, several athletes have the same result, but the causes of the same result are different. People of the same sex of the same age, even if they are identical twins, differ in height, weight, from birth onwards, differ in terms of success in school, sports, artistic talent, differ in mental and health levels, etc. Good or bad is generally easier to recognize and determine than the causes of bad and good. It is important to point out that without knowing the cause, it is impossible to act on the consequence. The problem of kinesiology, medicine, psychology, sociology is that there are no completely reliable and valid (pure tests) that measure the desired phenomenon. A serious question arises, what does the test actually measure. Some tests measure themselves and have no predictive value on specific criteria. The reliability and validity of tests is a permanent problem because the result in the test is influenced by a large number of factors that vary and it is impossible to control them without error. A valid and reliable test for people of the same age, sex, climate, social status, and profession may not be valid and reliable for people who live in a different place and time. Good tests in the present tense may not and will not be good in some past or future tense. The basic purpose of the test is to diagnose the condition and predict the future condition. So the metric ie. the utility value of the test is verified by retesting. Empirics says and dictates that test metrics should be checked frequently and corrected if necessary. An additional problem of the tests is determining the norms and positions of entities on a scale. There are several scales in circulation such as; Welkselor's intelligence scales, Gilford's, Likert's, etc. In addition to the high precision of modern measuring instruments, they must be calibrated from time to time or before each use. Testing, measuring, normalizing and scaling[8] is a virtual topic because there are no universal and permanently good tests. In all stages of life, from birth to the end, various measurements and tests are periodically performed. Immediately after birth, the baby's length and weight are measured. Physiological, anatomical, motor, conative and cognitive characteristics are more or less correlated with each other. Relationships and correlations during growing up change significantly, but never as violently, strongly, intensely and unpredictably as in pre-puberty and puberty. The respondents in this research are in a risky phase of growing up, which is confirmed by numerous previous studies.[9] The age group from 10 to 14 years belongs to the age group of this study, whose average age is eleven years ± six months. It is evident that the respondents do not differ significantly in terms of behavior, psychomotor skills, motivation, interest in knowledge and preferences. Differentiation in every respect begins already at the age of ten or eleven. According to relevant research, girls enter the pre-puberty and puberty phase earlier than their male peers. Finally, this research confirms it. What they have in common is their behavior towards parents, peers, teachers and the environment. Some children become cooperative, attentive and cultured. They care about being noticed in every way, starting with physical appearance, success in school, success in sports, art, music. They strive to be prestigious, to be respected by their peers and elders, have their own attitude, view and vision of the present and future life. They are persistent and struggle to impose their views and opinions on others. They tend to try everything and take risks, some form cliques with similar interests and preferences. Those are the years when they like to know and have everything, boys tend to take cars, weapons without authorization, they are interested in challenges such as adventures, leaving home without their parents' knowledge, etc. Girls prefer aesthetic grooming, painting, music, reading and writing poetry and prose, they show interest in the other sex more. In addition to behavior, thinking and a tendency towards irrational independence, to be noticed, and they themselves notice that something unusual is happening to them. Physical changes in height and weight are also noticeable, sometimes it becomes worrisome, especially in girls who gain abnormal weight, this phenomenon affects and changes the mood, some decide to go on a diet, which can certainly be dangerous. Taking photos and only taking photos (selfies) is especially present among girls. Boys again have some peculiarities, there is a change in the color of the voice (mutation). In both cases, hormones affect a significant change in body morphology. Boys like to take photos and measure their muscle mass, they tend to take various supplements to increase muscle mass without their parents' knowledge. At this age, body odor is also characteristic. Little is known that body odor is a characteristic of all ages, babies have a special, extremely pleasant body odor, teenagers in the puberty phase have a special odor, we should not forget that there is a body odor of people of the third age. A risky phase in growing up, a see-saw and a crossroads of which way to go next. Family is primary, school and environment are extremely important. In any case, in this crucial phase of growth and development, upbringing and education, family and school must know how children spend their free time and who they hang out with. Instead of criticizing,

**Citation:** Mijanovic M. Differences between girls and boys based on basic psychomotor skills. *MOJ Sports Med.* 2023;6(2):62–70.
DOI: 10.15406/mojsm.2023.06.00141

punishing and disparaging children, they should be encouraged and encouraged, there is a phrase “a child is a small man”. Adolescents think that the world is theirs, that they know everything and can do everything. Out-of-control children informally band together, elect a leader who is mostly known for his antisocial behavior. Hippocrates classified all medicines into four clusters. 1. A nice word 2. Movement, practicing sports 3. Tablets-medications and 4. Surgery. A kind word opens all doors and awakens all hopes. Movement, exercise and sports are the medicine of all medicines. The effectiveness of exercise is greater than a thousand medicines!

## Subject and goal of the research[10]

The subject of the research is the transformation and discrimination between the sexes based on the results in psychomotor abilities during one school year. The applied tests are nothing new, they have long been in mass use in Europe and beyond, the tests are recognized under the pseudonym “EuroFit” battery of tests. The tests were validated in terms of validity, reliability, discrimination and objectivity. The main purpose of the tests is to assess the latent psychomotor structure; strength, speed, endurance, balance, agility and flexibility. The above tests are widely known and generally recognized at the international level, which is why they have been in wide use for more than three decades. Physical and health education programs provide for monitoring the growth and development of students from the beginning of school. Monitoring students during the school year is the best indicator of the effectiveness of teaching, and the results at the beginning and end of the school year are a reliable and objective indicator. In some cases, testing is carried out monthly and, if necessary, weekly. Testing is not for the sake of testing, testing must be in the function of monitoring the transformational effects of students’ psychomotor skills. Long experience confirms that there are genetic specificities, ie. gender differences, similarities and differences are virtual. During growing up, especially during adolescence, some differences in some dimensions increase and some decrease. Under the influence of the physical education program, i.e. under the influence of sports and exercise, these differences can partially increase but also decrease. Whether there are differences, in which psychomotor skills and at what level are these differences, can be reliably determined through successive monitoring, i.e. measurements. The meaning and justification of monitoring is the timely correction of personal work with children. For the aforementioned reasons, the paper tested basic psychomotor skills at the beginning and end of the school year. Girls and boys are the same age, chronological age 11 years ± 6 months. It is known that the results in the tests depend on several factors that must be carefully taken into account in order for the testing to have a purpose. The basic thing with all repeated tests (test re test) is to ensure, create the same or approximately the same conditions in order to achieve the necessary objectivity. An example of some factors that can significantly affect the test result: The internal or external space in which the test is performed must be the same in repeated testing. The measuring instruments used during testing must be the same. Before using measuring instruments, it is necessary to calibrate them. The test taker’s equipment in repeated testing must be the same. It is desirable that the measurers and evaluators are the same. These are just some factors that can significantly affect test results. If the respondents are motivated, e.g. that the results in the test will affect the grade in the subject or will be selected for performance in the national team significantly changes the interest of students in testing, and thus in achieving the best results in the test. Test results should be made known in detail to test takers, parents and guardians. As you can see, the crucial problem of all testing is to get accurate original (raw) data. All psycho motor tests are of quantitative type and are significantly different from qualitative type tests. Psychomotor tests are more reliable than qualitative type tests. Long jump, running, trunk lifting, pull-ups, push-ups, balance tests, etc. are quantitative type tests. Test results are expressed in exact physical units; centimeters, seconds, kilograms, number of performed correct movements, etc. Tests that determine attitudes, commitment, opinion on a certain issue are tests of a qualitative type, e.g. “Are you satisfied with the teaching of Physical Education” YES or NO. Or if the question reads: “Rate the teaching of Physical Education from 1 to 5”. As you can see, the second question is of a quantitative type and is far more subtle than the first question, where the answer comes down to a dichotomy YES or NO. Body weight and height are extremely relevant anthropometric dimensions, they are measured immediately after birth and monitored throughout life. The weight and height of the body are strong indicators of the general physical, and therefore also the psychological state of the organism. Correlations between height and weight are especially important during adolescence, the mentioned dimensions are correlated with psychomotor skills. It is known that gross and fine motor skills are correlated with success in sports and numerous professions such as: chauffeurs, pilots, machine operators, fine motor skills of the hand are desirable for dentists, surgeons, musicians, painters, etc. Psychomotor tests are indicators, better or worse predictors; strength, speed, endurance, agility, coordination, flexibility and balance.

-H1: Based on decades of experience, practical, professional and scientific knowledge, it is expected that boys will have better results than girls on the first measurement, as well as that boys will have a higher body height than their female peers[11] H1:FMboys>Mgiris.

- H2: It is expected that in the second measurement the results will be better compared to the first measurement, as if the boys will be better than the girls in the second measurement as well. H2:SMboys>SMgiris. Hypotheses will be tested at an error level of Sig.< .05.

## Research methods[12]

The sample of respondents consists of female and male students aged eleven years ± six months. The number of girls was 52 and boys 45. A sample of seven basic psychomotor tests and body height was selected to assess the motor abilities of the subjects. All tests are metrically validated, so the tests meet the norms; reliability, validity, discrimination and objectivity.[13] These are tests that assess primary motor skills: speed, strength, endurance, agility, flexibility and balance. The tests are simple to apply and do not require expensive equipment, and can be performed in a short period of time.

Testing (measurement) was carried out in the following order:[14] “Body height” HIG, “Flamengo balance test” FLB, “Hand tappin” PLT, “Reach while sitting” SAR, “Lng jump” SBJ, “Sits up“ SUP, “Arm pull “ BAH and “Slalom run 5x10m” SHR. The detailed methodology of measurement and testing of all tests was done in accordance with the methodology of Eurofit.[15,16]

- “Flamingo balance” FTR is a test of general balance. The test is repeated three times. The best result in seconds is entered in the survey form. A higher numerical value in this test represents a better result.

- “Hand tappin” PLT. This test is intended to measure the speed of hand movement. The task is for the test taker to complete 25 correct cycles at the meter’s mark. The time for which the respondent completed the task is registered, i.e. made 25 correct cycles. This test is repeated twice. A better result is entered in the survey form. Note; a lower numerical value in this test represents a better result.


DOI: 10.15406/mojsm.2023.06.00141

- “Reach while sitting” SAR. Reach in gray is a test that evaluates general suppleness, i.e. general flexibility of the body. The unit of measurement in this test is centimeters. The test is repeated twice. A better result is entered in the survey form. A higher numerical value in this test represents a better result.

- “Lng jump” SBJ. The standing long jump is a well-known and recognized test for evaluating the explosive power of the lower extremities. There is no sport where explosive power, which is more or less correlated with all motor skills, is not desired. For the above reason as well as for the simple measurement methodology, long jump from standing is popular and because the obtained results can be reliably compared. The unit of measurement in this test is centimeters. The test is repeated three times. The best result is entered in the survey form.

- “Sits up” SUP. The trunk raise from a lying to a sitting position is a test that assesses the endurance of abdominal muscle strength. The number of correctly executed cycles, i.e. raising the trunk from a lying to a sitting position in thirty seconds is recorded in the survey form. This test is performed once. A higher numerical value in this test is a better result.

- “Arm pull” BAH. This test evaluates the static endurance of the arm and shoulder girdle muscles. Time is measured in the pull-up. This test is performed only once. The time it lasts in tenths of a second is entered in the survey form. A higher numerical value in this test represents a better result.

- “Slalom run 5x10m” SHR. The test measures running speed, agility and agility. The subject continuously runs 5 times between racks evenly distributed over a length of 10m. Time is measured in seconds. Note; a lower numerical value is a better score in this test.

## Statistical methods[17]

A large number of classical and neo-classical statistical methods and tests were applied according to the title of the research, the subject, the problem and the set hypotheses. Descriptive statistics are the basis of all analysis because descriptive statistics are understood by a wide readership. Tables 1&2 show the results of the first and second measurements separately for girls and boys. The values we refer to and analyze are: arithmetic means (Mean), standard deviations (Std.Dev.), Coefficients of Variation (Coe.Var.), skewness of the distribution (Skewness), height of the distribution (Kurtosis) and the Kolmogorov-Smirnov test of normality distribution (K-S Z). These statistics are necessary for two reasons. The first reason is that the analysis is started on the basis of descriptive indicators, the second reason is that complex multivariate methods are chosen based on the results of descriptive statistics, which enable the analysis of cause-and-effect relationships. Basic statistics gives a picture of the state of a phenomenon, and advanced statistics gives a picture of causes and consequences. The problem of both statistics is not software, the crucial problem is which statistical methods to choose. The choice of statistical and mathematical methods is large, so the problem is in the adequate selection of statistical methods.

Looking at the topic and issues of this research, the optimal choice of advanced statistical methods referred to the One-factor analysis of variance (Anova) and the multi-factor analysis of differences better known as Canonical discriminant analysis.[18] These are methods that determine differences between two or more groups and two or more treatments. In this case, it is about two independent groups of students observed by gender in two different time periods. Algorithm methods are familiar to those who deal with statistical methodology and quite confusing for many who use statistics as a tool. This research, as well as numerous other statistical methods and statistical methodology, are used as a necessary tool in order to make correct statements and conclusions. For the stated reasons, numerous matrices of correlations, variations, covariations, factor scores and a number of other supporting tests and criteria that are an integral part of the overall algorithm were omitted from the paper. Considering the mentioned facts, the presentation of numerous iterations of the statistical algorithm was missing in the paper. The decision to display only some statistical tables (matrices) was made to reduce the entropy of information in favor of greater parsimony. An objective indicator of the quality of any research is feedback from readers. Statistical data processing was performed using the statistical and mathematical program SPSS.[19]

## Results and discussion

Descriptive statistics of the first and second measurements are shown in Tables 1&2. The values of arithmetic means, standard deviations, coefficient of variation (Coe.Var.), Skewness, Kurtosis and One-Sample Kolmogorov-Smirnov test of the first and second measurements are noted. Measures of variation are particularly important because their sizes speak about the normality of the distribution and the representativeness of arithmetic means. The first and second tables show arithmetic means (Mean), Standard deviations (Std.Dev.), coefficients of variation (Coe.Var.), coefficient of curvature of the distribution (Skewness), coefficient of the height of the distribution (Kurtosis) and the Kolmogorov-Smirnov test (K-S Z). The standard deviation and its size are especially important. It should be noted that the tests ‘Flamingo balance’ FTR and ‘Arm pull’ BAH show a high variation. The static balance test is also very specific in that students of both genders in the first and second measurements show great variability on this test. A certain number of subjects had a problem to balance at all, while others were able to keep their balance for more than two minutes, (the minimum score was 1.48” and the maximum was 114.48”). The obtained results were expected and explained by the fact that girls and boys enter the period of intense puberty, girls a little earlier. In the period of puberty, there is a sudden growth of the extremities, and thus a disproportion between body height and other anthropometric dimensions. The sudden increase in body height does not sufficiently accompany the growth of muscle mass, which negatively affects not only balance and coordination, but also overall psychomotor skills. The change is best noticed by the respondents. The CNS reacts to changes, which is under the control of not only coordination but all motor skills. Therefore, it is not only about motor skills, but about psycho-motor skills, which primarily determines motor actions. It is known that the coordination tests to which the balance tests belong are highly correlated with the intelligence factor, especially the balance tests are highly correlated with the “motor intelligence” factor.[20] Impaired coordination in this period should not be understood and accepted as an alarm that something is wrong with the children. It is not a normal phase in the period of puberty that is individually manifested in a milder or stronger form. It is recommended that sport be intensified in this phase of growth and development, not only through mandatory physical education classes, but also with additional extracurricular sports activities. This period of growing up is very sensitive because the sudden growth of body height and other longitudinal dimensions of the arms and legs does not adequately follow the growth of muscle mass. As a consequence of the mentioned disproportion and hypokinesia, deformities of the hip column (kyphosis, lordosis, scoliosis, flat feet, etc.) are common causes. For the above reasons, in this phase of growth and development, adolescents should be monitored, measured, tested and analyzed more often, in order to act preventively against unwanted phenomena through physical exercise as the best medicine. The "Arm pull" variable is a specific test whose results depend on the muscle strength of the arm and shoulder girdle, showing high variability, similar to the Flamingo balance test. The reason for the high variation around the arithmetic mean is the fact that these tests were extremely difficult-demanding for a number of respondents and vice versa. The minimum results were just a few seconds and the maximum over two minutes. The measures of variation and the size of the Kolmogorov-Smirn test show what kind of variation and how much it is, see values in tables one and two columns (K-S Z). The linear correlation coefficient between the FTR and BAH tests is .185**, which is statistically significant at the p<.01 error level. In direct observation, subjects who had bad results in these tests were at the same time above average height and poorly developed muscle mass. Good results were shown by subjects with average body height and harmoniously developed and distributed muscle mass. The tests "Slalom run 5x10m", "Standing jump length" and "Body height" had a normal variation around the arithmetic mean, which confirms that the students of both sexes were normally and homogeneously distributed in relation to the arithmetic mean. The "Slalom run 5x10m" and "Standing jump length" tests have a significant correlation of .47**. The physiological mechanisms that regulate the results in these tests are similar, it is about the strength and speed of the excitation that comes from the CNS and is transmitted to the muscles that perform the action. Put simply, the results in these tests primarily depend on the explosive strength of the muscles of the lower extremities and the agility of the body.

Other values in the Tables 1&2 show the expected arithmetic means, standard deviations, coefficients of variation, K-S Z test and other measures of variation. The "Flamengo" and "Arm pull" tests are specific in that a number of subjects have problems with balance, while the other part of the subjects showed fantastic results. The same problem occurs with the results in the "Arm pull" test. The physiological mechanisms responsible for and regulating these two psychomotor abilities are also specific. The balance problem is associated with special centers located in the cerebellum, while the results in the "Arm pull" test are highly correlated with the static strength of the arms and shoulder girdle and depend on the mechanism that regulates the duration ekscitacije. Based on the sizes of the arithmetic means of the Mean of the first measurement, girls achieved better results than their male peers in the tests "Flamingo balance" FTR and the test "Reach while sitting" SAR. The "Flamingo balance" test is a static balance test, and the "Reach while sitting" test is a body flexibility test. Previous research confirms that women have better results than men in these tests.[21] There are differences, but the differences are not statistically significant. In other tests, boys achieved better results. As you can see, girls are on average slightly shorter than boys HIG: (144.75<146.42) cm. The mentioned difference is not statistically significant Table 3. Statistically significant differences were found in the tests: "Reach while sitting" SAR, "Lng jump" SBJ, "Arm pull" BAH and "Slalom run 5x10m" SHR. The SAR test is statistically significant at the level of error Sig.≤ .05* and the other three tests are statistically significant at the level of error Sig.≤.00** Table 3.

**Table 1** Statistics of the first measurement

| Gender | Variabels | Mean | Std. Dev. | Coe.Var. | Skewness | Kurtosis | K-S Z |
|---|---|---|---|---|---|---|---|
| Giris | „Flamingo balance" FTR | 20.65 | 22.12 | 1.07 | 2.28 | 6.32 | 1.6 |
| | „Hand tappin" PLT | 18.22 | 2.65 | 0.15 | 0.44 | -0.32 | 0.64 |
| | „Reach while sitting" SAR | 32.55 | 8.33 | 0.26 | -2.27 | 7.72 | 1.68 |
| | „Lng jump" SBJ | 127.78 | 24.82 | 0.19 | 0 | -0.08 | 0.57 |
| | „Sits up" SUP | 19.28 | 4.64 | 0.24 | 0.1 | -0.78 | 0.82 |
| | „Arm pull" BAH | 11.81 | 13.1 | 1.11 | 1.88 | 3.63 | 1.52 |
| Boys | „Slalom run" 5x10m SHR | 26.07 | 2.08 | 0.08 | 0.36 | 1.65 | 0.89 |
| | „Body heght" HIG | 144.75 | 8.22 | 0.06 | 0.07 | -0.25 | 0.74 |
| | „Flamingo balance" FTR | 16.28 | 15.33 | 0.94 | 1.91 | 4.07 | 1.15 |
| | „Hand tappin" PLT | 17.22 | 3.34 | 0.19 | 3.23 | 15.9 | 1.03 |
| | „Reach while sitting" SAR | 29.31 | 8.84 | 0.3 | -1.62 | 3.65 | 1.32 |
| | „Lng jump" SBJ | 143.88 | 23.18 | 0.16 | -0.7 | 0.28 | 0.64 |
| | „Sits up" SUP | 20.4 | 5.21 | 0.26 | -0.46 | 1.49 | 0.91 |
| | „Arm pull" BAH | 22.63 | 18.27 | 0.81 | 1.16 | 1.52 | 0.77 |
| | „Slalom run 5x10m" SHR | 24.24 | 2.19 | 0.09 | 0.57 | 0.25 | 0.68 |
| | „Body heght" HIG | 146.42 | 6.32 | 0.04 | 0.276 | -0.39 | 0.55 |

**Table 2** Statistics of the second measurement

| Gender | Variables | Mean | Std. Dev. | Coe.Var | Skewness | Kurtosis | K-S Z |
|---|---|---|---|---|---|---|---|
| Girls | „Flamingo balance" FTR | 17.83 | 14.55 | 0.82 | 1.26 | 1.42 | 1.1 |
| | „Hand tappin" PLT | 15.1 | 2.6 | 0.17 | 0.77 | -0.18 | 0.91 |
| | „Reach while sitting" SAR | 33 | 8.57 | 0.26 | -2.22 | 7.04 | 1.37 |
| | „Lng jump" SBJ | 150.86 | 25.41 | 0.17 | -0.75 | 0.74 | 0.87 |
| | „Sits up" SUP | 23.11 | 4.1 | 0.18 | 0.27 | -0.18 | 0.88 |
| | „Arm pull" BAH | 21.6 | 25.19 | 1.17 | 2.98 | 12.28 | 1.41 |
| | „Slalom run 5x10m" SHR | 24.31 | 2.71 | 0.11 | 0.25 | -0.82 | 0.78 |
| | „Body heght" HIG | 147.96 | 7.73 | 0.05 | 0.14 | 0.19 | 0.58 |
| Boys | „Flamingo balance" FTR | 18.92 | 15.98 | 0.84 | 1.39 | 1.05 | 1.58 |
| | „Hand tappin" PLT | 15.05 | 2.5 | 0.17 | 1.67 | 4.6 | 0.89 |
| | „Reach while sitting" SAR | 34.54 | 7.99 | 0.23 | -2.11 | 7.63 | 1.17 |
| | „Lng jump" SBJ | 143.97 | 23.14 | 0.16 | 0.12 | -0.21 | 0.56 |
| | „Sits up" SUP | 22.4 | 4.46 | 0.2 | -0.01 | 0.57 | 0.74 |
| | „Arm pull" BAH | 24.55 | 30.75 | 1.25 | 2.47 | 7.42 | 1.53 |
| | „Slalom run" 5x10m SHR | 24.09 | 2.08 | 0.09 | 0.09 | -0.73 | 0.75 |
| | „Body heght" HIG | 147.4 | 8.39 | 0.06 | -0.27 | -0.58 | 0.57 |

**Table 3** ANOVA tests of equality of group

| Variables | Wilks' Lambd | F | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| „Lng jump“ SBJ | 0.89 | 10.7 | 1 | 95 | .00** |
| „Sits up“ SUP | 0.98 | 1.23 | 1 | 95 | 0.26 |
| „Arm pull“ BAH | 0.89 | 11.4 | 1 | 95 | .00** |
| „Slalom run 5x10m“ SHR | 0.84 | 17.6 | 1 | 95 | .00** |
| „Body heght“ HIG | 0.98 | 1.22 | 1 | 95 | 0.27 |
| „Flamingo balance“ FTR | 0.98 | 1.24 | 1 | 95 | 0.26 |
| „Hand tappin“ PLT | 0.97 | 2.7 | 1 | 95 | 0.1 |
| „Reach while sitting“ SAR | 0.96 | 3.45 | 1 | 95 | .05* |

Table 3 shows the results of the one-factor analysis of variance “Anova”. It is a statistical method that determines the differences between two independent groups and several independent variables. In the example, the independent groups are girls and boys, while the independent variables are psychomotor tests and body height. The final decision to accept or reject the hypotheses was made based on the values in the Sig column. Table 3. However, in addition to the value of Sig. it is preferable to look at the values in column F. The value of F is the ratio Mean Square between Groups and Mean Square within Groups. The magnitude of the coefficient F shows the magnitude of the differences in each test. In the example, we are talking about the test “Slalom run 5x10m” SHR F=17.63. The smallest difference between girls and boys was in the tests “Sits up” SUP, F=1.23 and the test “Flamingo balance” FTR, F=1.24. Based on the differences of the arithmetic means, the conclusion would be wrong and superficial. The correct answer about the general difference was made on the basis of the discriminative function and its significance. Tables 4–6 show the relevant discrimination values between girls and boys at the first measurement. The obtained values ie. size of coefficients: Eigenvalue=.381*, Canon.Correla.=.525, ilks’Lambda=.724, Chi-square=29.36 and Sig.=.00. they speak precisely about the differences at the general and individual level. The structure of priority and relevance of tests in general discrimination is shown in Table 5. It should be noted that similar values were obtained in Table 3. According to these results, the biggest difference between girls and boys was in the test “Slalom run 5x10m”, and the smallest in the variable “Body height“. The small difference in body height between girls and boys should be traced to the fact that girls enter puberty a little earlier than boys. In the example, it is about the age of 11 years ± 6 months. Given that the girls had a disproportionate body height with active muscle mass, it had a negative impact on the result in the “Slalom run 5x10m” test. The difference and comparison between two or more groups in the case of two or more variables can be correctly determined if all variables are previously standardized. The standardization of variables was calculated according to the formula;

Zi=(xi-μ)σ-1, where the arithmetic mean is μ=Σxin-1., and the standard deviation is σ=Σ[( xi-μ)2n-1]-1/2.

**Table 4** Eigen values First 1 canonical discriminant functions-first measurement

| Eigen value | % of Variance | Cumula. | Canon. Corre |
|---|---|---|---|
| .381* | 100 | 100 | 0.52 |
| Wilks' Lambda | Chi-square | df | Sig. |
| 0.724 | 29.36 | 8 | 0 |

**Table 5** Structure Matrix-first measurement

| Variables | Function 1 |
|---|---|
| „Slalom run 5x10m“ SHR | 0.698 |
| „Arm pull“ BAH | -0.562 |
| „Lng jump“ SBJ | -0.546 |
| „Reach while sitting“ SAR | 0.309 |
| „Hand tappin“ PLT | 0.273 |
| „Flamingo balance“ FTR | 0.185 |
| „Sits up“ SUP | -0.185 |
| „Body heght“ HIG | -0.184 |

-Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

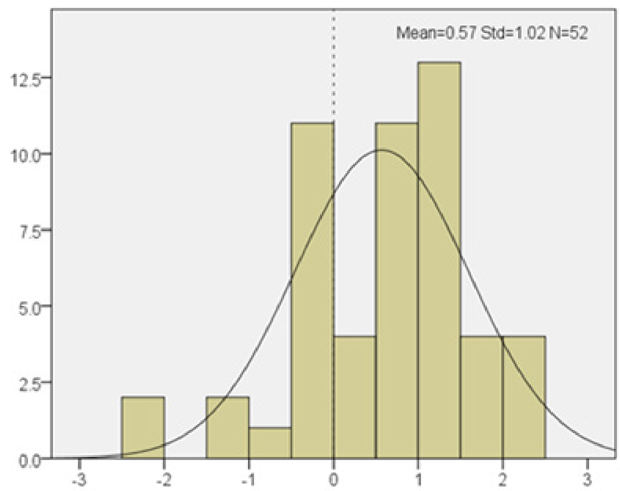
**Table 6** Functions at Group Centroids

| Gender | Function 1 |
|---|---|
| girls | 0.57 |
| boys | -0.66 |

-Unstandardized canonical discriminant functions evaluated at group means.

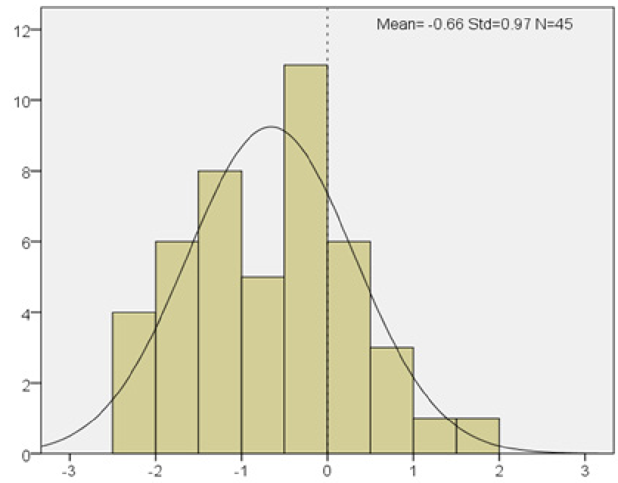
The rule applies that the arithmetic mean of standardized values is equal to zero and the standard deviation is equal to unity. μz=0 and σz=1. The centroid represents the arithmetic mean of all standardized variables, and the arithmetic mean is the mean of only one variable.

Centroids are relative values, i.e. coefficients, and arithmetic means are absolute values. In the example, we are talking about eight arithmetic means which, after standardization, were replaced with one named as the centroid. Considering two independent groups and eight independent variables, two centroids shared by one function were obtained. The individual test participation in the common difference is shown in Tables 5. Centroid is the common (group) arithmetic mean of all variables. In the example, there are two groups, i.e. two centroids and one function (discriminant function) that generally separates girls from boys. The statistical significance of the discriminant function depends on the size of the centroid distance. In the example, the size of the centroid for girls is .57 and for boys - .66. So, at the overall level, based on all tests, there is one statistically significant function that separates girls from boys (Tables 4&6) (Graphs 1&2).



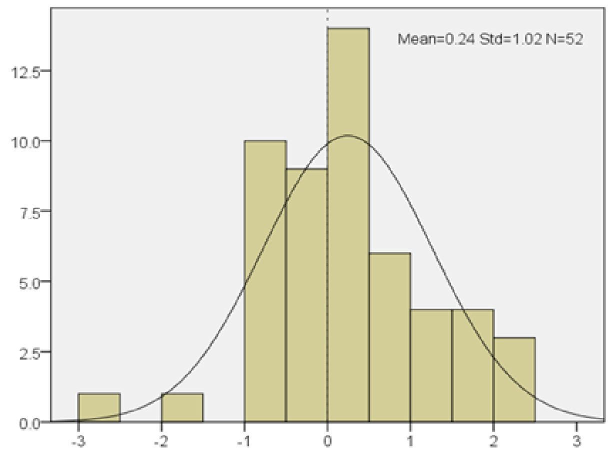

**Graph 1** Canonical discriminant function- Girls.

**Citation:** Mijanovic M. Differences between girls and boys based on basic psychomotor skills. *MOJ Sports Med.* 2023;6(2):62–70.
DOI: 10.15406/mojsm.2023.06.00141

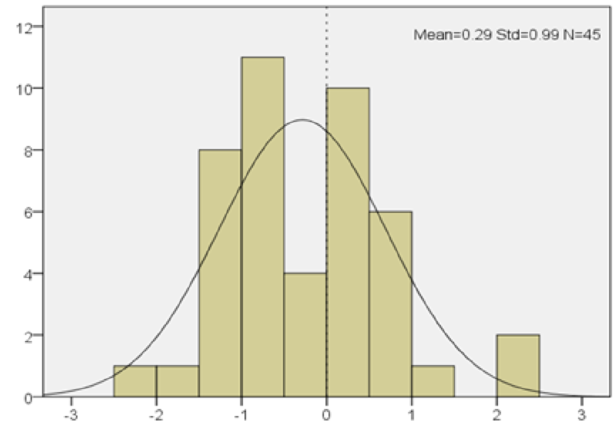



**Graph 2** Canonical discriminant function- Boys.

The results of the descriptive statistics of the second measurement are presented in table 2. Based on the statistical indicators in Tables 1&2, it is possible to make an initial comparison. It should be noted that the differences between arithmetic means are significantly smaller, as well as that there was an equalization between girls and boys, as shown by the results in Table 7. One-factor analysis of variance Anova column Sig. unequivocally confirms that differences exist but are statistically irrelevant. The size of Eigen values tested via Chi-square is 6.16 with degrees of freedom df=8 corresponding to Sig.=.63. The conclusion is that there is no statistically significant difference between girls and boys in the second measurement. Arithmetic means show that girls had greater gains on motor skills tests. The greater increase in body height of HIG stands out. In the first measurement, the boys were approximately two centimeters taller, and in the second measurement, the girls were half a centimeter taller. Given that the students were under the same treatment, these differences in psychomotor abilities should be attributed to endogenous factors related to biological, physiological, anatomical, psychosomatic dimensions that are stimulated by puberty, which is more intense in girls at this chronological age. In general, there was a slight delay in the boys, which was also reflected in the results in the psychomotor tests. The size of the “centroid”, i.e. of common arithmetic means in the second measurement is shown in Graphs 3&4.




**Graph 3** Canonical discriminant function- Girls.




**Graph 4** Canonical discriminant function- Boys.

According to the obtained results and set hypotheses, we can draw the following conclusions: The first hypothesis $H_1$ was that boys will have better results on the first measurement than their female peers Hypothesis H1 is accepted with a probability of error Sig.<.00. The second hypothesis $H_2$ was the same as the first, it is expected that in the second measurement boys will have better results than girls, as well as that the results of boys and girls will be better in the second measurement compared to the first. The results of the discriminant analysis show that we can partially accept the second hypothesis. It is evident that at the second measurement the results were better compared to the first measurement. It is important to point out that the girls had a significantly greater progress, so that in some tests, on the second measurement, they reached and overtook the boys of Tables 2&7. Based on the relevant discriminative coefficients, Table 8. Values: Eigen value .071,Wilks’Lambda .93, Chisquare 6.16, df8, Sig.=.63 indicate that there are no statistically significant differences. Hypothesis $H_2$ was not confirmed.

**Table 7** Tests of equality of group

| Varijables | Wilks' Lambda | F | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| 'Flamingo' balance-FTR | 0.999 | 0.121 | 1 | 94 | 0.728 |
| Hand tappin-PLT | 1 | 0.01 | 1 | 94 | 0.922 |
| Reach while sitting-SAR | 0.991 | 0.823 | 1 | 94 | 0.367 |
| Lng jump-SBJ | 0.98 | 1.89 | 1 | 94 | 0.171 |
| Sits up-SUP | 0.993 | 0.651 | 1 | 94 | 0.422 |
| Arm pull-BAH | 0.997 | 0.268 | 1 | 94 | 0.606 |
| Slalom run 5x10m-SHR | 0.998 | 0.189 | 1 | 94 | 0.664 |
| Body heght-HIG | 0.999 | 0.112 | 1 | 94 | 0.738 |

**Table 8** Eigen values First 1 canonical discriminant functions second measurement

| Eigen value | % of Variance | Cumu. | Canon. Corr. |
|---|---|---|---|
| .071a | 100 | 100 | 0.26 |
| Wilks'Lambda | Chi-square | df | Sig. |
| 0.93 | 6.16 | 8 | 0.63 |

## Summary of canonical discriminant functions

In this paper, a two-factor analysis of variance of independent groups was performed. It is about two independent groups of respondents observed according to gender in two different time periods. Discrimination criteria were seven psychomotor tests and


DOI: 10.15406/mojsm.2023.06.00141

body height. Table 9 shows the characteristic values of the differences. There are evidently three discriminative functions, two of which are statistically significant. The importance of discriminative functions is explicitly confirmed by the values: Eigen value, %Variance, Canonical Correlation, Wilks' Lambda and Sig. The biggest difference was between girls in the first and second measurements, followed by the difference between boys in the first and girls in the second measurement.

Table 10 shows a summary structure matrix where the individual contribution of each variable in discrimination is shown. Relevant discriminant coefficients are marked with an asterisk in the exponent. As you can see, the first discriminant function F1 consists of the variables: SHR, PLT, SBJ, BAH and HIG. The second discriminative function F2 is explained by the variables SAR and SUP, while the third discriminative function F3 is symbolically determined by the variable FTR whose coefficient is .282*.

The differences at the general level and the statistical significance of the discriminative functions are shown in Table 11. The coefficients of the third discriminative function F3 are evenly distributed and are statistically irrelevant. The biggest difference was between girls in the first and boys in the first and girls in the second measurement. Table 10 shows the Summary Structure Matrix where the individual contribution of each variable in discrimination is second measurements, followed by the difference between shown. Relevant discriminative coefficients are marked with an asterisk in the exponent. As you can see, the first discriminant function F1 consists of variables: SHR, PLT, SBJ, BAH and HIG. The second discriminative function F2 is explained with the variables SAR and SUP, while the third discriminative function F3 is symbolically determined by the variable FTR. The differences at the general level and the statistical significance of the discriminative functions are shown in Table 11. coefficients of the third discriminative function F3 are evenly distributed and are statistically irrelevant. Based on detailed and complex statistical procedures, students were classified based on the results achieved in both measurements.

Table 12 shows the absolute and relative classification values of who belongs to which group. It is about formal and informal classification. Formal classification was made according to gender, i.e. 52 girls and 45 boys. The classification based on the results achieved in the first measurement would be as follows: 28 girls or 53.8% remain in the formal group, and 24 or 46.2% belong to other clusters. The situation is similar with boys. According to the results of the first measurement, 23 or 51.5% of the group consisting of 45 boys would remain in the formal group. The classification based on the results in the second measurement would be as follows; 25 girls would keep the formal group or 49%, while the majority would be assigned to other groups. As can be seen, the best classified boys in the second measurement, 33 or 73.3% remain in the formal group. The clustering process achieves greater homogeneity of the set, and thus faster progress and greater efficiency. For the above reasons, cluster taxonomic procedures are desirable in education, sports, medicine, economy, industry, trade, agronomy, tourism, music, culture, art, management institutions, the military, etc. Given that the goal of this work was not classification but discrimination, a detailed cluster analysis was not done, although the results are extremely interesting.

**Table 9** Eigen values summary canonical disc. functions

| Function | Eigenva | % of Varian | Cumulativ | CanCor | |
|---|---|---|---|---|---|
| 1 | .443a | 63.5 | 63.5 | 0.554 | |
| 2 | .209a | 30 | 93.5 | 0.416 | |
| 3 | .045a | 6.5 | 100 | 0.208 | |
| Test of Function(s) | | Wilks'Lam | Chi-square | df | Sig. |
| giris first-giris second | | 0.548 | 111.809 | 24 | 0 |
| boys first-giris second | | 0.791 | 43.587 | 14 | 0 |
| 3 | | 0.957 | 8.226 | 6 | 0.222 |

**Table 10** Summary structure matrix

| Variables | F1 | F2 | F3 |
|---|---|---|---|
| "Slalom run 5x10m" SHR | .676* | -0.218 | 0.045 |
| "Hand tappin" PLT | .636* | 0.592 | 0.232 |
| "Lng jump" SBJ | -.631* | 0.06 | -0.036 |
| "Arm pull" BAH | -.389* | 0.11 | -0.073 |
| "Body heght" HIG | -.246* | -0.095 | -0.078 |
| "Reach while sitting" SAR | 0.061 | -.559* | -0.044 |
| "Sits up" SUP | -0.158 | -.633* | -0.067 |
| "Flamingo balance" FTR | 0.083 | -0.085 | .282* |

**Table 11** Functions at Group Centroids

| all | F1 | F2 | F3 |
|---|---|---|---|
| girls first measurement | .904* | 0.044 | 0.191 |
| boys first measurement | -0.087 | .663* | -0.224 |
| girls second measurement | -0.003 | -.622* | -0.2 |
| boys second measurement | -.954* | -0.01 | 0.23 |

-Unstandardized canonical disc. functions evaluated at group means

**Table 12** Classification Results a Predicted Group Membership

| Original | Group Memgership | girls first measur | boys first measur | girls second measur | boys second measur | Total |
|---|---|---|---|---|---|---|
| Count | girls first measur. | 28 | 10 | 11 | 3 | 52 |
| | boys first measr. | 7 | 23 | 5 | 10 | 45 |
| | girls second measur. | 8 | 8 | 25 | 10 | 51 |
| | boys second measur. | 2 | 4 | 6 | 33 | 45 |
| % | girls first measur. | 53.8 | 19.2 | 21.2 | 5.8 | 100 |
| | boys first measur. | 15.6 | 51.1 | 11.1 | 22.2 | 100 |
| | girls second measur. | 15.7 | 15.7 | 49 | 19.6 | 100 |
| | boys second measur. | 4.4 | 8.9 | 13.3 | 73.3 | 100 |

a. 56,5% of original grouped cases correctly classified.

## Conclusion

Following the set hypotheses and obtained results, the following conclusions can be drawn. The first hypothesis H1 assumes that boys will have better results than girls at the beginning of the school year (first measurement) and that these differences will be statistically significant at the Sig.≤.05 error level. Arithmetic means and One-factor analysis of variance "Anova" show that there is a statistically significant difference between boys and girls in favor of boys (Chi-square=29.36, df=8, Sig.<.00) Tables 1,3&4. Statistically significant correlation with the following variables had a discriminative function: (SHR, BAH, SBJ and SAR), Table 5. Differences between girls and boys were not established for the following variables: (FTR, PLT, SUP and HIG). That there is a difference on a general level is confirmed by the centroid distance, Table 6. According to the results in Table 1,3–6 as well as Graphs 1&2, hypothesis $H_1$ remains valid. The probability of statistical error is less than 1%. The second hypothesis $H_2$ assumes that even at the end of the school year (second measurement) boys will also have better results than their female peers, as well as that the difference will be statistically significant. Comparing the arithmetic means, it is evident that in the second measurement the results were better, as if on average the girls were slightly higher. Table 7 shows the results of the one-factor analysis of variance "Anova" and the statistical significance of the differences for each test, including body height. Values in Table 7 column Sig. shows and shows that there is no statistically significant difference between girls and boys in any test. There are small differences, but these differences are not large enough to be statistically significant. Discriminative coefficients: Eigen value=.071,Shisque=6.16, centroid distance (.242:-.286) and finally Sig.=.63 confirm that the differences are not statistically significant. Considering the results of the research, hypothesis $H_2$ can be rejected, noting that girls have improved more.

## Acknowledgements

None.

## Conflicts of interest

The author declares that there are no conflicts of interest.

## References

1. What part of the brain controls fine motor skills and coordination?
2. Daehyoung Lee, Rudolf Psotta, Milena Vagaja. Motor skills interventions in children with developmental coordination disorder: A review study. *EUJAPA*. 2016;9(2):20–29.
3. Cattell JM. Statistics of American Psychologists. *American Journal of Psychology*. 1903.
4. James McKeen Cattell. Statistics of American Psychologists.
5. Daniel L Schcter, Daniel T Gilbert, Daniel M Wegner. Psychology: The evolution of a science. 2009.
6. Galton F. Inquiries into human ability and its development. London: J.M. Dent & Company; 1883.
7. Fleishman Edwin A. The structure and measurement of physical fitness. Englewood Cliffs, NJ: Prentice Hall; 1964.
8. Mijanovic M. Measurement, testing, scaling and norming. *Acta Kinesiologica*.2007;1(1):95–101.
9. Janelle Stewart. 12-to14-year-olds: Ages and stages of youth development. 2013.
10. Mijanovic M. Effects of the EuroFit program. *MOJ Sports Med*. 2022;5(4):108–114.
11. Škrkar Stanislav, Madić Dejan, Popović Boris, et al. The effects of innovative and traditional physical education classes on the motor skills of younger school-aged children. *Norma*. 2020;25(2):239–252.
12. Mijanović M, Vojvodić M. Methodology of anthropology of sport. Faculty of Physical Education and Sports; Banja Luka: 2008.
13. Council of Europe Committee of Ministers- on the EuroFit tests of physical fitness.
14. Hadžikadunić M. General instructions for measuring the battery of EuroFit tests.
15. Hadžikadunić M. Monitoring evaluation and assessment in the teaching of physical and health education. Faculty of Physical and Health Education Sarajevo Homo Sporticus. 2004;1:6–15.
16. Mijanović M. Selection of statistical methods. University of Montenegro. Podgorica; 2000.
17. Pallant J. SPSS Survival Manual. 4th ed. Micro book; Belgrade; 2011.
18. Deepak Dhamnetiya, Manish Kumar Goel, Ravi Prakash Jha, et al. How to Perform Discriminant Analysis in Medical Research. *J Lab Physicians*.2022;14(4):511–520.
19. Sheridan J Coakes. SPSS 20 Analysis without the hassle.
20. Individual and group differences. Psychomotor learning.
21. Renata Pavić. Sexual differentiation of morphological characteristics and motor abilities of students from 11 to 14 years old.