Professional paper

COMPARATIVE ANALYSIS OF ANTHROPOMETRIC CHARACTERISTICS AND ANTHROPOMOTOR ABILITIES OF THE YOUTH OF SECONDARY SCHOOL POPULATION

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Abstract: The subject of this study is the operational plans and programs of a physical education course in a short period of time and how they affect the anthropometric characteristics and anthropomotor abilities of the youths of this age who are engaged in a physical activity, that is, who are engaged in some kind of sport recreationally and those who are not physically active. The overall objective of the study is the comparison of results in order to determine the effect of sports activities on the secondary school population and the course of teaching in the school itself.

The research was of a transversal character because it was aimed to determine the current state of the selected sample. By hypothesizing, we examine the general assumption that, as for the anthropometric characteristics, there will be no significant differences between young athletes and non-athletes, whereas, in regard to anthropomotor abilities, there will be considerable differences, and even greater if the youth are engaged in sports for a long time. The results of anthropometric characteristics and anthropomotor abilities were related, i.e. they were in synergy.

Based on the subject, objective and tasks of the study, the population from which a sample of respondents is taken is defined as a population of young people of secondary school education (the 2nd year) attending the Polytechnic School in the city of Kragujevac, divided into two sub-samples: the sub-sample of young athletes and the sub-sample of young non-athletes. Each sub-sample contained 30 respondents, which made a total sample of 60 respondents. On the day of measurement, the respondents were 17 years and +/-6 months old,

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all clinically healthy and without physical disabilities. The average age of the sub-samples was in the range of +/-6 months.

Regarding the sample of variables, i.e. as a part of the assessment of anthropometric characteristics of the young, the measurements were carried out as follows: longitudinal dimensionality of skeleton – body height, volume of body – body mass and, thereafter, the BMI, or body mass index, known also as the Quetlet index, was treated. To assess the anthropomotor abilities of the young, the measurements were carried out using the Eurofit battery of tests, and the criterion for their selection was the relevance of the researches of a number of authors (mentioned later in this paper): the flamingo balance test MFBT, hand tapping test MHTT, standing long jump test MSLJT, sit-ups test MSUT and MBFRT agility test, that is back and forth10 x 5m running.

The statistical significance of the differences in the arithmetical means of the compared samples was assessed by the t-test for small dependant samples, at the level of statistical significance of 0.05. In order to protect the level of significance of the t-test in this research, the initial value of 0.05 was divided by the number of tests, which is, in the first case, 3 and 5 in the second, and the resulting level of statistical significance is therefore 0.01. In these kinds of researches, this is a generally accepted procedure.

The research results show that we can accept the hypothesis regarding the anthropometric characteristics as well as the anthropomotor abilities of general balance, explosive strength of legs, and endurance strength of the abdominal muscles and running speed, i.e. agility at 0.05 level. The hypothesis regarding the anthropomotor ability of rapid performance of movements with a given amplitude, also at 0.05 level, is rejected. All these indicators were of the same conclusion at the level of significance of 0.01.

Key words: *sport and physical education, anthropometry, anthropomotorics, the youths, evaluation*

INTRODUCTION

With this research we wish to examine the effect of the program of secondary education institutions in the field of physical education, as already stated. In this field, education in secondary schools aims 'to form healthy, physically well and harmoniously developed, skillful and bold youth, who completely freely, efficiently and gracefully master their motor skills'.

It is well known that only a few prior researches were essentially engaged in examining the effects of physical education teaching programs in secondary schools on the anthropometric characteristics and anthropomotor abilities of the young, in our case the young male population. Therefore,

the need to define which the impacts of the physical education programs on anthropometric characteristics and anthropomotor abilities are, based on the appropriate sample, i.e. respondents engaged and not engaged in sports, respectively, has emerged as a research problem.

The overall objective of our paper is to compare the results of anthropometric characteristics and anthropomotor abilities of young athletes and non-athletes in order to determine the effect of sports activities on the secondary school population.

Based on the subject and objective of our research, earlier studies and age characteristics of the youth of the secondary school population, by hypothesizing we consider and examine a general assumption that, as for anthropometric characteristics, there are no significant differences between youth athletes and youth non-athletes, whereas, in regard to anthropomotor abilities, there are considerable differences, and even greater if the youth are engaged in sports for a long time.

As already mentioned, there is minimal research on the subject, mainly of an older date, but they were the trigger for the preference of the given research problem and a good reason for the justification of this type of research. On the basis of everything stated here, this study is set to be both methodologically and substantively correct.

In the book by authors Bokan and Radisavljevic (1995) the related studies dealing with very similar issues were mentioned and thus the author of this study, in the course of the research, mentions them as well.

Bokan (1977) in his study The impact of extracurricular activities on improving the motor performance and physical development of pupils in Belgrade high schools, under the mentorship of Slavko Ivančević, PhD, presented a research aimed at determining the level of the transformational impact of extracurricular activities on improving some motor skills (primary) and some characteristics of physical development as well (secondary) of the pupils in Belgrade high schools.

The research included 360 pupils from the Fifth and Fourteenth High School, divided into groups or sub-samples from 15 to 18 years, and additionally divided into an experimental group (E) and two control groups (C1 and C2). Each group counted 120 pupils (60 males and 60 females) so there were 30 pupils in each age group. The 'ex-post-facto' method was applied as a special kind of experiment in which the experimental factors already operated.

Within the physical development, body height and body weight were measured, whereas, within the motor skills, the following measurements were carried out: running speed, i.e. 30m flying start running; explosive and repetitive strength, that is standing long jump and the mixed lying pull-up in females and standard pull-up in males; balance, i.e. standing on the front part

of foot of one leg on a narrow backing surface; agility, i.e. bouncing a ball against the wall and catching it in a 15 second period; and endurance, i.e. 500m running for females and 800m running for males.

Respecting the order of hypotheses set up, the results obtained allow the following conclusions:

– in the first group of motor skills in males, where the basic hypothesis was confirmed on the whole, i.e. in all age groups from 15 to 18 years, there is a statistically significant difference between the males of the experimental group and the males of the control groups regarding the following abilities: running speed, explosive strength and endurance. These indicators gave the same results in our research as well;

– in the second group of motor skills in males, where the basic hypothesis was only partly confirmed, that is, in certain age groups from 15 to 18 years, there is a statistically significant difference between the males of the experimental group and the males of the control groups regarding the following characteristics: balance in males of 15, 17 and 18 years of age, agility in males of 16, 17 and 18 years of age and repetitive strength in males of 15 and 18 years of age. The same age of the males was included in our study as well, and identical results were obtaine;

– in the group of motor skills in females, where the basic hypothesis was confirmed on the whole, i.e. in all age groups from 15 to 18 years, there is a statistically significant difference between the females of the experimental group and the females of the control groups regarding the following abilities: running speed, repetitive strength and endurance;

– in the group of motor skills in females, where the basic hypothesis was only partly confirmed, that is in certain age groups from 15 to 18 years, there is a statistically significant difference between the females of the experimental group and the females of the control groups regarding repetitive strength in females of 15, 16 and 17 years of age and agility in females of 16 and17 years of age.

The research results confirm the beneficial effect of an increased range of exercising, a diverse content of exercises and an increased exercise intensity applied in the extracurricular activities in Belgrade high schools.

Stojiljkovic (1983) in his study, The effect of physical education methods, covered by the new program tasks, on the development of anthropometric and biomotor dimensions in pupils of the third grade of secondary vocational education in the city of Nis and Nis region, under the mentorship of Paul Opavski, PhD, presented a research aimed at determining the anthropometric and biomotor latent dimensions of the pupils of mentioned education, who, with two classes per week and other activities, have a well-organized physical education.

The differences in anthropometric and biomotor space between 3rd year males and females involved in this research were determined using the comparative method and they were compared with the results of the researches of Mr. N. Kurelic and his colleagues on the same sample of the Yugoslav population.

The data obtained in the study points out the research conducted on the safe theoretical bases of the impact of elective courses methods in a morphological and biomotor space, on which the process of physical education in terms of reformed school can be diagnosed, programmed, immediately implemented and controlled.

The research results showed the following:

– The implementation of the new curricula with two P.E. classes per week and other extracurricular activities had no statistically significant effect on the development of body height in males in the instrumental group as well as in the control groups, whereas certain statistically significant changes occurred in females but they were negligible and in the limits of systemic error in the measurement. The given results in the males were of the same conclusion as in our research.

– The implementation of the new curricula with two P.E. classes per week and other extracurricular activities statistically significantly developed ballistic muscular potential in terms of larger loads and shorter duration, projected on the development of power and endurance in all respondents of both sexes in the experimental group and control groups as well, so it is assumed that the development of this potential is more the result of a mastered technique of test implementation rather than a real indicator of the development of the aforementioned muscular potential (the tests for determination were the long standing jump and shot put).

– The implementation of new curricula statistically significantly influenced the development of ballistic-repetitive muscular potential (anaerobic repetitions) in terms of larger loads and longer duration, projected on the development of power and endurance in all respondents of both sexes in the experimental group and control groups as well (the test for determination were sit-ups in a 30 second period).

– The implementation of the new curricula statistically significantly influenced the development of ballistic-repetitive muscular potential in terms of smaller loads and shorter duration, projected on the development of speed and endurance in all respondents of both sexes in the experimental group and control groups as well (the test for determination were hand tapping and foot tapping).

The physical education methods with two classes a week are not sufficient to positively influence the development of anthropometric and

biomotor dimensions, which, on the basis of the scientific experiment, indicates that there is a need for a revision of physical education curricula in secondary vocational education.

Djukić (1975) in his study „Some possibilities for improving the quality of physical education in schools by an intensification of classes and a rationalization of learning motor tasks", under the mentorship of Slavko Ivančević, PhD, showed that the process of adopting motor structures occurs in the conditions of a certain pedagogical impact which, by the most suitable methodological procedures, directs it in a certain way.

The rationalization of physical education teaching in school in order to improve the psychophysical personality traits is achieved by:

– didactic rationalization, that is, the application of economical teaching methods in the training of motor tasks,
– implementation of methods for intensification of classes and reducing ineffective time for exercising, thus increasing performance, and an intensified process of practicing.

The sample consisted of 1st and 2nd year females of the Koca Kolarov High school and the Second High School in the city of Zrenjanin. The research was conducted on 140 respondents of the 1st year and 140 respondents of the 2nd year where, in the course of testing, 134 respondents of the 1st year in the experimental group and control groups completed the experimental procedure, as well as 128 respondents of the 2nd year in the experimental group and control groups.

The selection of variables:
– physical characteristics: body height, body weight, circumference of forearm and wrist diameter;
– physical abilities: factor of explosive strength of the legs, i.e. standing long jump; factor of repetitive strength of abdomen, i.e. sitting-up from lying on the back to sitting position; factor of static strength of arms and legs, i.e. endurance regarding pull-ups on the shaft and endurance regarding squats;
– earlier motor skills: handball, i.e. passing a ball at shoulder height or hand work, the basic stance or leg and abdomen work, and shooting to score by jumping; volleyball, i.e. rebounding the ball by fingers, the basic stance, rebounding by 'bump' and serving upwards;
– interview;
– records of teaching.

Based on the results achieved, the research confirmed the running hypotheses:
– that the applied optimal learning processes influenced a faster adopting of motor structures, thus giving a great opportunity for an intensified process

of practicing, and an even greater efficiency of the teaching process regarding the development of primary psychophysical personality traits;
– that rationalization of the teaching processes and increasing of performance also raised the level of physical fitness, enabling a faster adoption of the technical forms of movement;
– that the teaching process primarily depends on the professional and pedagogical guidance of teachers, whereas the improvement of teaching depends on the ability and energy of teachers to use all available instruments. All of these findings also emerged as indisputable facts in our research.

METHOD OF RESEARCH

The dialectic method and a specific type of natural experiment were used in this research.

The research was of a transversal character as it was aimed to determine the current state and the value of physical development or anthropometric characteristics and the anthropomotor abilities of the selected sample.

This research has the character of a 'natural experiment', where the group of athletes is an experimental group, whereas the group of non-athletes is the control group.

In theory, this kind of experiment is known as the so-called ex-post-facto method, where the experimental factor has already operated, so it is necessary to determine the effect of this factor after the start of its activity (i.e. ex-post) and therefore, the experimental factor is the sports activity itself with all its characteristics in those periods for the young athletes and non-athletes engaged or not engaged in sports, respectively, and what kind of effect the activity will produce on P.E. teaching regarding, in our case, the secondary school pupils.

It was already said that by setting up the hypotheses, we consider and examine a general assumption that, as for the anthropometric characteristic, there will be no significant difference between young athletes and non-athletes, whereas, in regard to anthropomotor abilities, there will be considerable differences, and even greater if the youth are engaged in sports for a long time.

Sample of respondents

Based on the subject, objective and tasks of this research, that is, how the recreational activity of the young people itself will contribute to the improvement of physical education and the above mentioned comparisons, the specific population from which the sample of respondents was taken is

defined as the population of young people of secondary school education (the 2nd year), from a secondary school in the city of Kragujevac, divided into two sub-samples:

– a sub-sample of youth athletes and
– a sub-sample of youth non-athletes.

Each sub-sample counted 30 respondents, which makes a total sample of 60 respondents. The sample consisted of youth from the Polytechnic School in Kragujevac. It included youth who, on the day of the measurement, were 17 years and +/- 6 months old, all clinically healthy and without any physical disabilities. Therefore, the average age of the sub-samples was within the limits of +/-6 months. The time spent in sports activities was regarded as the time spent in continuity until the time of measurement, and the given data were taken from the school records which every P.E. teacher keeps for each youth.

All respondents, the recreational athletes as well as the youths not involved in sports, voluntarily agreed to participate in our research. Before they started the recreational exercise program, the recreational athletes were submitted to medical examinations by a specialist in sports medicine. The recreational athletes kept their own records of exercising. The respondents were of those with 3 to 4 years of practicing for 4 times a week with the frequency of one training a day.

The most important part of training for developing endurance and improvement of running techniques was running, so the recreational athletes practiced running 3 times a week for 50 to 60 minutes, whereas the exercises for developing muscular strength and elasticity once a week for 45 minutes were also an important part of the program. All training sessions ended with a 10 minute stretching exercise of all major muscle groups and joints.

Each respondent or youth recreationally engaged in sports had an individual exercise program designed by several P.E. teachers who taught the respondents in primary schools, while, in the first year of secondary education, the author, as a P.E, professor, continued the program of recreational activities of the respondents.

The implementation of training, apart from exceptional individuals, was not fully completed in relation to the scope of the planned program. The average implementation based on the records of the respondents was 82%.

Sample of variables

To evaluate the state of the anthropometric characteristics of the youths, the measurement of the following anthropometric measures was carried out:

– body height was measured for the assessment of the longitudinal dimensionality of the skeleton;

- body mass was measured for the assessment of body volume.

After the above mentioned parameters, the body mass index (BMI), also known as Quetlet index, was measured, which is also a method of detecting obesity which is widespread in the world and accepted by reference organizations such as the World Health Organization (WHO) and the International Association for the Study of Obesity (IASO).

To evaluate the anthropomotor abilities, the measurement was carried out using the following tests:

– the flamingo balance test – to measure general balance;
– the hand tapping test – to assess the speed of movements, which is defined as the ability of a rapid performance of movements with a given amplitude;
– standing long jump test – to estimate the explosive strength of legs;
– sit-ups test – to estimate the strength of the abdomen (or endurance strength of the abdominal muscles) and
– back and forth 10 x 5 meters running test – to measure running speed and agility.

All the above mentioned are encrypted with the first letter A to indicate anthropometric measurements, whereas M stands for anthropomotor tests:

Anthropometric dimensions (with encrypts):
1. Body height (AH),cm
2. Body mass (AM), kg, and
3. Body mass index (BMI).

Anthropomotor tests (with encrypts):
1. Flamingo balance test (MFBT), sec., which must always be performed first,
2. Hand tapping test (MHTT), the number of repetitions measured in tenths of a second,
3. Standing long jump test (MSLJT), cm,
4. Sit-ups test (MSUT), number of repetitions in 30 seconds, and
5. Back and forth 10 x 5 meters running test (MBFRT), the number of repetitions, i.e. the performing of 5 complete cycles of running, measured in tenths of a second, and always performed last.

Terms and techniques of measuring anthropometric characteristics

The measurement of anthropometric characteristics of the youths was carried out in the P.E. hall in the Polytechnic, specially prepared for this purpose. The measurements were carried out in the period April – May 2013. The temperature, relative humidity and lighting of facilities made the participants feel comfortable.

The measurement was performed by three appraisers (professors of sport and P.E.) with the help of other teachers, i.e. the author of this paper and another two P.E. professors.

The respondents were in underwear and barefoot. All measurements were performed in the morning between 9 a.m. and 12 a.m.

Before measuring, each respondent was marked by relative anthropometric points and levels:

– the Frankfurt plane – a line connecting the bottom edge of the left orbit and the top edge of the left, external auditory opening.

During the measurement the result was read while the instrument was on the respondent, and the person noting down the result as a form of control, loudly repeated the result while recording it in the list of measures carried by every pupil.

The following instruments were used for the measurement:

– a medical scale with measuring possibility from 0.1 kg,
– Martin type anthropometer with the possibility to read the results from 0.1 cm,
– calculator for measurement of BMI.

All measurements predicted by the program were carried out using the method of the international biological program (Weiner, Lourie 1969), as follows:

The body mass is measured by a scale placed on a horizontal surface. A respondent, barefoot and only in his/her underwear, stands still in the middle of the scale in an upright posture. When the needle on the scale is still, the results are read with the accuracy of 0.1 kg. (manufacturer of medical scales Birotehna Ltd., Smederevo). The body height was measured by the Martin type anthropometer.

During the measurement the respondent, barefoot and in underwear, stands in an upright posture on the firm horizontal surface. The head of the respondent should be in such a position so that the Frankfurt plane is horizontal.

The respondent straightens the back as straight as possible, while pulling the feet together. The appraiser stands to the left of the respondent controlling whether the anthropometer is placed vertically along the back of the body, and then he drops the metal ring-slider so that the horizontal crossbar reaches the head (the top of the head of the respondent). At that point of measurement, the measurer reads the result on the scale at the level of the upper side of the triangular slot of the ring-slider. The result is read with the accuracy of 0.1 cm.

Terms and techniques of the measurement of anthropomotor abilities

The measurement of anthropomotor abilities was carried out in the P.E. in the Polytechnic. All measurements were performed in the morning from 8

a.m. to 12 a.m. in the period April – May 2013. During the measurement, the respondents were in sportswear (shorts, T-shirt, sneakers). The air temperature in the hall ranged from 18 to 22 degrees Celsius throughout the measurement.

The measurement of anthropomotor abilities was performed by three appraisers, professors of sport and P.E., i.e. the author of this paper and another two professors of sport and P.E., especially trained for this purpose.

During the research, the respondents came to the measurement by classes, and each respondent carried a measuring list with himself/herself and handed it over in the next stage. The following instruments were used for the measurement of the anthropomotor abilities: Elan mats, CATIGA CG – 503 stopwatches with the possibility to read the results of 0.1 sec, and traffic cones.

Tests using the Eurofit battery of tests were conducted by Aldin Avdić, Admir Hadžikadunić, and Muriz Hadžikadunić (2000) as well as Franci Ambrožić, Gustav Bala and Dejan Madic (2002), which served to establish the differences in anthropomotor abilities.

During the process of training and research of the youth regarding the development of anthropological characteristics (according to Drabik, 1996, and Malacko, 2002), effective procedures in the selection of the contents of working methods, organizational forms, load intensity and recovery were applied.

In view of that, positive effects of the transformation process can be expected only if the methodological design of training is customized to individual abilities and characteristics of the subject (Kondrić and co-authors, 2002). The tests are explained in the order of performance.

Flamingo test

Factor: general balance.

Description of the test: balancing on one leg on the beam of the given dimensions.

Equipment and props needed for the test performance: a metal or wooden 50 cm long x 4 cm high x 3 cm wide beam covered with material with a maximum thickness of 5 mm firmly affixed to the beam. Stability of the beam is provided with two 15 cm long x 2 cm wide supports.

Description of the test: each respondent balances as long as possible on the longitudinal axis of the beam while standing on a chosen leg. S/he bends the leg backwards and, with the ipsilateral hand, catches the upper part of the foot standing like a flamingo. The teacher helps the respondents take the proper position by supporting him/her with his forearm. The test starts when the teacher withdraws his/her hand. The respondent tries to balance in this position as long as possible. The test is finished the moment the respondent

loses balance (i.e. drops the free leg, the one s/he holds) or touches the floor with any part of the body. The test is repeated three times, and the best time is counted. The measurer stands in front of the respondent and the test begins after the trial attempt. The stopwatch is turned on when the respondent lets go of the teacher's arm. The stopwatch is stopped when the respondent loses balance, drops the free leg and touches the floor with any part of the body. After each fall, the measurer helps the respondent take the starting position.

Assessment of the test: the longest time of balancing in the given position on the beam.

Hand tapping test

Factor: assessing the speed of movements which is defined as the ability of rapid performance of movements with a given amplitude.

Description of the test: rapid alternating, touching the two plates by a hand by choice.

Equipment and props needed for test performance: a table whose height is adjustable, two rubber discs of 20 cm diameters attached horizontally on the table, the distance between the centers of the discs is 80 cm (between the edges 60 cm), rectangular 10 x 20 cm plate placed at an equal distance between the two discs, a stopwatch.

Description of the test: the respondent sits at the table with feet slightly spread and with the hand of the free arm placed on the rectangular plate in the centre. The respondent places the hand of the chosen arm on the opposite disc. Then s/he passes the chosen hand back and forth between the two discs as fast as possible over the other hand placed in the middle of the table on the rectangular plate, and the respondent must be sure that each time the disc is touched. When the teacher says 'Ready… now!' the respondent should perform 25 cycles as quickly as possible (one cycle is touching the opposite disc and returning to the starting disk). The respondent stops when the teacher gives the signal 'stop'. During the test, the teacher loudly counts the cycles. The test is repeated twice and the better time is taken. The appraiser must adjust the height of the table so that its surface is just below the level of the respondent's navel. Throughout the test, the appraiser stands by the table paying attention to the disc the respondent chose at the beginning of the test and counting the respondent's touching of the disc.

The stopwatch is turned on after the teacher's word 'now!' Assuming that the respondent started the test at the disc marked as A, the stopwatch is stopped when the respondent touches the disc 25 times, so the total number of touches of the two discs (A and B) is 50 or 25 cycles of touches between the discs A and B. It is recommended that the test is performed by two appraisers: one to measure time and encourage the respondent and the other to count the touches.

Assessment of the test: the task consists of 25 cycles. The fastest time is the result recorded and the best result is the assessment. The assessment is the time needed for 25 touchings of the disc, measured in tenths of a second. The appraiser does not count the attempts when the respondent does not touch both plates. If the respondent fails to touch the disk, one touch more is added to attain the obligatory 25 cycles.

Standing long jump test

Factor: Explosive strength, i.e. the assessment of explosive strength which is the ability to activate the maximum number of motor units in a unit of time during the implementing of simple motor structures with a constant resistance or with resistance proportional to body mass. A large number of researchers (Chu 1998, Matvejev 2000, Antekolović 2003) state that explosive strength is the dominant dimension in most sports activities, and that it is the most common in athletic jumps, and we absolutely agreed with this in our research.

Description of the test: long jump from a standing position.

Equipment and props needed for the test performance: Elan mats joined together to the length from 3 to 4 m, chalk, magnesium, a meter tape, a ruler in the 'T' shape, a spring board and a picture of tasks.

The respondent takes off with both feet from the end of the reversely set springboard (the higher end of the board faces backward) and jumps as far as possible, always by both feet, on the mat. Arms swinging and lifting on the toes are allowed only before the jump. Double take-off is not permitted. The respondent must jump barefoot. Take-off and landing surface must be in the same plane. The place of take-off is marked by a line (Scotch tape). If possible, the measuring tape up to 300 cm can be placed alongside the landing place, which makes the reading of the length of the jump simpler. The result is recorded in centimeters, for example, a 201 cm jump is written as 2/0/1, or the 95 cm jump is entered as 0/9/5. The test is controlled by a teacher, assistant and recording secretary, who must draw the parallel lines on the landing mat every 10 cm starting from 1m away from the starting line. The measuring tape (meter) placed on this line give the exact measure. The teacher stands on the side and measures the length of the jump. The length is measured from the front edge of the starting line to the point where the back of the foot (closest to the take-off line) lands down on the mat. If the respondent falls backwards or touches the mat with any part of the body, an extra attempt is allowed. The take-off and landing mat must be in the same plane and firmly attached to the floor. Since the differences in the estimates can be significant, the measurement should be precise.

Assessment of the test: the respondent jumps twice in a row, and the longest jump is assessed. A meter tape is used to measure the distance from the line of take-off to the nearest mark on the landing mat. If footprints are not

clearly visible, it is necessary to smear the respondent's heels with magnesium. Improperly performed jumps are repeated.

Sit-ups test

Factors: abdomen strength (endurance strength of the abdominal muscles).

Description of the test: the maximum number of raises from lying to sitting position done in half a minute.

To perform the test we need two Elan mats (placed one by the other by length), a a CATIGA CG – 503 stopwatch.

The respondent sits on the mat with a straight back, hands clasped behind the head, knees bent at 90 degrees, and heels and feet placed flat on the mat. First s/he lies on their back touching the mat with their shoulders, and then s/he returns to a sitting position with their elbows in front of them so that they can touch their knees. All the time, the respondent keeps their hands clasped behind their head. When the teacher says 'Ready…now!', the respondent repeats this action as quickly as possible during 30 seconds and continues until the teacher says 'stop!' This test is done only once. The appraiser should kneel beside the respondent and make sure that the respondent has taken the proper starting position. The appraiser sits facing the respondent, with legs spread and the thighs over the respondent's feet to keep them on the ground, and puts the hands under the respondent's knee, keeping both knees at a right angle of 90 degrees, and legs still. After instructions are given and before starting the test, the respondent performs the entire movement in order to check if the respondent understood the instructions. The stopwatch is started at the words 'Ready… now!' and is stopped after 30 seconds. We count each sit-up when the elbows touch the knees, while improper attempt is not counted. During the performance of the test, we correct the respondent if he does not touch the mat properly with the shoulders or knees by elbows when they return to the sitting position.

Assessment of the test: the total number of correctly performed sit-ups in 30 seconds is the assessment of the test.

Running 10 x 5m test

Factors: running speed, agility.

Description of the test: running and agility at full speed.

To perform the test, we need a clean non-slip floor, a stopwatch, a tape measure (meter), school chalk or tape, traffic cones.

The respondent gets ready behind the line. One foot must be right behind the line. When the 'start' is signaled, the respondent should run as fast

as possible to the other line and return to the starting line, crossing both lines with both feet. This is one cycle, and the respondent must do five cycles. The appraiser draws two parallel lines spaced five meters on the floor (using school chalk or Scotch tape).

The line is 1.20 m long and the ends of each line are marked by traffic cones. The appraiser checks if the respondent had crossed the line with both feet each time s/he ran the given path and whether the turns were performed as quickly as possible. The total number of performed cycles is announced after each cycle. The test ends when the respondent crosses the finish line with one foot. The respondent must not slide during the test and therefore it is necessary that the floor is of a non-slip material.

Assessment of the test: the time required to perform five complete cycles of running back and forth expressed in tenths of a second is the assessment of the test.

Method of processing data

The basic descriptive statistics is separately calculated for each of these two sub-samples: the arithmetic mean (Mean), standard deviation (SD), coefficient of variation (cV%) and the minimal and maximal results (Min-Max).

The statistical significance of the differences in the arithmetic means of the appropriate variables between the compared samples is estimated using the t-test for small dependent samples at the level of significance of 0.5. The aforementioned method is applied to the sample of all youths in this research for all anthropometric measures and anthropomotor tests.

The statistical analysis of the data obtained in this research was done on the Pentium IV in the program – Microsoft Office 2010 – Excel.

RESULTS AND DISCUSSION

Table 1. *The experimental group (athletes) – the results of anthropometric measures of young athletes of the secondary school population*

	Year	Gender	AH (cm)	AM (kg)	BMI
Mean value - MEAN	1996	M	178.03	69.93	22.05
Standard deviation - SD	1996	M	6.38	5.99	1.37
Coefficient of variation - cV%	1996	M	3.58	8.56	6.22
Min	1996	M	163	58	18.41
Max	1996	M	190	85	25.66

Table 2. *The control group (non-athletes) – the results of anthropometric measures of young non-athletes of the secondary school population*

	Year	Gender	AH (cm)	AM (kg)	BMI
Mean value - MEAN	1996	M	179.57	71.17	22.01
Standard deviation - SD	1996	M	7.14	11.82	3.02
Coefficient of variation - cV%	1996	M	3.97	16.61	13.73
Min	1996	M	168	52	16.98
Max	1996	M	195	94	28.70

Table 3. *Significance of differences (t-test) in the arithmetic means of anthropometric characteristics of young athletes and non-athletes of the secondary school population*

Ordinal number	Parameters	The experimental group – the average	The control group – the average	t- test	t- test The level of significance
1	AH (cm)	178.03	179.57	0.38	t < 0.05
2	AM (kg)	69.93	71.17	0.61	t < 0.05
3	BMI	22.05	22.01	0.95	t < 0.05

A discussion of the basic anthropometric characteristics of young people of secondary school age, athletes and non-athletes, produced Table 1, which shows the indicators of young athletes and, Table 2 which shows young non-athletes.

Table 3 shows the statistical significance of the differences (t-test) in the arithmetic means of anthropometric characteristics of young athletes and youth non-athletes.

The average body height of the youths engaged in sports and young non-athletes is 178.03 cm and 179.57 cm, respectively. Between these two groups, there is no statistically significant difference regarding body height (t=0.38) at the significance level of 0.05, and the results obtained can be considered practically equal.

The relative variability of body height of the young athletes (cV% - 3.58) and the young non-athletes (cV% - 3.97) is approximately the same, i.e. the homogeneity of the groups in the observed characteristic is about equal.

The average body mass of the young athletes is 69.93 kg, and 71.17 kg of the young non-athletes. The difference in the mean values of body mass between the observed groups is not statistically significant (t=0.61) at significance level of 0.05, and the results obtained can be considered practically equal.

The relative variability of the body mass of young athletes (cV% - 8.56) is lesser that in the young non-athletes (cV% - 16.61), i.e. young athletes are a more homogenous group in the observed characteristics.

The average value of the BMI of young athletes is 22.05 and of the young non-athletes it is 22.01. Between these two groups, there is no statistically significant difference in the measurement of the BMI (t=0.95) at the significance level of 0.05, and the results obtained can be considered practically equal.

The relative variability of the BMI of young athletes (cV% - 6.22) is lesser than of the young non-athletes (cV% - 13.73), i.e. the young athletes are a more homogenous group in the observed characteristics.

From the above mentioned, we come to the knowledge that the anthropometric characteristics of the young athletes in relation to the anthropometric characteristic of the young non-athletes are practically the same mean (t=0.38, 0.61, 0.95) at the significance level of 0.05.

Table 4. *The experimental group (athletes) – the results of anthropomotor tests of young athletes of the secondary school population (in the already described tests and with the given order of testing)*

	MFBT, sec.	MHTT, sec. – number of repetitions	MSLJT, cm	MSUT, sec. – number of repetitions	MBFRT, sec.
Mean value - MEAN	18.37	14.07	224.60	23.00	20.10
Standard deviation - SD	13.00	3.49	20.28	3.71	2.59
Coefficient of variation - cV%	70.78	24.83	9.03	16.13	12.89
Min.	6	8	190	20	15.8
Max.	70	25	280	36	25.1

Table 5. *The control group (non-athletes) – the results of anthropomotor tests of young non-athletes of the secondary school population (in already described tests and with the given order of testing)*

	MFTR, sek.	MTR, sek. – br. ponavljanja	MSDM, cm	MLUS, sek. – br. ponavljanja	MTTO, sek.
Mean value - MEAN	8.63	15.50	200.73	20.97	24.08
Standard deviation - SD	6.52	3.12	19.29	4.23	3.12
Coefficient of variation - cV%	75.47	20.10	9.61	20.18	12.94
Min.	2	8	160	13	18.4
Max.	26	25	240	28	30.2

Table 6. *Significance of differences (t- test) in the arithmetic means of anthropomotor characteristics of young athletes and young non-athletes of the secondary school population*

Ordinal number	Parameters	The experimental group – the average	The control group – the average	t- test	t- test The level of significance
1	MFBT, sec.	18.37	8.63	0.000676	t < 0.05
2	MHTT, sec.- number of repetitions	14.07	15.50	0.098948	t < 0.05
3	MSLJT, cm	224.60	200.73	0.000018	t < 0.05
4	MSUT, sec.- number of repetitions	23.00	20.97	0.000004	t < 0.05
5	MBFRT, sec.	20.10	24.08	0.000002	t < 0.05

A discussion of the basic anthropometric abilities of young people of secondary school age, athletes and non-athletes, produced Table 4, which shows the basic descriptive statistical indicators of anthropomotor abilities of young athletes, and Table 5 which shows young non-athletes. Table 6 shows the statistical significance of the differences (t-test) in the arithmetic means of anthropomotor abilities of young athletes and non-athletes.

The average value of the results of the test for estimating general balance, the Flamingo balance test, of young athletes and non-athletes is 18.37 and 8.63 seconds, respectively. The difference in the mean values of the results of the general balance of young athletes and non-athletes is statistically significant (t=0.000676) at the 0.05 level and the results obtained can be considered practically unequal, i.e. there are significant differences between the groups regarding general balance.

In both groups, there were great variations (from 6-70 to 2-26 seconds) and coefficients of variation (cV% - 70.78, and cV% -75.47) in the test of general balance between young athletes and non-athletes, and greater variability was found in young non-athletes, which indicates that none of these two groups is homogeneous in the observed characteristic, and therefore a conclusion can be made about the weaknesses of the Flamingo test, and large differences in the general balance in both groups.

The average value of the results of the test for the assessment of the ability of rapid performance of movements with a given amplitude, hand tapping, of

young athletes and young non-athletes is 14.07 and 15.50, respectively. The difference in the mean values of the results of the above described test and the given groups is not statistically significant (t=0.098948) at the 0.05 level, and the results obtained can be considered practically equal.

The relative variability of the results of the ability of rapid performance of the movements with a given amplitude of young athletes and non-athletes (cV% -24.83 and cV% -20.10, respectively) is approximately equal, i.e. the homogeneity of the groups in the observed characteristic is about equal, but young non-athletes are the more homogenous group regarding the observed characteristic.

The average value of the results of the test for assessing explosive strength, the standing long jump, of young athletes and non-athletes is 224.60 and 200.73 cm, respectively. The difference in the mean values of the results of the explosive strength test of young athletes and non-athletes is statistically significant (t=0.000018) at the 0.05 level, and the results obtained can be considered practically unequal, i.e. there are significant differences regarding the explosive strength between the groups.

The relative variability of the results of explosive strength of young athletes and non-athletes (cV% -9.03 and cV% -9.61, respectively) is approximately equal, i.e. the homogeneity of the groups in the observed characteristic is about equal, but young athletes are a more homogenous group regarding the observed characteristic.

The average value of the results of the test for assessing the strength of the abdomen, i.e. endurance strength of the abdominal muscles, sit-ups, of young athletes and non-athletes is 23.00 and 20.97 repeats, respectively. The difference in the mean values of the results of the abdomen strength between the given groups is statistically significant (t=0.000004) at the 0.05 level, and the results obtained can be considered practically unequal.

The relative variability of the results of the strength of the abdomen, i.e. endurance strength of the abdominal muscles of young athletes and non-athletes (cV% -16.13 and cV% -20.18, respectively) is approximately equal, i.e. the homogeneity of the groups in the observed characteristic is about equal, but the young athletes are a more homogenous group regarding the observed characteristic.

The average value of the results of the test for assessing running speed, i.e. agility, back and forth 10 x 5m running, of the young athletes and non-athletes is 20.10 and 24.08 seconds, respectively. The difference in the mean values of running speed, i.e. agility results in both groups is statistically significant (t=0.000002) at the 0.05 level, and the results obtained can be considered practically unequal.

The relative variability of the results of running speed, i.e. agility, of the young athletes (cV% -12.89) is lesser than that of the young non-athletes (cV% -12.94), i.e. the young athletes are a more homogenous group in the observed characteristic. And the result is approximately the same so the homogeneity of the groups regarding the observed characteristic is about equal.

Based on the results obtained and research of a general assumption, we can accept the hypothesis that between the young athletes and non-athletes, there are no significant differences regarding anthropometric characteristics.

On the other hand, based on the given research, between the young athletes and non-athletes, there are statistically significant differences regarding the anthropomotor ability of general balance, the flamingo balance test, at the 0.05 level, in favor of young athletes, which means that we also confirmed the earlier hypothesis that there will be significant differences regarding the results of anthropomotor abilities, and even greater if the youth are engaged in sports for a long time.

Between the young athletes and non-athletes, there are no statistically significant differences regarding the anthropomotor abilities of rapid performance of the movements with a given amplitude, the hand tapping test, at the 0.05 level.

Based on the results obtained, we reject the hypothesis which states that there are significant differences in the observed characteristic between young athletes and non-athletes, in favor of young athletes.

Between the young athletes and non-athletes, there are statistically significant differences regarding the anthropomotor ability of explosive strength, the standing long jump test, at the 0.05 level.

Based on the results obtained, we can accept the hypothesis that there are significant differences regarding the anthropomotor abilities between young athletes and non-athletes, in favor of young athletes.

Between the young athletes and non-athletes, there are statistically significant differences regarding the anthropomotor ability of the endurance strength of the abdominal muscles, the sit-ups test, at the 0.05 level.

Based on the results obtained, we can accept the hypothesis that there are significant differences regarding the anthropomotor ability between young athletes and non-athletes, in favor of young athletes.

Between the young athletes and non-athletes there are statistically significant differences regarding the anthropomotor ability of running speed, i.e. agility, back and forth 10 x 5 m running test, at the 0.05 level.

Based on the results obtained, we can accept the hypothesis that there are significant differences regarding the given anthropomotor ability between young athletes and young non-athletes, in favor of young athletes.

In order to protect the level of significance of the t-test of this research, it is necessary that the initial value of 0.05 is divided by the number of tests, that is 3, and in that case the resulting level of statistical significance is 0.01. In such researches, this is a generally accepted procedure.

Table 7. *Significance of differences (t- test) in the arithmetic means of anthropometric characteristics of young athletes and non-athletes of the secondary school population (protection of the level of t-test significance)*

Ordinal number	Parameters	The experimental group – the average	The control group – the average	t- test	t- test The level of significance
1	AH (cm)	178.03	179.57	0.38	t < 0.01
2	AM (kg)	69.93	71.17	0.61	t < 0.01
3	BMI	22.05	22.01	0.95	t < 0.01

In order to protect the level of significance of the t-test of this research, we used the same procedure, i.e. it is necessary that the initial value of 0.05 is divided by the number of tests, that is 5, and in that case the resulting level of statistical significance is 0.01. In such researches, this is also a generally accepted procedure.

Table 8. *Significance of differences (t- test) in the arithmetic means of anthropomotor characteristics of young athletes and non-athletes of the secondary school population (protection of the level of t-test significance)*

Ordinal number	Parameters	The experimental group – the average	The control group – the average	t- test	t- test The level of significance
1	MFBT, sec.	18.37	8.63	0.000676	t < 0.01
2	MHTT, sec.-number of repetitions	14.07	15.50	0.098948	t < 0.01
3	MSLJT, cm	224.60	200.73	0.000018	t < 0.01
4	MSUT, sec.-number of repetitions	23.00	20.97	0.000004	t < 0.01
5	MBFRT, sec.	20.10	24.08	0.000002	t < 0.01

A discussion of the research of anthropometric characteristics and anthropomotor abilities of young athletes and non-athletes at the level of

significance of 0.05, which was carried out in order to protect the significance level of t-test of this research, showed equal results, and confirmed the earlier imposed hypothesis in all cases, except the hand taping test, and therefore, we consider this research very relevant. No changes occurred in relation to the level of statistical significance of 0.05.

CONCLUSION

The research carried out in the study 'A comparative analysis of anthropometric characteristics and anthropomotor abilities of young athletes of the secondary school population' carried out in the city of Kragujevac, arose as a need and a message about the importance of practice and further research, and that, at this stage of the development of the secondary school system, their effects are to be observed in the field of physical education as well (in other fields, for example, in the field of intellectual and social development, such research has already been carried out).

In regard to the numerous tasks in the field of physical education in primary and secondary schools, which are generally very complex to study, our objective was aimed at determining the effects of physical education programs in secondary schools, especially in the part related to the stimulation of anthropometric characteristics and anthropomotor abilities of the youths.

With respect to the size of the sample, which was relatively small, and an insufficient uniformity of the sub-samples, for example, by socio-economic status and the conative-cognitive abilities of respondents, the results obtained at the conclusion should be taken with reserve.

The differences in anthropometric characteristics and anthropomotor abilities which can be found in youth, should be considered not only in the programming of physical education, which includes extracurricular activities as well, i.e. various forms of recreation of the pupils, but also while forming the 1st year class in secondary school as well, because in forming this class a number of factors is considered, such as intellectual ability, educational and economic status of the family, and others. On the other hand, the factors of anthropometric characteristics and anthropomotor abilities are particularly ignored even though they, among other things, determine to a large extent how the youth will submit school assignments.

Similar research was conducted by the authors Batričević and Jakovljević (2008) in the study "The effects of the models of explosive strength on the development of motor and functional abilities of pupils" and they came to very similar results and parameters as in this study.

Therefore, all these findings can serve as a basis for a new research of this problem and a test of the results obtained on a larger sample with more variables, that is, tests and thorough methods of data processing.

The research gives a contribution to the development of research methodology in the field of physical education, especially in the research of this or similar problems. In the classical approach to evaluation, the experimental group working on a special program is compared with the control group that did not receive such incentives.

However, such a model is subject to various measurement errors (the majority of errors relate to the expectations of the experimenter), and besides, it is not methodologically clean regarding the separation of the effects of the program from the spontaneous process.

In our research, as the final conclusion, we can say that we have conducted an evaluation of the results of a finite product formed in a spontaneous process, which in itself contains the practice of an 'experimental program'.

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