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Review Article

The influence of anthropometric parameters and of muscle-joint mobility on the speed of execution in the handball game

BAŞTIUREA EUGEN[1], STAN ZENOVIA[2], MIHĂILĂ ION[3], CREȚU NICOLETA[4]

[1-2]University „Dunărea de Jos" of Galați, Faculty of Physical Education and Sport, Romania

[3]University of Pitesti, Faculty of Physical Education and Sport, Romania

[4]Gymnasium „Maria Grecu" Odaia Manolache, Galați, Romania

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Abstract
The present study aims at improving the evaluation and rating of students in physical education on the basis of findings regarding the influence of anthropometric parameters and of the musculo-articular mobility on the speed of execution of specific technical elements of the handball game.
In handball, physical training means to develop the body's ability to support driving activities at a higher level. Lack of *mobility* can generate a lot of problems, such as: increasing the period of learning and reinforcing driving activities, favoring the occurrence of accidents, limiting the development of other driving skills, losing the efficiency in the execution of driving actions and decreasing the quality of execution (movements are slowly executed).
In terms of *speed of execution,* it should be noted that it has a significant share in the practice efficiency of handball game. A particular importance in forming this driving quality is age, since it is known that *speed* is trainable mostly in the period of 7-15 years.
The scientific approach shows that there is a significant influence of anthropometric parameters on the speed of execution, mainly at students of 13-15 years old (values of chest size and elasticity). At age 14, chest elasticity affects the speed of execution, in all technical elements evaluated. The conclusions are that there is a decrease in mobility with age, and that only specific driving actions of the goalkeeper receives its' input.
The key concept has to be individualization of teaching, especially the individualization of evaluation, taking into account the values of anthropometric and musculo-articular mobility assigned to each subject. It is recommended the development of musculo-articular mobility (especially at higher ages), and the increase of thoracic elasticity at young ages.
Based on the fact that school physical education is one of the determining factors in preparing students for integration in society, research and dissemination of all necessary theoretical and practical knowledge essential for improving the teaching process are needed.

Keywords: *morpho-functional development, school handball, mobility, speed of execution*

Introduction

Impetuous development of contemporary society requires reconsidering the process of preparing the individual for life, something that cannot be conceived without qualitative changes in educational content.
In this context, school physical education, with other fields of study, should contribute to the comprehensive training and education of students, which is why it is necessary that the benchmarks of physical education could effectively complete the overall objectives of modern education (Scarlat E., 1993; Badiu T., Ciorbă C., Badiu G., 1999; Todea S.F., 2001; Dragomir P., Scarlat E., 2004; Colibaba-Evuleț D., 2007; Șerbănoiu S., Tudor V., 2007).
Peculiarities of development of the pupils of 7-15 years old need the multilateral stimulation of the body, because only this way an optimal state of health, on the one hand and a smooth and proper physical development, on the other hand, can be provided.
Proportionality of body, correct posture, raised functional indices, driving skills development, training and strengthening basic driving skills and interest in physical exercise are essential elements of multilateral training (Demeter A., 1989; Bota C., 1997; Dragnea A., Bota A., 1999; Stan Z., 2004, 2009; Cordun M., 2009).
With our current society, which is constantly changing, there is a need for specialists standing concerns about the organization of physical education lessons more efficient, attractive and various through the demands imposed to

Correspondence: Baştiurea Eugen Email: *ebastiurea2001@yahoo.com*

the body. Speaking of the importance of physical education classes, reflected in curricular objectives, they must also positively influence the driving, intellectual, moral and volitional preparation, something that leads to the formation of an autonomous and creative personality.
Basically, the comprehensive education of students is accomplished by enrolling physical education in the means system. This way physical education should contribute not only to strengthening both health and physical development in a harmonious way, but also to improving their driving ability.
Research in pedagogy field and in methodology of teaching physical education determines the accumulation of some scientific concepts that will allow recruitment of students as real subjects for training (Cârstea Gh., 1993; Epuran M., 1996; Niculescu M., 2002; Simion Gh., Amzăr L., 2009).
Secondary school graduate's personality formation is conditioned by the unity of mental, physical and intellectual qualities, but according to the values of Epuran M. (1982) physical qualities should be primary.
At present, it is more required to increase students' training of driving skills, therefore physical education teachers need to focus their work towards finding the most rational ways of improving the teaching process (Roman C., 2008; Balint Gh., 2009; Stan Z. 2009).
School physical education aims to integrate the young in society, according to the needs imposed by the society's constant and uneven development, the average school age being the best time in many ways.
Ensuring multilateral physical training can be achieved in physical education classes with an appropriate and attractive content, which then will allow students to successfully participate to physical activities practiced in leisure time or to performance sporting physical activities.
From this perspective, we can say with certainty that the game of handball is one of the most important means of physical education in schools with which we can solve the task of physical education lessons, but also the training of driving skills, both necessary for implementing specific technical elements of the game or even activities of daily living (Ghermănescu-Kunst I. et al., 1983; Baştiurea E., 1994; Negulescu I., 2000; Acsinte A., Alexandru E., 2000; Baştiurea E., Sârbu D., Stan Z., 2001; Mihăilă I., Popescu D.C., 2009; Rizescu C., Cazan F., Georgescu A., 2009).
To improve the execution of the elements and techniques by students, the teacher should be alert to the development of all driving qualities, including *suppleness* and *mobility*.
First of all, the presence of mobility is required by technical requirements, and second of all, for executing movements with maximum speed, ease and efficiency it is required high amplitude.
Handball players greatly benefit from this joint mobility, whereas most technical actions require more amplitude.
Speed and coordination are important driving qualities for improving the execution tehnique of elements and techniques. Between them, there is a certain level of correlation, too (Baştiurea E., 2004).
Exercises used to develop mobility strengthen joints, secure ligaments, increase muscle elasticity and their ability to stretch, which is an effective means to prevent muscle injuries. A good joint mobility is useful in all driving acts, which together with other qualities, determines the parameters and characteristics of motion (Raţă G., Raţă B.C., 2006; Stan Z., Baştiurea E., 2008; Niculescu I.I., 2009).
The success of actions depends very much on the speed of execution of driving acts, making teachers to be alert to those students who have inherited this driving quality in their structure. However, morpho-functional features of pupils of 7-15 years old favor its development.
Execution speed is of increased interest for all branches of sport and its contribution is decisive in the achievement of performance in athletics sprint competitions or in sports games, such as handball (counterattack, retreat, marking, demarcation).
After Thörner, quoted by Raţă G., Raţă B.C. (2006), average values of reaction time corresponding to the main stimulations we operate in physical education and sports activities are as follows: *140 m/sec for cutaneous stimulations, 150 m/sec for sound stimulations and 180 m/sec for visual stimulations*.
Execution speed can be developed using selected judiciously and methodically allocated exercises in physical education classes. The link for developing driving quality is speed. Execution speed can also be developed in the circle of sports activities practiced outside school hours.

Research hypothesis
It is assumed that the influence of joint mobility and anthropometric parameters of the body on the *speed of execution* of specific elements and technical procedures of handball game will provide an objective basis for training, evaluation and assessment, but also a choice of the most effective means of developing this driving quality.

Materials and methods
The correlative study was conducted at General School No. 25 “Petru Rareş” from Galaţi during 2008-2009 school-years, and the sample of subjects consisted of 82 students from grades V-VIII.

Measurements were made at the end of the school year for evaluation and final grading of students, taking into account the influence of anthropometric parameters and of muscle-joint mobility on the speed of execution of technical elements specific to the handball game.
To measure the *anthropometric parameters* the following calibrated tools were used: a taliometer, a metric band and an electronic weighing scale. Measuring the *spinal mobility* has been achieved with the ruler and roulette. The tests were conducted after a preliminary training of children on how to do the measurements and data recording procedure.
There have been discussions with the subjects taken in the study about the importance of data, meaning that records must reflect the real possibilities, as well as their usefulness as a means of checking and assessing the level of preparedness.
Also, subjects were informed that these measurements and tests represent a point of reference for teachers involved in delivering this paper.
During the survey, the students' content preparation process was designed to meet the technical elements and processes assigned to this cycle of education, age and their peculiarities.
The following **anthropometric parameters** were measured: *stature, chest, weight, size, chest perimeter, thoracic elasticity.*
The measurement of the muscle-joint mobility was obtained using the following tests:

- *Schober test* – for trunk flexion and extension. The spinal apophysis of the S1 sacral vertebra is determined and it is 10 cm proximally measured from standing. It is then executed the trunk flexion or extension, through which, normally, the distance between the two marks is modified with 2-4cm. The result for the lower back is recorded. After that, the distance between the point at 10cm and C7 is measured, from standing. It is then executed the trunk flexion or extension, through which, normally, the distance between the two marks is modified with 3-5cm. The result for the chest area is recorded. The results can be separately used on the spine segments. In this case, the two values (lumbar and thoracic) were collected on the extension and flexion to evaluate mobility throughout the entire spine, except the cervical area (Cordun M. 1999; Tudor V., 2005).
- *The "finger-ground" test* – to evaluate the complex mobility of trunk and leg muscles. It is estimated by measuring the distance between the ground and the top medius, after spinal flexion (Tudor V., 2005; Niculescu I.I., 2009).
- *The "dactyl-fibula" test* – to evaluate the side mobility of the trunk. A lateral bending of the trunk is executed from foreground and the distance dactylion - head of fibula is measured (Tudor V., 2005; Niculescu I.I., 2009).
- *Measurement of trunk rotation (with shoulder-pelvis marks)* – The movement level of shoulders foreground compared with the pelvis plane is measured. The subject is seated astride on a bench to limit the movement of the pelvis (Niculescu I.I., 2009).

The speed of execution of driving actions has been evaluated by applying five tests that targeted the main technical elements of the handball game. The tests are not calibrated and they are used to specific evaluation of physical education class for handball game.
Test 1. From fundamental position of defender in the corner of field (left or right), a lateral movement on the semicircle of 6 m to the 7 m line and back is performed for 40''. The total number of executions, one way and back, will be timed and recorded.
Test 2. From fundamental position of striker, in twos, face to face, at 6 m one from another, tossed passes over the shoulder for a minute are performed. The total number of passes executed will be recorded.
Test 3. The striker positioned at the 7 m line, has near him five handball balls that he will have to throw at the gate in the shortest time possible. The total time of the five throws is timed.
Test 4. From fundamental position of striker, dribble for one minute is executed from put. Dribbling will be executed on the side of the body up to the height of the hip. The total number of executions will be recorded.
Test 5. The goalkeeper, who is in fundamental position in the center of the gate, performs for 40'', lateral movements on a semicircle drawn on the ground at a distance of 50 cm in front of it. The goalkeeper is forced to alternately touch the two vertical bars, without deviating from the path marked on the ground. The total number of contacts the gate's bars are recorded.
For the statistical calculation, the correlation coefficient was used (the inter-series method), providing a great significance between two or more variables (Epuran M., Marolicaru M., 1998; Niculescu M., 2002). It varies between "-1" and "+1", where extreme values assume a perfect relationship between variables, while "0" means a lack of linear relationship. A more appropriate interpretation of the obtained values is made by comparing the result with some values set in correlation tables dependent on the number of subjects, type of connection and desired importance rank.
Thus, the correlation coefficient was calculated between each anthropometric parameter and each evaluation of speed of execution test for each class. Separately, the correlation coefficient was calculated between each value

of mobility and each evaluation of speed of execution test for each class. The conclusions were drawn based on these correlations separately reported for each age group.

Results

The values of arithmetic mean recorded in the measurement of ***anthropometric parameters*** (Table 1) show a normal increase in both height and weight of middle-aged children (11-15 years old), which means that bones grow more from the increase in length by calcium and phosphorus deposition, and also due to consolidation of internal functional structure.
As regards the trunk, there is a slight increase up to age 13, then a small decrease (13-14 years old) and another slight increase towards the age of 14-15 years old. At spreading, there is an increase between 11-14 years old and a small decrease at the age of 15 years old.
Thoracic elasticity increases slightly from 11 years old to 15 years old.

Table1

The values of arithmetic mean recorded in the measurement of anthropometric parameters

Grade	Age	Height (cm)	Trunk (cm)	Spreading (cm)	Thoracic elasticity (cm)	Weight (kg)
V	11/12	150	69	150	2	43
VI	12/13	155	77	151	3	47
VII	13/14	159	76	159	3	53
VIII	14/15	163	80	158	3.5	52

In Table 2, the values of arithmetic mean are recorded in the measurement of ***muscle-joint mobility.***
In fifth grade there is a sharp increase in *joint mobility* for flexion of the trunk compared with other grades in gymnasium, while for extension of the trunk there is an average *mobility* compared with the rest of the grades. *The suppleness*, measured with the "finger-ground" test, is higher at fifth grade compared to the VI-VIII grades, the lateral joint amplitude is balanced, while the mobility on clockwise rotation is higher than on the anti-clockwise rotation.
In sixth grade there is a decrease of *mobility* on flexion and a slight growth of trunk extension compared to other grades. With age there is a decrease in mobility values on flexion-extension and on lateral bending of the trunk balanced by an increased mobility on rotation of the trunk. The values of the subjects in eighth grade are higher towards left, which shows that most of them are right-handed.

Table 2

The values of arithmetic mean are recorded in the measurement of muscle-joint mobility

Grade	Schober test		Finger-ground test (cm)	The lateral mobility of the trunk		The mobility on rotation of the trunk	
	Flexion (cm)	Extension (cm)		Dactyl-fibula (right) (cm)	Dactyl-fibula (left) (cm)	Shoulder-pelvis (right) (cm)	Shoulder-pelvis (left) (cm)
V	12	2.7	10	12	12	3.4	4
VI	10	3	7	13	12	5	5
VII	11	3	7	11	11	5	6
VIII	10	2	7	10	10	7	7.5

At the evaluation tests of the speed of execution (Table 3), we can see an increasing number of executions with aging and an improving of driving experience, a better coordination partly replacing the reduction of mobility.
Table 3

The values of arithmetic mean at the evaluation tests of the speed of execution

Grade	Test 1 (executions)	Test 2 (passes)	Test 3 (sec.)	Test 4 (executions)	Test 5 (touches)
V	13.75	17.12	9.5	52.62	16
VI	16	20.81	8.44	55.06	18.44
VII	16.12	20.5	9.12	60.69	21.25
VIII	15.75	23.75	8.62	69.56	20

To demonstrate whether and how ***anthropometric parameters*** influence the speed of execution in relation to age, correlations were made among the four parameters measured and the five specific handball game tests applied (Tables 4-7).

At the fifth grade (Table 4) we can highlight significant correlation of weight with the values of the speed of execution for four tests, while the other parameters have less significant values.

Table 4

Correlations among anthropometric values with the results of evaluation tests of the speed of execution, at fifth grade

Anthropometry	Evaluation tests of the speed of execution (handball)				
	Test 1	Test 2	Test 3	Test 4	Test 5
Height	0.24	0.05	0.16	0.02	0.37
Weight	0.55	0.53	0.45	0.30	0.36
Trunk	0.07	0.16	0.35	0.07	0.07
Spreading	0.21	0.00	0.12	0.01	0.36
Thoracic elasticity	0.21	0.36	0.23	0.35	0.17

In sixth grade (Table 5), the spreading has the best correlation with three of the five handball tests proposed.

Table 5

Correlations among anthropometric values with the results of evaluation tests of the speed of execution, at sixth grade

Anthropometry	Evaluation tests of the speed of execution (handball)				
	Test 1	Test 2	Test 3	Test 4	Test 5
Height	0.24	0.19	0.34	0.03	0.16
Weight	0.02	0.06	0.04	0.09	0.12
Trunk	0.13	0.22	0.08	0.13	0.03
Spreading	0.50	0.26	0.45	0.27	0.47
Thoracic elasticity	0.04	0.04	0.37	0.13	0.07

In Table 6, we can see an increasing number of significant correlations between them, the thoracic elasticity clearly coming out. So, a greater capacity of effort is to significantly increase the speed of execution of the technical elements.

Table 6

Correlations among anthropometric values with the results of evaluation tests of the speed of execution, at seventh grade

Anthropometry	Evaluation tests of the speed of execution (handball)				
	Test 1	Test 2	Test 3	Test 4	Test 5
Height	0.06	0.18	0.02	0.31	0.11
Weight	0.27	0.44	0.21	0.21	0.48
Trunk	0.17	0.38	0.01	0.35	0.15
Spreading	0.18	0.27	0.02	0.50	0.42
Thoracic elasticity	0.66	0.71	0.40	0.35	0.68

At eighth grade (Table 7), the increased number of correlation between the most anthropometric parameters and the specific techniques of handball game is clear.

Table 7

Correlations among anthropometric values with the results of evaluation tests of the speed of execution, at eighth grade

Anthropometry	Evaluation tests of the speed of execution (handball)				
	Test 1	Test 2	Test 3	Test 4	Test 5
Height	0.17	0.70	0.47	0.56	0.38
Weight	0.18	0.17	0.21	0.07	0.01
Trunk	0.13	0.44	0.47	0.39	0.34
Spreading	0.28	0.59	0.71	0.62	0.65
Thoracic elasticity	0.10	0.09	0.12	0.02	0.02

To observe the influence of ***joint mobility*** on the speed of execution such correlations were performed, on each grade, separately (Tables 8-11).

In Table 8, we can see the degree of correlation of the overall mobility on flexion, by almost all values of the tests, and the specific handball game test that benefits most of the degree of mobility in the trunk is moving into the gate (Test 5).

Table 8

Correlations among mobility values with the results of evaluation tests of the speed of execution, at fifth grade

Mobility		Evaluation tests in handball				
		Test 1	Test 2	Test 3	Test 4	Test 5
Schober	Flexion	0.13	0.15	0.15	0.35	0.12
	Extension	0.11	0.27	0.02	0.48	0.04
Finger-ground test		0.36	0.52	0.47	0.07	0.38
Lateral mobility	Right	0.04	0.21	0.22	0.30	0.50
	Left	0.05	0.06	0.30	0.25	0.42
Rotation	Right	0.03	0.12	0.39	0.01	0.08
	Left	0.03	0.04	0.16	0.14	0.24

In table 9 it is shown the contribution of mobility on the quality of speed of execution on the same test specific for handball goalkeepers (Test 5). The throwing to the gate test (Test 3) is also influenced by the joint mobility on rotation, normally, clockwise.

Table 9

Correlations among mobility values with the results of evaluation tests of the speed of execution, at sixth grade

Mobility		Evaluation tests in handball				
		Test 1	Test 2	Test 3	Test 4	Test 5
Schober	Flexion	0.29	0.33	0.33	0.12	0.36
	Extension	0.31	0.00	0.36	0.19	0.04
Finger-ground test		0.18	0.15	0.15	0.10	0.41
Lateral mobility	Right	0.07	0.23	0.15	0.05	0.42
	Left	0.21	0.03	0.05	0.09	0.44
Rotation	Right	0.10	0.26	0.48	0.10	0.18
	Left	0.13	0.23	0.14	0.07	0.23

At the seventh grade (Table 10) the same general line is also kept, test 5 being the most influenced by joint mobility.

Table 10

Correlations among mobility values with the results of evaluation tests of the speed of execution, at seventh grade

Mobility		Evaluation tests in handball				
		Test 1	Test 2	Test 3	Test 4	Test 5
Schober	Flexion	0.24	0.19	0.23	0.19	0.01
	Extension	0.12	0.04	0.18	0.31	0.09
Finger-ground test		0.27	0.47	0.13	0.18	0.34
Lateral mobility	Right	0.20	0.21	0.38	0.22	0.38
	Left	0.26	0.27	0.42	0.26	0.43
Rotation	Right	0.37	0.19	0.08	0.04	0.05
	Left	0.15	0.08	0.07	0.03	0.13

At the eighth grade (Table 11), with the values of tests 3 and 5, there is significant correlation of trunk extension, lateral mobility on the left side and rotation anti-clockwise.

Table 11

Correlations among mobility values with the results of evaluation tests of the speed of execution, at eighth grade

Mobility		Evaluation tests in handball				
		Test 1	Test 2	Test 3	Test 4	Test 5
Schober	Flexion	0.05	0.13	0.16	0.33	0.21
	Extension	0.18	0.31	0.50	0.54	0.51
Finger-ground test		0.25	0.08	0.23	0.05	0.36
Lateral mobility	Right	0.35	0.12	0.16	0.20	0.24
	Left	0.48	0.08	0.43	0.21	0.38
Rotation	Right	0.23	0.16	0.38	0.01	0.02
	Left	0.19	0.07	0.16	0.01	0.01

Conclusions

For our study, the research hypothesis is confirmed. There is a significant influence of *anthropometric parameters* on the speed of execution of the basic technical elements specific to the handball game.

Joint mobility, in this case, partially affects only the speed of execution of the technical elements mentioned. Based on these results some conclusions can be drawn on how to address specific educational and instructive process for pupils of 7-15 years old.

At fifth grade, the evaluation and assessment will be made taking into account that those with greater weight will have an advantage in performing the technical elements, while the VIth and VIIth grade the spreading will affect all executions. Increasing thoracic elasticity is targeted, given the fact that in seventh grade it affects the speed of execution for all the technical elements.

For older pupils, the influence of *anthropometric parameters* on the speed of execution of the technical elements is significant. Only at this age, the evaluation in all aspects of execution of the basic technical elements will be done at maximum level, at the high values of anthropometric parameters, adding the driving experience gained during previous years.

In the *joint mobility* case it may be added that specific driving actions performed by the goalkeeper receive its contribution. On the general fund of decreased mobility, it is advisable to insist more on its development during physical education classes, with age (Table 2).

At eighth grade there is a significant correlation of lateral mobility to the left and clockwise rotation, which corresponds to specific body postures while throwing and passing during handball game.

According to the data in Table 2 it is recommended approaching the mobility exercises with clockwise rotation (these will decreasing from VIth grade), and so two goals are reached: *stopping the emergence of right scoliosis posture* and *addressing the needs necessary for passing and throwing, specific to handball game*.

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