

Power abilities: recognition of the level of development in girls aged 12-14 years

Ivashchenko O.V.^{1ABCDE}, Khudolii O.M.^{1ABCDE}, Iermakov S.S.^{2ABCDE}, Veremeenko V.Yu.^{1ABCDE}, Lopatiev A.O.^{3ABCDE}

¹Faculty of Physical Education and Sports, H.S. Skovoroda Kharkiv National Pedagogical University, Ukraine

²Department of Tourism and Recreation, Gdansk University of Physical Education and Sport, Poland

³Department of Shooting and Technical Sports, Lviv State University of Physical Culture, Ukraine

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Abstract

Purpose: The purpose of the study is to determine the possibility of recognizing the state of power abilities development in girls aged 12-14 years based on the methodology of multidimensional statistics.

Material: The study involved girls: 12 (n = 21), 13 (n = 20), 14 (n = 19) years old. The study used the following methods: analysis and collation of scientific and methodological literature, general scientific methods of theoretical level, such as analogy, analysis, synthesis, abstraction, induction, as well as general scientific methods of empirical level: observation, testing, experiment. The testing program included well-known tests.

Results: In the recognition of the state of power abilities development in girls aged 12-14 years the most important are the results in tests: Pull-Up / Chin Up Test (Rope Climbing), quantity of times (0.877); Squats Test (two legs), quantity of times (0.723); Single Leg Squat (SLS) Test - left leg, quantity of times (-0.567); Pull-Up / Chin Up Test (low crossbar), quantity of times (-0.467). These tests describe the level of muscle strength development of the shoulder girdle and legs. In the recognition of the state of power abilities development in girls aged 13-14 years the most important are the results in tests: Single Leg Squat (SLS) Test - left leg, quantity of times (-0.825); Single Leg Squat (SLS) Test - right leg, quantity of times (0.735); Single Leg Squat (Pistol) - left leg (0.672); Hand tapping test, sec. (0.682). These tests describe the level of development of relative and static strength of the legs.

Conclusions: Discriminant analysis allowed to determine informative indicators for cross-control of the development of power abilities in girls aged 12-14 years; answer the question of how significantly the state of development of power abilities in girls of 12, 13 and 14 years is different; which motor tests most significantly affect the differentiation of classes; which class the object belongs to (based on the values of discriminant variables). In order to recognize the level of development of power abilities in girls aged 12-14 years, it is necessary to be guided by the indicators of relative and static strength and strength endurance; at girls of 13 and 14 years – strength endurance.

Keywords: discriminant analysis, pattern recognition, girls 12-14 years old, tests.

Introduction¹

Motor activity and its impact on the health of the population is one of the problems actively studied in the field of physical education [1, 2]. Physical education of schoolchildren is aimed at optimizing the physical development of the child [3, 4], improving the process of development of motor abilities [5, 6], strengthening and health [7]. Power abilities relate to the basic, their level of development affects the effectiveness of teaching physical exercises of schoolchildren [5, 8].

Based on numerous studies, conclusions are the following:

- on the effectiveness of complex development of strength, vigor, coordination, endurance and flexibility in children [9, 10];
- on the influence of the level of development of force on the process of learning the physical exercises of schoolchildren [5, 11];
- on the effectiveness of the use of tools and methods of training in the development of power capabilities [12, 13].

In previously published works, attention was focused

on the study of the relationship of indicators of the level of schoolchildren motor abilities development [5, 14], as well as on the definition of their structure [15, 16].

Multidimensional methods of mathematical statistics such as factor and discriminant analysis [5, 17] are effective for studying the structure of motor readiness of schoolchildren. The use of factor analysis allowed to establish the structure of development of motor abilities of schoolchildren [18]. However, in available literature there is not enough data on the peculiarities of the dynamics of the development of power abilities in high school students.

Thus, the study of the peculiarities of the dynamics of power abilities development on the basis of recognition of the state of their development in girls of middle classes is relevant.

The purpose of the study is to determine the possibility of recognizing the state of development of power abilities in girls aged 12-14 years based on the methodology of multidimensional statistics.

Materials and methods

Study participants. The study involved girls: 12 (n = 21), 13 (n = 20), 14 (n = 19) years old.

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The study protocol was approved by the Ethical Committee of H. S. Skovoroda Kharkiv National Pedagogical University. In addition, the children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed-consent document was obtained from all the parents.

Study organization. The study used the following methods: analysis and collation of scientific and methodological literature, general scientific methods of theoretical level, such as analogy, analysis, synthesis, abstraction, induction, as well as general scientific methods of empirical level: observation, testing, experiment.

Testing procedure. The testing program included well-known tests [5, 9, 19]. To evaluate motor preparedness, the study recorded the results of motor tests:

- Test 1. Pull-Up / Chin Up Test (low crossbar), quantity of times;
- Test 2. Bent Arm Hang Test (two hands), sec.;
- Test 3. Pull-Up / Chin Up Test (Rope Climbing), quantity of times;
- Test 4. Cadence Push-Up Test, quantity of times;
- Test 5. The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds;
- Test 6. Pull Up Bar- Straight Leg Hanging Leg Raises, quantity of times;
- Test 7. Hanging Leg Raises, sec.;
- Test 8. Trunk Lift Test, quantity of times;
- Test 9. Squats Test (two legs), quantity of times;
- Test 10. Single Leg Squat (SLS) Test - right leg, quantity of times;
- Test 11. Single Leg Squat (SLS) Test - left leg, quantity of times;
- Test 12. Single Leg Squat (Pistol) - right leg;
- Test 13. Single Leg Squat (Pistol) - left leg;
- Test 14. Handgrip Strength Test, kg;
- Test 15. Standing Long Jump Test (Broad Jump), cm;
- Test 16. Eurofit Sit Up Test (for 30 sec.), quantity of times;
- Test 17. 4x9 m shuttle test, sec.;
- Test 18. Hand tapping test, sec.;
- Test 19. Seated Forward Bend, cm;
- Test 20. Flamingo Balance test - single leg balance test.

Statistical analysis.

In discriminant analysis we formed prognostic model of belonging to group. This model builds discriminant function (or if the quantity of groups is more than two – a set of discriminant functions) in the form of linear combination of variables-predictors that ensures the best groups' division. These functions are built by a set of observations, for which their belonging to groups is known. Further, these functions can be used for new observations with known values of variables- predictors and unknown belonging to group.

For every variable we calculated the following: mean values, standard deviations, single - factorial dispersion analysis for every variable (Box's M test, in-group correlation matrix, in-group covariance matrix, covariance matrixes for separate groups, general covariance matrix). For every canonic discriminant function we calculated: eigenvalue, dispersion percentage, canonic correlation, Wilks' *Lambda*, Chi-square. For every step we calculated: priory probabilities, Fisher function's coefficients, non-standardized coefficients of function, Wilks' *Lambda for every canonic function*

Results

The tables show the results of discriminant analysis, which allow to recognize the state of development of power abilities in girls of 12-14 years old.

The first canonical function explains the variation of the results by 87.8%, the second - by 12.2%, which indicates their informativity (see Table 1). The coefficients of canonical correlation ($r = 0.892$; $r = 0.592$) indicate the prognosticity of the first and second functions.

Table 2 shows the analysis of canonical functions. The first line contains the value $\lambda = 0,133$ ($p = 0,001$) for the entire set of canonical functions, the second line is the data after the first function is excluded ($\lambda = 0,650$; $p = 0,087$). The first and second functions have a high discriminative ability and meaning in the interpretation of the general population.

Table 3 shows the normalized coefficients of the canonical discriminant function, which allow us to determine the ratio of the contribution of variables to the result of the function. The greatest contribution to the first canonical function is the variables No. 3, 9, 11, 1: the

Table 1. Summary of Canonical Discriminant Functions. Eigenvalues. Girls of 12-14 years

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|----------|--------------------|---------------|--------------|-----------------------|
| 1 | 3,884 ^a | 87,8 | 87,8 | ,892 |
| 2 | ,539 ^a | 12,2 | 100,0 | ,592 |

Table 2. Canonical discriminatory functions. Wilks' Lambda. Girls of 12-14 years

| Test of Function(s) | Wilks' Lambda | Chi-square | df | Sig. |
|---------------------|---------------|------------|----|------|
| 1 through 2 | ,133 | 130,096 | 40 | ,000 |
| 2 | ,650 | 27,796 | 19 | ,087 |

larger the values of these variables, the greater the value of the function. The greatest contribution to the second canonical function is the variables No. 11, 10, 13, 18: the larger the values of these variables, the greater the value of the function.

In identifying the state of development of power abilities in girls aged 12-14 years old the most important are the results in the tests: № 3 (0,877), № 9 (0,723), № 11 (-0,567), №1 (-0,467). These tests describe the level of muscle strength development of the shoulder girdle and legs.

In recognition of the state of development of power abilities in girls aged 13-14 years old, the most important are the results in the tests: No. 11 (-0,825), No. 10 (0,735), No. 13 (0,672), No. 18 (0,682). These tests describe the level of development of relative and static strength of the legs.

Table 4 shows the structural coefficients of the first and second canonical discriminant functions, which are coefficients of the correlation of variables with a function. Thus, the first canonical discriminant function is most closely connected with the results of tests No. 9, 5, 3, 8, 6, 14: hence, the significant difference between girls of 12, 13, and 14 years is observed in the level of development of relative, static strength and strength endurance.

The structural coefficients of the second canonical

discriminant function indicate that the function is most closely related to the variables No. 18, 16: hence, the significant difference between girls of 13 and 14 years is observed in the level of development of force and endurance of muscles of the abdominal press.

Table 5 shows the results of classification of groups, 89.6% of the output grouped observations are categorized correctly. Thus, a canonical discriminatory function can be used to recognize the state of development of power abilities in girls of 12-14 years old.

Discussion

The results show that discriminant analysis allows to recognize the state of development of power abilities in girls aged 12-14 years on the results of testing and supplement data on the use of discriminant function in the classification of schoolchildren by motor activity [20, 21]. Also, works of Geoffrey D. et al. [22], Ivashchenko et al. [23] show a high discriminant and predictive ability of the functions obtained in assessing the strength of girls aged 12-14 years old.

It is confirmed that multidimensional methods of mathematical statistics such as factor and discriminant analysis [5, 17] are effective for studying the strength training structure of girls aged 12-14 years old. It is added that the use in the analysis of the structural coefficients

Table 3. Standardized Canonical Discriminant Function Coefficients. Girls aged 12-14 years old

| № | Test | Function | |
|----|--|--------------|-------------|
| | | 1 | 2 |
| 1 | Pull-Up / Chin Up Test (low crossbar), quantity of times | -,467 | -,132 |
| 2 | Bent Arm Hang Test (two hands), sec. | ,064 | ,157 |
| 3 | Pull-Up / Chin Up Test (Rope Climbing), quantity of times | ,877 | ,291 |
| 4 | Cadence Push-Up Test, quantity of times | ,366 | ,176 |
| 5 | The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds | ,220 | ,113 |
| 6 | Pull Up Bar- Straight Leg Hanging Leg Raises, quantity of times | ,185 | ,398 |
| 7 | Hanging Leg Raises, sec. | ,358 | -,033 |
| 8 | Trunk Lift Test, quantity of times | ,290 | -,421 |
| 9 | Squats Test (two legs), quantity of times | ,723 | ,012 |
| 10 | Single Leg Squat (SLS) Test - right leg, quantity of times | -,101 | ,735 |
| 11 | Single Leg Squat (SLS) Test - left leg, quantity of times | -,567 | -,825 |
| 12 | Single Leg Squat (Pistol) - right leg | ,140 | -,536 |
| 13 | Single Leg Squat (Pistol) - left leg | -,046 | ,672 |
| 14 | Handgrip Strength Test, kg | ,295 | -,089 |
| 15 | Standing Long Jump Test (Broad Jump), cm | -,202 | -,404 |
| 16 | Eurofit Sit Up Test (for 30 sec.), quantity of times | -,154 | ,625 |
| 17 | 4x9 m shuttle test, sec. | ,257 | -,205 |
| 18 | Hand tapping test, sec. | -,373 | ,682 |
| 19 | Seated Forward Bend, cm | ,305 | ,323 |
| 20 | Flamingo Balance test - single leg balance test | ,154 | ,168 |

of the discriminant function allows to determine the structure of the development of power abilities and their interrelation with endurance at girls aged 12-14 years [18, 23].

For the practical application of the results of discriminant analysis, the coefficients of the canonical discriminant function are used (see Table 6). The

probability that some case belongs to the predicted group is calculated based on the substitution of the discriminant function of the values of the set of variables that correspond to the case. Comparison of the obtained results with the magnitude of centroids makes it possible to determine the group to which the result refers (Table 7).

The above data supplements the results of study of the

Table 4. Structure Matrix. Girls aged 12-14 years old

| № | Test | Function | |
|----|--|--------------|--------------|
| | | 1 | 2 |
| 9 | Squats Test (two legs), quantity of times | ,458* | ,051 |
| 5 | The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds | ,306* | ,006 |
| 3 | Pull-Up / Chin Up Test (Rope Climbing), quantity of times | ,296* | ,086 |
| 8 | Trunk Lift Test, quantity of times | ,279* | -,253 |
| 6 | Pull Up Bar- Straight Leg Hanging Leg Raises, quantity of times | ,238* | ,130 |
| 14 | Handgrip Strength Test, kg | ,237* | -,052 |
| 19 | Raising of a straight legs to the head from the position of lying on a bench angularly 45 and holding the wall bar, times ^b | ,210* | -,020 |
| 7 | Hanging Leg Raises, sec. | ,205* | ,094 |
| 13 | Single Leg Squat (Pistol) - left leg | ,149* | ,112 |
| 2 | Bent Arm Hang Test (two hands), sec. | ,146* | ,014 |
| 10 | Single Leg Squat (SLS) Test - right leg, quantity of times | ,142* | ,000 |
| 12 | Single Leg Squat (Pistol) - right leg | ,139* | ,064 |
| 1 | Pull-Up / Chin Up Test (low crossbar), quantity of times | ,137* | ,132 |
| 11 | Single Leg Squat (SLS) Test - left leg, quantity of times | ,099* | -,046 |
| 18 | Hand tapping test, sec. | -,352 | ,411* |
| 16 | Eurofit Sit Up Test (for 30 sec.), quantity of times | ,124 | ,391* |
| 20 | Flamingo Balance test - single leg balance test | ,058* | ,200 |
| 19 | Seated Forward Bend, cm | ,119* | ,199 |
| 4 | Cadence Push-Up Test, quantity of times | ,114* | ,179 |
| 15 | Standing Long Jump Test (Broad Jump), cm | ,078* | -,175 |
| 17 | 4x9 m shuttle test, sec. | ,013* | -,123 |

*. Largest absolute correlation between each variable and any discriminant function

b. This variable not used in the analysis.

Table 5. Classification Results^a. Girls aged 12-14 years old

| Scale | Age (years) | Predicted Group Membership | | | Total | |
|----------|-------------|----------------------------|-------|-------|-------|-------|
| | | 12,00 | 13,00 | 14,00 | | |
| Original | Count | 12,00 | 20 | 0 | 0 | 20 |
| | | 13,00 | 0 | 21 | 6 | 27 |
| | | 14,00 | 0 | 2 | 28 | 30 |
| | % | 12,00 | 100,0 | ,0 | ,0 | 100,0 |
| | | 13,00 | ,0 | 77,8 | 22,2 | 100,0 |
| | | 14,00 | ,0 | 6,7 | 93,3 | 100,0 |

^a. 89,6% of original grouped cases correctly classified.

Table 6. Canonical Discriminant Function Coefficients (Unstandardized coefficients). Girls aged 12-14 years old

| № | Test | Function | |
|----|--|----------|--------|
| | | 1 | 2 |
| 1 | Pull-Up / Chin Up Test (low crossbar), quantity of times | -,193 | -,054 |
| 2 | Bent Arm Hang Test (two hands), sec. | ,081 | ,198 |
| 3 | Pull-Up / Chin Up Test (Rope Climbing), quantity of times | ,363 | ,121 |
| 4 | Cadence Push-Up Test, quantity of times | ,108 | ,052 |
| 5 | The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds | ,082 | ,042 |
| 6 | Pull Up Bar- Straight Leg Hanging Leg Raises, quantity of times | ,120 | ,258 |
| 7 | Hanging Leg Raises, sec. | ,326 | -,030 |
| 8 | Trunk Lift Test, quantity of times | ,058 | -,084 |
| 9 | Squats Test (two legs), quantity of times | ,163 | ,003 |
| 10 | Single Leg Squat (SLS) Test - right leg, quantity of times | -,107 | ,782 |
| 11 | Single Leg Squat (SLS) Test - left leg, quantity of times | -,615 | -,895 |
| 12 | Single Leg Squat (Pistol) - right leg | ,122 | -,467 |
| 13 | Single Leg Squat (Pistol) - left leg | -,044 | ,642 |
| 14 | Handgrip Strength Test, kg | ,173 | -,052 |
| 15 | Standing Long Jump Test (Broad Jump), cm | -1,241 | -2,481 |
| 16 | Eurofit Sit Up Test (for 30 sec.), quantity of times | -,039 | ,158 |
| 17 | 4x9 m shuttle test, sec. | ,426 | -,339 |
| 18 | Hand tapping test, sec. | -,454 | ,830 |
| 19 | Seated Forward Bend, cm | ,129 | ,137 |
| 20 | Flamingo Balance test - single leg balance test | ,079 | ,087 |
| | (Constant) | -10,210 | -9,678 |

Table 7. Functions at Group Centroids. Girls aged 12-14 years old

| Group | Function | |
|-------|----------|-------|
| | 1 | 2 |
| 12,00 | -3,029 | -,451 |
| 13,00 | ,184 | ,977 |
| 14,00 | 1,853 | -,579 |

peculiarities of schoolchildren motor readiness [15, 24, 25].

Conclusions

Discriminant analysis allowed to determine informative indicators for cross-control of the development of power abilities in girls aged 12-14 years old; answer the question of how significantly the state of development of power abilities in girls of 12, 13 and 14 years is different; which motor tests most significantly affect the differentiation of classes; to which class the object belongs, based on the values of discriminant variables.

In order to recognize the level of development of power abilities in girls aged 12-14 years old, it is necessary to be

guided by the indicators of relative and static strength and strength endurance; at girls of 13 and 14 years - strength endurance.

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Conflict of Interest

The authors state that there is no conflict of interest.

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Information about the authors:

Ivashchenko O.V.; <http://orcid.org/0000-0002-2708-5636>; Faculty of Physical Education and Sports, H.S. Skovoroda Kharkiv National Pedagogical University; Alchevskiyh str. 29, Kharkiv, 61002, Ukraine.

Khudolii O.M.; (Corresponding author); <http://orcid.org/0000-0002-5605-9939>; tmfv@tmfv.com.ua; Faculty of Physical Education and Sports, H.S. Skovoroda Kharkiv National Pedagogical University; Alchevskiyh str. 29, Kharkiv, 61002, Ukraine.

Iermakov S.S.; <http://orcid.org/0000-0002-5039-4517>; Department of Tourism and Recreation, Gdansk University of Physical Education and Sport; Kazimierza Górskiego 1, 80-336 Gdańsk, Poland.

Veremeenko V.Yu.; <http://orcid.org/0000-0002-9826-9678>; Faculty of Physical Education and Sports, H.S. Skovoroda Kharkiv National Pedagogical University; Alchevskiyh str. 29, Kharkiv, 61002, Ukraine.

Lopatiev A.O.; <http://orcid.org/0000-0002-4474-7558>; Department of Shooting and Technical Sports, Lviv State University of Physical Culture, Ukraine; str. Kostiuushka, 11, m. Lviv, 79007, Ukraine.

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