



Discriminant Analysis: the Influence of Exercise Modes on the Effectiveness of the Process of Learning to Throw A Small Ball for 9-Year-Old Boys

Oleg Khudolii^{1ABCD}, Olha Ivashchenko^{1ABCD}, Mirosława Cieślicka^{2ABCD} and Oleksii Rafikov^{3ABCD}

¹Kharkiv State Academy of Physical Culture

²Collegium Medicum: Bydgoszcz, Kujawsko Pomorskie

³H. S. Skovoroda Kharkiv National Pedagogical University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

DOI: 10.17309/jltm.2024.5.1.03

Abstract

The purpose of the study is to determine the effect of the number of repetitions on the effectiveness of the process of learning to throw a small ball for 9-year-old boys.

Materials and methods. The study involved 27 9-year-old boys, divided into three groups of 9 people in random order. Children and their parents were aware of all the features of the study and gave consent to participate in the experiment. The influence of the number of repetitions on the effectiveness of the process of learning to throw a small ball at a target in 9-year-old boys was studied. In a pedagogical experiment, the effect of 6, 12 and 18 repetitions with a rest interval of 60 s on the increase in the level of training in exercises of 9-year-old boys was studied. In the first group, boys repeated the task 6 times with a rest interval of 60 s, in the second group – 12 times with a rest interval of 60 s, in the third group 18 times with a rest interval of 60 s. In the process of teaching throwing exercises in a lesson, the level of training (“completed”, “failed to complete”) was assessed using an alternative method, and the probability of completing the exercise was calculated ($p = n/m$, where n is the number of successfully completed attempts, m is the total number of attempts).

The method of algorithmic prescriptions was used in teaching 9-year-old boys. The transition to the next exercise was carried out after three successful attempts. Throwing a ball at a vertical target was studied.

The research materials were processed in the statistical analysis program – IBM SPSS 20. In the process of discriminant analysis, a prognostic model for group membership was created.

Results. Discriminant analysis made it possible to determine the influence of the number of repetitions on the effectiveness of developing the skills of throwing a small ball at a target; answer the question how reliably the repetition modes differ in terms of the effectiveness of the formation of motor skills, what class the object belongs to based on the discriminant values of the variables.

Conclusions. Based on the analysis of group centroids, it was determined that 18 repetitions (6 sets of 3 times with a rest interval of 60 s) has a significant impact on the increase in the level of learning in physical education lessons. The group classification results show that 63.0% of the original grouped observations were correctly classified.

Keywords: 9-year-old boys, ball throwing, discriminant analysis.

Introduction

The problem of developing motor skills in schoolchildren was considered in the context of gender characteristics of motor readiness (Ivashchenko, Nosko, Bartik, & Makanin, 2020), determining the priority of developing motor skills in the process of physical education (Shevchenko, Khudolii, &

Potop, 2020; Petrov, Khudolii, & Cieślicka, 2020; Khudolii, Golovnin, & Bartík, 2020), the influence of physical exercise regimes on the effectiveness of motor skills formation (Ivashchenko, 2020; Ivashchenko, Iermakov, Khudolii, Cretu, & Potop, 2017; Ivashchenko, Holovko, 2015), the influence of training loads on dynamics of strength development (Khudolii, Ivashchenko, & Beketov, 2015; Ivashchenko, & Cieślicka, 2017; Cieślicka, & Ivashchenko, 2017).

The formation of motor skills in schoolchildren is a necessary condition for optimizing motor activity and improv-

© Khudolii, O., Ivashchenko, O., Cieślicka, M., & Rafikov, O., 2024.

ing their health (Barnett, Hardy, Lubans, Cliff, Okely, Hills, & Morgan, 2013; Chan, Ha, & Ng, 2016; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Research indicates the importance of developing children's skills in performing exercises with a ball Mathisen (2016), Nurulfa, Lubis, Dlis, Aningar, and Mamesah (2021), Fernández-Valero, Soto-Sánchez, Páez, Leyton-Dinamarca, Kain, Hurtado, and Reyes-Amigo (2021).

Important in obtaining objective results about the patterns of the learning process is planning an experiment and using multivariate statistics. The effectiveness of discriminant analysis in studying the patterns of the learning process of children and adolescents has been established (Medko & Khudolii, 2021; Marchenko et al., 2021, 2022; Yunak, Ivashchenko, Nosko, & Nosko, 2022). Consequently, the use of discriminant analysis will allow us to obtain new information about the age-related characteristics of the formation of basic motor skills in primary schoolchildren.

In connection with the need to increase the physical activity of children, research into the effectiveness of the learning process for schoolchildren is relevant.

The purpose of the study is to determine the effect of the number of repetitions on the effectiveness of the process of learning to throw a small ball for 9-year-old boys.

Materials and Methods

Study Participants

The study involved 27 9-year-old boys who were randomly divided into three groups of 9 people. The children and their parents were aware of all the features of the study and gave consent to participate in the experiment.

Organization of the Study

The influence of the number of repetitions on the effectiveness of the process of learning to throw a small ball at a target in 9-year-old boys was studied.

In a pedagogical experiment, the effect of 6, 12 and 18 repetitions with a rest interval of 60 s on the increase in the level of training in exercises of 9-year-old boys was studied. In the first group, boys repeated the task 6 times with a rest interval of 60 s, in the second group – 12 times with a rest interval of 60 s, in the third group 18 times with a rest interval of 60 s.

In the process of learning throwing exercises in a lesson, the level of training (“completed”, “failed to complete”) was assessed using an alternative method, and the probability of completing the exercise was calculated ($p = n/m$, where n is the number of successfully completed attempts, m is the total number of attempts).

The method of algorithmic prescriptions was used in teaching 9-year-old boys. The transition to the next exercise was carried out after three successful attempts. Throwing a ball at a vertical target was studied.

Statistical Analysis

The work used well-known methods for analyzing the results of a full factorial experiment of type 2k (Khudolii & Ivashchenko, 2014; Ivashchenko, 2016).

The research materials were processed in the statistical analysis program – IBM SPSS 20. In the process of discriminant analysis, a predictive model for group membership was created. This model constructs a discriminant function (or, when there are more than two groups, a set of discriminant functions) as a linear combination of predictor variables, which provides better separation of groups. These functions are constructed from a set of observations for which their group membership is known. These functions can then be applied to new observations with known values of predictor variables and unknown group membership.

For each canonical discriminant function, the following were calculated: value, percentage of variance, canonical correlation, Wilks' Lambda, χ -square (Chi-square).

To determine the impact of the proposed physical exercise regimens for 7-year-old boys, a discriminant analysis was carried out. The influence of the number of approaches, the number of repetitions in an approach and the rest interval on the level of training in the following movements was analyzed: 1. Throws of a ball on the floor; 2. Throws of a ball forward and upward with feet shoulder width apart; 3. Throws of a ball forward and up, left foot forward; 4. Throws of a ball forward and upward with the left side towards the throwing side; 5. Throws of a ball at the target from a distance of 3 m.

The study protocol was approved by the Ethics Committee of the educational institution. In addition, children and their parents or legal guardians were fully aware of all features of the study, and a signed informed consent document was obtained from all parents.

Results

To determine the influence of different modes of physical exercise on the level of training, a discriminant analysis was carried out (see Tables 1-4).

The first canonical function explains the variation of results by 96.9%, which indicates high information content ($r=0.662$) (see Table 1). Materials from the analysis of canonical functions indicate the statistical significance of the first and second canonical functions ($\lambda_1=0.549$; $p_1=0.05$; $\lambda_2=0.976$; $p_2=0.970$). The first function has a high discriminant ability and significance in interpretation relative to the general population (Table 2).

Table 3 shows the normalized coefficients of the canonical discriminant function, which allow us to determine the

Table 1. Canonical discriminant function. Eigenvalues. Boys 9 years old

Function	Eigenvalues	% of explained variance	Cumulative %	Canonical correlation
1	0.779	96.9	96.9	0.662
2	0.025	3.1	100.0	0.155

Table 2. Canonical discriminant function. Wilks' Lambda. Boys 9 years old

Checking functions	Wilks' Lambda	Chi-square	degrees of freedom	P
from 1 to 2	0.549	13.210	10	0.050
2	0.976	0.538	4	0.970

Table 3. Coefficients of the canonical discriminant function. Wilks' Lambda. Boys 9 years old

No	Exercise	Normalized coefficients		Structural coefficients	
1	Throws of a ball on the floor	0.751	0.141	0.551*	0.161
2	Throws of a ball forward and upward with feet shoulder width apart	0.418	0.828	0.125	0.859*
3	Throws of a ball forward and up, left foot forward	0.293	-0.022	0.212*	0.046
4	Throws of a ball forward and upward with the left side towards the throwing side	0.144	-0.414	0.156	-0.383*
5	Throws of a ball at the target from a distance of 3 m	0.840	-0.209	0.535*	-0.521

ratio of the contribution of variables to the result of the function. The variables with the greatest contribution to the first canonical function include variables No. 5 "Throws of a ball at the target from a distance of 3 m", No. 1 "Throws of a ball on the floor", the second canonical function includes exercise No. 2 "Throws of a ball forward and upward with feet shoulder width apart": the greater the increment in the learning ability of these exercises, the greater the importance of the functions. The above indicates that exercises No. 5, 1, 2 are most sensitive to the number of repetitions in 9-year-old schoolchildren.

Table 3 shows the structural coefficients of the canonical discriminant function, which are the correlation coefficients of the variables with the function. Thus, the function is most significantly related to the results of an increase in exercise learning No 1 "Throws of a ball on the floor", No 5 "Throws of a ball forward and upward with feet shoulder width apart", No 2 "Throws of a ball forward and upward with feet shoulder width apart": therefore, a significant difference between training modes is observed in exercises No. 1, 5, 2.

Table 4 shows the centroid coordinates for the two groups. They allow the canonical function to be interpreted in relation to its role in classification. On the positive pole is the centroid for the exercise mode of 18 repetitions, on the negative pole is the centroid for the exercise mode of 6 repetitions (see Figure 1). This indicates a significant difference in the influence of the number of repetitions on the increase in the level of learning in physical education lessons. The group classification results show that 63,0% of the original grouped observations were correctly classified.

Table 4. Functions in group centroids. Boys 9 years old

Options for operating modes	Function	
	1	2
6 reps, 60 s rest	-0.990	-0.113
12 reps, 60 s rest	-0.056	0.209
18 reps, 60 s rest	1.046	-0.096

Discussion

It is assumed that it is possible to use a discriminant function to assess the effectiveness of various modes of performing physical exercises in the process of training a series of throwing exercises, since the verification of canonical functions indicates their statistical significance.

Based on the analysis of group centroids, it was determined that 18 repetitions (6 sets of 3 times with a rest interval of 60 s) has a significant impact on the increase in the level of learning in physical education lessons. Group classification results show that 63,0% of the original grouped observations were classified correctly.

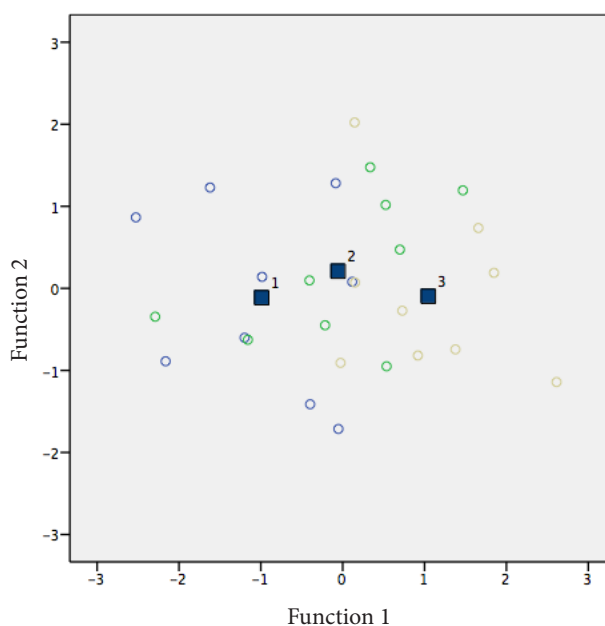


Fig. 1. Canonical discriminant functions. Graphic display of the results of classification of the level of training in exercises of 9-year-old boys: ■ — centroids for data groups after 1 – 6 repetitions, 2 – 12 repetitions, 3 – 18 repetitions

The data obtained complement the information on the influence of exercise regimes on the formation of motor skills in children (Ivashchenko, 2020; Ivashchenko, Iermakov, Khudolii, Cretu, & Potop, 2017; Ivashchenko, Khudolii, Iermakov, Chernenko, & Holovko, 2015; on the effectiveness of using the method algorithmic prescriptions for the formation of motor skills (Ivashchenko, 2020; Yunak et al., 2022; Marchenko et al., 2022), and also confirm data on the effectiveness of using discriminant analysis to optimize the process of physical education of schoolchildren (Samanta & Mukherjee, 2021; Djordjevic, Valkova, & Petkovic, 2021; Begu, Miftari, Dalip, & Haxhnikaj, 2023).

The results of the study can be used in the process of planning regimes for performing physical exercises in teaching manipulative motor skills to children of primary school age, which will improve the effectiveness of teaching fundamental motor skills and will help increase their motor activity.

Conclusions

Discriminant analysis made it possible to determine the influence of the number of repetitions on the effectiveness of developing the skills of throwing a small ball at a target; answer the question how reliably the repetition modes differ

in terms of the effectiveness of the formation of motor skills, what class the object belongs to based on the values of the discriminant variables.

Based on the analysis of group centroids, it was determined that 18 repetitions (6 sets of 3 times with a rest interval of 60 s) has a significant impact on the increase in the level of learning in physical education lessons. Group classification results show that 63,0% of the original grouped observations were classified correctly.

Conflict of interest

The authors declare that there is no conflict of interest.

References

- Ivashchenko, O., Nosko, Y., Bartik, P., & Makanin, O. (2020). Gender-Related Peculiarities of 7-Year-Old Schoolchildren's Motor Fitness. *Physical Education Theory and Methodology*, 20(4), 228–233. <https://doi.org/10.17309/tmfv.2020.4.05>
- Shevchenko, T., Khudolii, O., & Potop, V. (2020). Motor Skills in Physical Fitness Structure of 8-Year-Old Girls. *Journal of Learning Theory and Methodology*, 1(2), 64–69. <https://doi.org/10.17309/jltm.2020.2.03>
- Petrov, D., Khudolii, O., & Cieślicka, M. (2020). Motor Skills: Motor Fitness Structure of 9-Year-Old Boys. *Journal of Learning Theory and Methodology*, 1(2), 58–63. <https://doi.org/10.17309/jltm.2020.2.02>
- Khudolii, O., Golovnin, V., & Bartik, P. (2020). Peculiarities of Motor Fitness Structure of 9-Year-Old Girls. *Journal of Learning Theory and Methodology*, 1(2), 53–57. <https://doi.org/10.17309/jltm.2020.2.01>
- Ivashchenko, O. (2020). Research Program: Modeling of Motor Abilities Development and Teaching of Schoolchildren. *Physical Education Theory and Methodology*, 20(1), 32–41. <https://doi.org/10.17309/tmfv.2020.1.05>
- Ivashchenko, O., Iermakov, S., Khudolii, O., Cretu, M., & Potop V. (2017). Level of physical exercises' mastering in structure of 11-13 yrs age boys' motor fitness. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 21(5), 236–43. <https://doi.org/10.15561/18189172.2017.0506>
- Ivashchenko, O., Khudolii, O., Iermakov, S., Chernenko, S., & Holovko, A. (2015). Pedagogical Control of Motor Readiness of Junior School Boys. *Physical Education Theory and Methodology*, 15(2), 32–40. <https://doi.org/10.17309/tmfv.2015.2.1140>
- Khudolii, O., Ivashchenko, O., & Beketov, V. (2015). Technological Approaches to Evaluating Training Effects of Power Load in Primary Schoolers. *Physical Education Theory and Methodology*, (1), 16–25. <https://doi.org/10.17309/tmfv.2015.1.1121>
- Ivashchenko, O., & Cieślicka, M. (2017). Features of evaluations of power loads in boys 7 years old. *Journal of Education, Health and Sport*, 7(1), 175–183. <http://dx.doi.org/10.5281/zenodo.249184>
- Cieślicka, M., & Ivashchenko, O. (2017). Features of formation of the cumulative effect of power loads in boys 7 years old. *Journal of Education, Health and Sport*, 7(1), 198–208. <http://dx.doi.org/10.5281/zenodo.250599>
- Barnett, L. M., Hardy, L. L., Lubans, D. R., Cliff, D. P., Okely, A. D., Hills, A. P., & Morgan, P. J. (2013). Australian children lack the basic movement skills to be active and healthy. *Health Promotion Journal of Australia*, 24(2), 82–84. <https://doi.org/10.1071/HE12920>
- Chan, C., Ha, A., & Ng, J. Y. Y. (2016). Improving fundamental movement skills in Hong Kong students through an assessment for learning intervention that emphasizes fun, mastery, and support: The A + FMS randomized controlled trial study protocol. *SpringerPlus*, 5(1). <https://doi.org/10.1186/s40064-016-2517-6>
- Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents: Review of associated health benefits. *Sports Medicine*, 40(12), 1019–1035. <https://doi.org/10.2165/11536850-000000000-00000>
- Mathisen, G. E. (2016). Motor competence and implications in primary school. *Journal of Physical Education and Sport*, 16(1), 206–209.
- Nurulfa, R., Lubis, J., Dlis, F., Aninggar, R., & Mamesah, E. (2021). Fundamental movement skills project: Efforts to keep children in Indonesia active during the pandemic. *Journal of Physical Education and Sport*, 21, 2350–2356. <https://doi.org/10.7752/jpes.2021.s4315>
- Fernández-Valero, P., Soto-Sánchez, J., Páez, J., Leyton-Dinamarca, B., Kain, J., Hurtado, J., & Reyes-Amigo, T. (2021). Fundamental movement skills and physical activity recommendations for preschool children. *Journal of Physical Education and Sport*, 21, 3286–3293. <https://doi.org/10.7752/jpes.2021.s6436>
- Medko, D., & Khudolii, O. (2021). Pattern Recognition: Effectiveness of Teaching Girls Aged 15 Acrobatic Exercises. *Journal of Learning Theory and Methodology*, 2(3), 134–139. <https://doi.org/10.17309/jltm.2021.3.05>
- Marchenko, S., Ivashchenko, O., Jagiello, W., Iermakov, S., Khudolii, O., & Yermakova, T. (2022). Discriminant analysis: Features of training 10-year-old boys in the technique of kicks in kyokushin karate. *Archives of Budo*, 18, 1–11.
- Marchenko, S., Jagiello, W., Iermakov, S., Ivashchenko, O., & Khudolii, O. (2021). Pattern recognition: Modes of teaching boys aged 10 mae-geri (front kick) technique in kyokushin karate. *Archives of Budo*, 17, 253–261.
- Yunak, I., Ivashchenko, O., Nosko, M., & Nosko, Y. (2022). Pattern Recognition: Age-Specific Features of Fundamental Movement Skills Formation in Elementary School Students. *Physical Education Theory and Methodology*, 22(3), 430–436. <https://doi.org/10.17309/tmfv.2022.3.19>
- Samanta, A., & Mukherjee, S. (2021). Surface Electromyography Based Core Muscle Fatigue Analysis During Repetitive Plank Using Multivariate Dimensionality Reduction Methods in Boys Aged 12-14. *Physical Education Theory and Methodology*, 21(3), 253–263. <https://doi.org/10.17309/tmfv.2021.3.09>
- Djordjevic, I., Valkova, H., & Petkovic, E. (2021). Differences of Motor Proficiency in Preschool Girls Related to Organized Physical Activity. *Physical Education Theory and Methodology*, 21(4), 357–364. <https://doi.org/10.17309/tmfv.2021.4.11>
- Begu, B., Miftari, F., Dalip, M., & Haxhnikaj, L. (2023). Comparing Situational and Motor Abilities Among Kosovo Junior Basketball Players in Super and Unique Leagues. *Physical Education Theory and Methodology*, 23(4), 552–559. <https://doi.org/10.17309/tmfv.2023.4.09>

Дискримінантний аналіз: вплив режимів виконання вправ на ефективність процесу навчання метання малого м'яча хлопчиків 9 років

Олег Худолій^{1ABCD}, Ольга Іващенко^{1ABCD}, Мирослава Цислицька^{2ABCD}, Олексій Рафіков^{3ABCD}

¹Харківська державна академія фізичної культури

²Медичний колегіум: Бидгощ, Куявсько-Поморське воєводство

³Харківський національний педагогічний університет імені Г.С. Сковороди

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 5 с., 4 табл., 1 рис., 23 джерела.

Мета дослідження – визначити вплив кількості повторень на ефективність процесу навчання метання малого м'яча хлопчиків 9 років.

Матеріали і методи. У дослідженні прийняли участь 27 хлопчиків 9 років, які були розділені на три групи по 9 чоловік у випадковому порядку. Діти та їхні батьки були інформовані про всі особливості дослідження і дали згоду на участь в експерименті.

Досліджувався вплив кількості повторень на ефективність процесу навчання метання малого м'яча в ціль у хлопчиків 9 років. У педагогічному експерименті вивчався вплив 6, 12 і 18 повторень з інтервалом відпочинку 60 с на приріст рівня навченості вправ хлопчиків 9 років. У першій групі хлопчики повторювали завдання 6 разів з інтервалом відпочинку 60 с, у другій групі – 12 разів з інтервалом відпочинку 60 с, у третій групі 18 раз з інтервалом відпочинку 60 с. У процесі навчання кидкових вправ у занятті оцінювався альтернативним методом рівень навченості («виконав», «не виконав»), розраховувалася вірогідність виконання вправи ($p = n/m$, де n – кількість успішно виконаних спроб, m – загальна кількість спроб).

У навчанні хлопчиків 9 років використовувався метод алгоритмічних розпоряджень. Перехід до наступної вправи здійснювався після трьох успішних спроб. Вивчалися метання м'яча у вертикальну ціль.

Матеріали дослідження опрацьовані в програмі статистичного аналізу – IBM SPSS 20. У процесі дискримінантного аналізу була створена прогностична модель для належності до групи.

Результати. Дискримінантний аналіз дозволив визначити вплив кількості повторень на ефективність формування навичок метання малого м'яча в ціль; дати відповідь на питання наскільки достовірно різняться режими повторення за результативністю формування рухових навичок, до якого класу належить об'єкт на основі значень дискримінантних змінних.

Висновки. На основі аналізу центротидів груп визначено, що 18 повторень вправи (6 підходів по 3 рази з інтервалом відпочинку 60 с) має суттєвий вплив на приріст рівня навченості на уроках фізичної культури. Результати класифікації груп показують, що 63,0 % вихідних згрупованих спостережень класифіковано вірно.

Ключові слова: хлопчики 9 років, метання м'яча, дискримінантний аналіз.

Information about the authors:

Khudolii Oleg: khudolii.oleg@gmail.com; <https://orcid.org/0000-0002-5605-9939>; Department of Olympic and Professional Sports, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Ivashchenko Olha: ivashchenko.olha21@gmail.com; <https://orcid.org/0000-0002-2708-5636>; Department of Theory and Methods of Physical Education, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine

Cieślicka Mirosława: cudaki@op.pl; <https://orcid.org/0000-0002-0407-2592>; Collegium Medicum: Bydgoszcz, Kujawsko Pomorskie, Chodkiewicza St, 30, 85-064 Bydgoszcz, Poland.

Rafikov Oleksii: rafikov9778@gmail.com; <https://orcid.org/0000-0003-4793-4743>; H. S. Skovoroda Kharkiv National Pedagogical University, Department of Theory and Methodology of Physical Education, Alchevskykh St, 29, Kharkiv, 61002, Ukraine.

Cite this article as: Khudolii, O., Ivashchenko, O., Cieślicka, M., & Rafikov, O. (2024). Discriminant Analysis: the Influence of Exercise Modes on the Effectiveness of the Process of Learning to Throw A Small Ball for 9-Year-Old Boys. *Journal of Learning Theory and Methodology*, 5(1), 20–24. <https://doi.org/10.17309/jltm.2024.5.1.03>

Received: 12.02.2024. Accepted: 22.04.2024. Published: 30.04.2024

This work is licensed under a Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0>).