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Artificial Intelligence Usage in Prediction of the Sports Results of Athletes Competing in Greco-Roman Wrestling

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Abstract. Today, the use of machine learning algorithms and neural networks to increase the effectiveness of sports selection at the early stages of the athletes' training process is becoming particularly relevant. The aim of this scientific work: to develop a program for predicting the athletic performance of young athletes, who competing in Greco-Roman wrestling, based on artificial intelligence technology.

Collection and processing of individual data of 18–25 years old athletes (n=67) on 21 comparison criteria, ranked into categories in two directions, were implemented: sports space and individual achievements. Two forecasting categories were determined: participants who have obtained a sports title or the highest category (n=16), and participants who have not reached this level (n=17).

The control testing of the created program showed only a 14 % probability of error in predicting the participants competition performance. According to the functionality of the program in the field of classification of signs by categories, the author's intellectual development with 100 % probability on the basis of experimental approbation revealed key categories of signs that reliably affect the results of the athletes future sports performance.

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This research defines the main categories of signs that positively or negatively affect the possibility of a wrestler achieving the highest sports rank or title of Russia. Its practical implementation will allow the most accurate, with the minimum level of error in advance to identify athletes predisposed to obtain the highest competition result in Greco-Roman wrestling.

Keywords: combat sports, analysis and forecasting, competition performance, combat athletes, artificial intelligence.

Research area: theory and methodology of sport. Management of athletes' training (planning, modeling, including computer, informational, mathematical, simulation; forecasting, programming, control; scientific and methodological support of the training process; discharge standards and qualification requirements).

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Использование искусственного интеллекта для прогнозирования спортивных результатов атлетов, соревнующихся в греко-римской борьбе

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Аннотация. Сегодня использование алгоритмов машинного обучения и нейронных сетей для повышения эффективности спортивного отбора на ранних этапах тренировочного процесса спортсменов становится особенно актуальным. Цель научной работы: разработать программу прогнозирования спортивных результатов молодых спортсменов, выступающих в греко-римской борьбе, на основе технологии искусственного интеллекта.

Был выполнен сбор и обработка индивидуальных данных спортсменов в возрасте 18–25 лет (n=67) по 21 критерию сравнения, ранжированных по категориям по двум направлениям: спортивное пространство и индивидуальные достижения. Были определены две категории прогнозирования: участники, получившие спортивный титул или высшую категорию (n=16), и участники, которые не достигли этого уровня (n=17).
Контрольное тестирование созданной программы показало лишь 14 %-ную вероятность ошибки в прогнозировании соревновательных результатов участников. Согласно функционалу программы в области классификации признаков по категориям, интеллектуальные разработки автора со 100 % вероятностью на основе экспериментальной апробации выявили ключевые категории признаков, которые достоверно влияют на результаты будущих спортивных выступлений единоборцев.
Выводы: в этой научной работе определены основные категории признаков, которые положительно или отрицательно влияют на возможность достижения борцом высшего спортивного разряда или титула в России. Практическая реализация результатов исследования позволит наиболее точно, с минимальным уровнем погрешности, заранее выявить спортсменов, предрасположенных к получению наивысшего соревновательного результата в греко-римской борьбе.

Ключевые слова: спортивные единоборства, анализ и прогнозирование, соревновательный результат, единоборцы, искусственный интеллект.

Научная специальность: 5.8.5 – теория и методика спорта. Управление подготовкой спортсменов (планирование, моделирование, в том числе компьютерное, информационное, математическое, имитационное; прогнозирование, программирование, контроль; научно-методическое обеспечение тренировочного процесса; разрядные нормативы и квалификационные требования).

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Introduction

Recently, artificial intelligence technologies have become an important tool for providing support for the implementation of various processes in the field of physical education (PE) and sports (Liu & Zhu, 2022; Morhat, 2018). When using large data based on intelligent technologies, a systematic analysis of the indicators of PE and sports activities is carried out. Specifically, for optimizing professional and athletic orientation and early identification of athletes with outstanding physical abilities (Bullock et al., 2022; Xu, 2022; Yang & Lin, 2022; Liu et al.; 2021). As well as automation of the quality assessment of technical and tactical preparation and analysis of information on the results of the training process (Nagovitsyn et al., 2023; Qiu et al., 2022; Koliada et al., 2021). Intelligent analytics is beginning to play an important role in improving the quality of PE and athletic training (Tang et al., 2022; Wang & Syed, 2021). At the same time, it is most practically significant through the implementation of informational, methodological and consulting assistance to coaches and PE teachers in various sports organizations (Xu, 2022; Yang & Lin, 2022; Zhang et al., 2022; Wang & Park, 2021).

In specific scientific studies and reports, the use of artificial intelligence (AI) technologies for analyzing large data in the field of sports activities is justified as one of the significant

and effective tools for improving the quality of health and motor indicators of novices and elite athletes (Liu & Zhu, 2022; Li et al., 2021; Morhat, 2018). This makes it possible to solve many problems, such as differentiating those involved to identify dependencies and links between their abilities, analyzing the quality of sports training (Tang et al., 2022; Wang & Syed, 2021) and the risk of achieving low-level physical development (Qiu et al., 2022; Yang & Lin, 2022), automatically building recommendations on the use of information resources and materials to better master the sports training program (Lu, 2022; Minbaleev & Titova, 2020).

In professional sports and fitness, in the last decade, various AI systems with continuous dynamics are beginning to have an increasingly significant impact (Xu, 2022; Koliada et al., 2021; Liu et al., 2021). Intelligent technology is used to analyze large amount of sports data, from the perspective of sports analytics and monitoring referees by video recordings of a match or PA indicators of competitors (Tang et al., 2022; Wang & Syed, 2021; Morhat, 2018). These systems support the physical and athletic performance potential of athletes in the implementation of cyber connections and various virtual sports activities (Dhar, 2017). At various stages of the training and competition process, coaches and athletes use the results of intellectual analytics to personalize training (Yang & Lin, 2022; Wang & Syed, 2021). And also in certain sports situations, AI and machine learning technologies allow you to fully automate the training process (Liu & Zhu, 2022).

However, there are differing opinions on the effectiveness of AI in the fields of PE, sports and fitness (Qiu et al., 2022; Xu, 2022). As some scientific works (Liu et al., 2021; Minbaleev & Titova, 2020) show, the introduction of these technologies without the implementation of experimental studies can be partially negative (Yang & Lin, 2022). As a consequence, it is possible that the next generation of coaches and athletes will be ill-equipped for a dynamic and changing sports world in the space of innovation amid the growing development of large amount of data (Dhar, 2017). However, the approach of this investigation is not to introduce global standards based on the introduction of intelligent technologies. And also, not in finding ways to replace trainers and coaches in sports in the field of combat sports (Nagovitsyn et al., 2023). With our scientific work, we aim to create such an AI program, in the implementation of which the coach and administration of sports organizations will be able to significantly improve the sports training of combat athletes (Tang et al., 2022; Zhang et al., 2022; Wang & Park, 2021).

Based on the above analysis, a hypothesis was put before the investigation: sports selection for competition performance in wrestling will be more effective if the author's intellectual program for predicting the athletic performance of athletes is created and practically tested. A theoretical analysis of the existing possibilities for using AI to improve the quality of sports training of the younger generation shows that today there is a special need and need for experimental research in this direction. In this regard, the main purpose of this scientific work: to develop a program for predicting the athletic performance of athletes, who competing in Greco-Roman wrestling, based on the AI technology.

Material & methods

At the first stage of this investigation (September-December, 2022) collection and processing of individual data of athletes 18–25 years old (n=67), who competing in Greco-Roman wrestling or already ended wrestling career are carried out. To collect information, an analysis of archival data of athletes from sports schools of three constituent entities of Russian Federation was implemented: the Republic of Tatarstan (Kazan), Krasnoyarsk region (Krasnoyarsk) and the Udmurt Republic (Glazov). Additionally, their personal and telephone survey was carried out. For the investigation, data were collected from athletes during the period when they were just starting a sports career in Greco-Roman wrestling. The focus of the group included elite athletes, who have the high sports category "Candidate for Master of Sports of Russia" or the sports title "Master of Sports of Russia" (n=16), athletes, who have various sports categories (n=34) and

athletes, who have youth categories or do not have them at all (n=17).

At the second stage of this investigation (January-March, 2023), the development of a forecasting program was implemented. This program is aimed at analyzing the competition performance of participants in the conditions of using AI technologies on the «Orange» platform. Deep neural networks and specially selected machine learning algorithms for categorization were used to carry out the investigation (Nagovitsyn et al., 2023).

For the process of "training the intelligence" of the program on the «Orange» platform, data from combat athletes, who competing in Greco-Roman wrestling, of not the entire experimental sample were used. This process includes data from only athletes selected by special sampling (n=33) for training testing. The main condition for testing the program was the uniformity of the samples. So, the tested samples should have included athletes, who having sports ranks and titles (n=16), and not having a sports result at all (n=17).

At the third stage (April-May, 2023), a classification analysis of the developed program was implemented. On the «Orange» intelligent platform, the process of predicting the competition performance of participants was completed and the main classification characteristics for predicting athletic performance were determined. At the final of this process, the program was analyzed using a control sample (n=34) of athletes, who competing in Greco-Roman wrestling and have various sports categories. The control sample data entered into the program made it possible to identify the final percentage of prediction reliability of the author's intellectual development.

In this scientific work, Spearman's rank correlation coefficient and Pearson correlation coefficient were used to determine the degree of dependence of indicators and the relationship between quantitative variables affecting sports success in Greco-Roman wrestling, where possible.

Based on a comparative analysis of specific scientific knowledge and the peculiarities of sports monitoring, a system of signs and their categories was compiled to implement the forecast of the sports success of Greco-Roman wrestlers (Nagovitsyn et al., 2023; Bullock et al., 2022; Tang et al., Qiu et al., 2022; Xu, 2022; Zhang et al., 2022; Koliada et al., 2021; Liu et al., 2021; Nagovitsyn et al., 2018). This classification was ranked by 21 features, each of which was divided into 2–4 categories. In turn, each in two categories: 12 features by Sports Space and 9 features by Individual Achievements (Table 1).

Further, during the experiment, the individual data of athletes, who competing in Greco-Roman wrestling and participating in the experiment, collected at a time when they were still starting a sports career, were uploaded to the «Orange» analytical system. Based on the processing of this data using deep neural networks and a complex of special machine learning algorithms, two categories of prediction were identified. On the one hand – Greco-Roman wrestlers who have achieved a high sports result (sports title or highest rank). On the other hand, there are Greco-Roman wrestlers who have not reached this level. As a result of analyzing the control sample data, only 2 statistical errors out of 14 tested wrestlers were detected, which corresponds to only 14 % of the error probability of the created author's intellectual program. Thus, the author's intellectual program was tested, finally developed and ready for the implementation of sports selection of athletes, who competing in Greco-Roman wrestling.

Results

By using the functionality of this intelligent program, the categories of signs that most reliably affect the high sports result "Perform KMS/MS" were identified. As a result, the program identified key categories for this result. The identified categories by signs indicate their most reliable significance in the process of implementing the forecast. In turn, the categories of signs that most reliably affect the negative result in Greco-Roman wrestling "Not perform MS/MS" were also revealed. After identifying the main categories of the forecast that most significantly affect the wrestling result (6 categories for each), using the analysis of the data of the entire experimental sample, a mathe-

Table 1. Data classification of Greco-Roman wrestlers by features and their categories

Designation	Features	Category by coding number
Sports Space		
SS1	Age of the wrestler at the time of arrival in the section	7–8 (0), 9–10 (1), 11–12 (2)
SS2	Marital status of a wrestler	Orphan (0), incomplete family (1), complete family (2)
SS3	Wrestler's place of residence	Village (0), city less than 100 thousand (1), city more than 100 thousand (2)
SS4	The older brother or sister of the wrestler	Not or not playing sports (0), has a rank (1), has a sports title (2)
SS5	Wrestler's father	
SS6	Wrestler's mother	
SS7	Coach qualification	It has the rank (0), has the rank of **KMS** or the rank of **MS** (1), has the rank of **MSMK**
SS8	Performance of the trainer's pupils over the past 5 years	Sports rank (0), **KMS** (1), **MS** or **MSMK** rank (2)
SS9	Trainer experience	< 5 years (0), 5–15 years (1), 16–30 years (2), > 30 years (3)
SS10	Wrestler's father / wrestler's mother works in sports	No (0), yes (1), part-time (2)
SS11	The education of a wrestler	School (0), gymnasium (1), lyceum (2)
SS12	Who brought the wrestler to the section	Self or friend (0), grandparents (1), brother or sister (2), father or mother (3)
Individual Achievements		
IA1	Average School Score for the Preceding Year	< 4,2 (0), 4,2–4,7 (1), > 4,7 (2)
IA2	Skipping training to the number of all classes (%)	> 10 (0), 5–10 (1), < 5 (2)
IA3	Physical development for testing "Ready for work and defense"	unsigned (0), bronze/silver (1), gold (2)
IA4	Average performance of a wrestler in the first two or three competitions (place)	< 3 (0), 2–3 (1), > 2 (2)
IA5	Cooper's power endurance test (min)	< 1,2 (0), 1,2–2 (1), > 2 (2)
IA6	Muscle Mass Index to Height and Weight	< 15 (0), 15–20 (1), > 20 (2)
IA7	Maximum oxygen consumption	< 25 (0), 25–35 (1), > 35 (2)
IA8	Vital capacity of lungs (mL)	< 1500 (0), 1500–2000 (1), > 2000 (2)
IA9	Respiratory volume (mL)	< 180 (0), 180–250 (1), > 250 (2)

Note: **KMS** – Candidate for Master of Sports of Russia; **MS** – Master of Sports of Russia; **MSMK** – Master of Sports of international class.

matically reliable ratio was obtained in various combinations of feature categories (Table 2).

As a result, the forecast at the level of 100 % is recorded if the wrestler manifests himself during monitoring a combination of 3 categories of signs in one of the different options. In turn, if the athlete's mother goes in for sports and has a sports title or one of the older brothers or sisters has a sports title, then he is more than 84 % likely to be effective in future competition activities. And if he is additionally coached by a mentor with work experience from 16 to 30 years old or the performance of his previous pupils over the past 5 years will be

Table 2. Categories of features that reliably affect forecasting in various combinations among Greco-Roman style wrestlers

Category of features by result "Perform KMS/MS"		1	1–2	1–3
1	Sports mother: holds the sporting title of **SS 6(2)** / Older brother or sister: has the sporting title of **SS 4(2)**	> 84	> 91	100
2	The performance of the pupils of the coach over the past 5 years: the title of MS/MSMK **SS 8(2)** / The experience of the coach: from 16 to 30 years **SS(2)**			
3	Father or mother works in the field of sports: part-time **SS 10(2)** / Place of residence: city more than 100 thousand **SS 3(2)**			
Category of features by result "Not perform KMS/MS"		1	1–2	1–3
1	Who brought the wrestler to the section: grandmother or grandfather **SS 1(1)** / Wrestling training: Lyceum **SS 11(2)**	> 82	> 89	100
2	Average School Score for the Preceding Year: < 4.2 **IA1(0)** / Omission to Total (%): > 10 **IA2(0)**			
3	Physical development on testing "Ready for work and defense": without a sign **IA3(0)** / Marital status of a wrestler: orphan **SS 2(0)**			

at least the level of MS/MSMK (1 and 2 signs), then the likelihood of reaching the highest sports category and the title of Russia already rises to 91 %.

On the other hand, if a wrestler was "recorded" in the Greco-Roman wrestling section by a grandmother or grandfather or he studied at a moment in an unsportsmanlike lyceum (1 sign), then he later more than 82 % probability will not achieve a high wrestling result in his career. And if he will still additionally miss classes in the Greco-Roman wrestling section or the average score in the school for the previous year will be less than 4.2, then the probability of not reaching the wrestling highest rank and the title of national champion increases to 89 %.

Discussion

In the current period of improving domestic sports training routine, many mathematical methods are used to predict the competition performance of athletes at various stages of the training routine (Minbaleev & Titova, 2020; Koptev et al., 2019; Morhat, 2018). In the context of large data analytics, the level of confidence in identifying a significant sports selection strategy begins to increase significantly (Lu, 2022; Wang & Syed, 2021), despite the insufficiency of identifying individual hereditary features and achievements of the athlete (Yang & Lin, 2022; Li et al. 2021; Dhar, 2017). The implementation of AI programs makes it possible to increase the possibilities of reliable forecasting and significantly increase the accuracy in the processing of athletes' data upon admission to the sports section (Bullock et al., 2022; Liu & Zhu, 2022; Qiu et al., 2022; Xu, 2022). As the present investigation showed, the use of various machine learning algorithms and neural networks made it possible to relatively accurately implement the process of predicting the performance of athletes, who competing in Greco-Roman wrestling, with a minimum level of error. In turn, it is significant to identify athletes, who are not predisposed at the initial stage of the training process to combat sports. The identification of such combat athletes at an early stage of sports training will contribute to further correction of the trajectory of educational impact and individualization of the training process with this contingent of athletes (Tang et al., 2022; Nagovitsyn et al., 2019).

Increasing of competition performance in elite sports today is increasingly dependent on the introduction of innovative forms, methods and means and on accurate and timely sports selection even in the early stages of sports activities of novice athletes (Liu et al., 2021; Wang & Syed, 2021). This process is reduced to the search for certain patterns, and as the results of the study showed, combinations of features by categories in comparison with

the indicators of the entire study group (Nagovitsyn et al., 2023). Which, in turn, can be reduced to the task of systematization by the signs of comparing the indicators of combat athletes and the final sports results as predictive models based on large amount data analysis (Tang et al., 2022; Xu, 2022). The created program on intellectual patterns according to the characteristics of comparison reached a high level of 100 % with a combination of minimum three characteristics. And if only one category of the sign coincides, the probability was 84 % to achieve the wrestling category Candidate for Master of Sports of Russia or the title Master of Sports of Russia and 82 % to not fulfill this sports level.

Conclusions

Thus, in scientific work, an author's program based on artificial intelligence was created and tested to implement the forecast of the competitive performance of Greco-Roman martial arts. The study statistically defines the main categories of signs that positively or negatively affect the possibility of a wrestler achieving the highest sports rank or title of Russia. Its practical implementation will allow the most accurate, with the minimum level of error in advance to identify athletes predisposed to obtain the highest result in Greco-Roman wrestling. As the statistical results of the study showed, the introduction of the functionality of neural networks and a specially selected complex of machine learning algorithms increases the quality of sports selection in Greco-Roman wrestling. This ultimately allows you to timely individualize and improve the training process of wrestlers. In this view, it is intelligent technologies using special algorithms for the implementation of forecasting that have effective and reliable practical significance in the process of sports selection. Especially to the ability of mining, the processes of classification and identification of significant data that are statistically reliable to increase the efficiency of the sports trek of athletes, who competing in Greco-Roman wrestling.

Limitations

Any inferences made in this scientific work have some important limitations. These limitations associated with the total low number of participants (non-elite and elite athletes, who competing in Greco-Roman wrestling). A possible limitation is also the lack of data of athletes, who competing in Freestyle wrestling, which does not allow comparing, evaluating and analyzing the factors of sporting success in Freestyle and Greco-Roman wrestling.

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Conflicts of interest

The authors declare that this scientific work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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