Wrestling performance prediction based on improved RBF neural network

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Abstract. As the earliest competitive sport, wrestling has become a world-class event through continuous development and improvement. Practitioners of competitive sports combine modern science such as life science, nutrition, statistics and so on to study the techniques and methods of improving wrestling performance. In this paper, a quantitative prediction model of wrestling performance is established by improving RBF neural network based on dropout theory. By analyzing the quantitative factors such as hemoglobin, blood urea and the technical factors such as reaction strength, speed and endurance of athletes, data were collected and network training was conducted. The predicted results have a high fitting degree with the real results, which can be used to predict the achievements of wrestlers and provide important reference for relevant practitioners in making training plans, selecting competitors and improving the competitive level.

1. Introduction
Wrestling refers to the traditional sports of two people embracing each other, using various technical skills and winning opponents in accordance with the rules of competition. It occupies an important position in modern sports and is an extremely gold-containing and ornamental game in the Olympic Games [1]. In recent years, with the development of national competitive wrestling competitions, the important factors and scientific assessment methods that affect wrestling performance have gradually been paid attention to. At present, our country's research on wrestling mainly focuses on the analysis of rules, the status of training, and the biochemical indicators of athletes. In 2012, Lu Dan and others monitored the biochemical indicators of excellent wrestlers, using hemoglobin, creatine kinase, blood urea and other indicators to monitor the exercise load, and selected three winning wrestlers from the Jilin Provincial Sports Team for 18 Monthly tracking and monitoring proves that the above three indicators can objectively and accurately reflect the athlete's athletic ability and training load [2]. In order to compare the differences between some physical fitness indicators of China's outstanding male wrestlers and foreign athletes, Liu Jian and others compiled 53 wrestlers from 7 levels in China and 35 international athletes from the United States, Canada, Iran and other countries, targeting 55kg to 120kg Statistics of differences in sit-up, push-up, pull-up, deep squats, bench presses, and grip strength were used to analyze the muscle strength and endurance qualities of wrestlers [3]. In 2019, Wang Xu used SPSS to conduct a comparative experiment on single-leg activation and double-leg activation of 8 wrestlers in Beijing Institute of Sport, and took the performance of 5-meter and 3-way running as the evaluation standard. The results showed that single-leg fractional activation could improve performance better [4]. However, the current research does not have a systematic and clear
quantitative model for the analysis of influencing factors and the improvement of performance, which also lacks a targeted training plan. There are many factors that affect wrestling competition, and the importance of each factor is unequal, and there is a linear or complex non-linear relationship with the performance. Using ordinary mathematical models, it is impossible to make accurate quantitative predictions of the performance through each influencing factor. BP neural network is proposed based on the principle of feature vector clustering analysis and is widely used in nonlinear data fitting. However, the problem of BP network’s minimum limit has always affected its accuracy. Based on this, RBF neural network changes the core function through the selection of radial basis function, improves the fitting degree of nonlinear data, and predicts the results more accurately.

2. Principle
The radial basis neural network was proposed by Powell in 1985. It uses the radial basis function to obtain the value characteristic, that is, the real value function of the distance from the far point, that is, the multidimensional norm. In general, any function that satisfies the Euclidean distance is a radial basis function, and the most widely used activation function is the Gaussian kernel function.

\[ k(||d - d_c||) = e^{-\frac{||d - d_c||^2}{2\sigma^2}} \]

The output of the network is:

\[ y_{out} = \sum_{c=1}^{n} w_{cp} e^{-\frac{||d - d_c||^2}{2\sigma^2}} \mu_{set} \]

Where, the value range of \( p \) is 1, 2, 3, ..., \( m \). The essence of RBF neural network is similar to BP neural network, except that RBF replaces the weight connection by the way of center point confirmation, which is equivalent to mapping input neurons to high dimensions to achieve linear separability. The adjustment of the network is only a linearly adjustable parameter, so that it can avoid falling into the minimum problem while ensuring the convergence speed.

RBF mapping input neurons to high-dimensional through kernel function is the most important step in establishing neural network, and it is often prone to mapping deviation. This paper proposes the idea based on ‘dropout’, so that when mapping, some hidden layer neurons can be randomly lost, which can increase the robustness of RBF and make the network structure more stable and reliable. That is, the transfer formula output at the hidden layer is modified to:

\[ y_{out} = \sum_{c=1}^{n} w_{cp} e^{-\frac{||d - d_c||^2}{2\sigma^2}} \mu_{set} \]

Where, \( \mu_{set} \) is the predetermined neuron loss rate, that is the proportion of dropout. The value range is 0-1. The network structure is shown in Figure 1. Neurons in the hidden layer are lost with a certain probability (shown by dashed lines). In this way, iterative divergence due to rapid gradient descent will be avoided during the iteration process.
3. Results and discussion

Among the factors that affect wrestlers, they can be divided into two categories according to their nature: quantitative factors and technical factors. Among them, the quantitative factors are mainly athletes’ own physical fitness indicators, such as height, weight, hemoglobin, blood urea, testosterone, serum creatinine, etc. Technical factors mainly refer to the athletes through the acquired training, in the judgment of competitive skills, such data generally cannot be directly measured, but through different training index to express the strength, speed, endurance of the athletes, such as deep squat maximum kg, bench press maximum kg, time the number of pull-up, etc. When calculating comprehensive results through quantitative factors or technical factors, direct linear calculations cannot be performed, because both of them have a complicated non-linear relationship with comprehensive performance evaluation, see Figures 2 and 3. Among the quantitative factors, serum creatinine showed a good positive correlation with overall score, and hemoglobin was the negative correlation. Among other items, there is no obvious correlation with the overall score. Among the technical factors, the push-up completed per minute showed a good correlation with the bench press, and also showed a certain correlation with the overall score. Pull-up and sit-up showed a low correlation with overall score, and deep squats were not significantly related to overall score.
In this paper, the physical fitness indexes and training data of 40 college female wrestlers are used as input neurons, and the assessment results are used as output neurons to establish an improved dropout RBF neural network. Among them, 30 sets of data are used as training samples, see Table 1 (partial data). Take the remaining 10 sets of data as prediction samples, in which the type of input neurons is consistent with that of the training group, and the final comprehensive score is predicted through the trained neural network. The results are shown in Figure 4.
Table 1. Training samples of improved RBF score prediction model for female college wrestlers (part).

| Hight (cm) | 163.1 | 163.8 | 162.5 | 158.9 | 164.9 | 161.8 | 159.2 | 158.2 | 162.2 |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Weight (kg)| 57.7  | 59.6  | 57.5  | 58.4  | 57.8  | 57.8  | 58    | 58.6  | 58.2  |
| Hemoglobin (g/L) | 124.02 | 99.95 | 145.4 | 122.11 | 99.04 | 157.67 | 152.12 | 118.38 | 121.51 |
| Blood urea (nmol/L) | 7.54  | 8.27  | 8.34  | 7.89  | 8.33  | 7.34  | 8.74  | 8.11  | 7.93  |
| Testosterone (nmol/L) | 13.21 | 10.73 | 14.61 | 17.33 | 15.88 | 15.31 | 17.72 | 17.4  | 17.06 |
| Serum creatinine (U/L) | 223.72 | 255.55 | 262.3 | 196.73 | 257.2 | 222.12 | 274.42 | 189.99 | 195.64 |
| Sit-up (times/min) | 57    | 65    | 56    | 56    | 65    | 57    | 64    | 54    | 56    |
| Push-up (times/min) | 65    | 63    | 64    | 55    | 64    | 63    | 63    | 55    | 55    |
| Deep squat (kg/weight) | 1.91  | 1.98  | 1.69  | 1.65  | 1.71  | 1.93  | 1.94  | 1.92  | 1.91  |
| Bench press (kg/weight) | 1.68  | 1.66  | 1.7   | 1.69  | 1.94  | 1.68  | 1.72  | 1.94  | 1.94  |
| Overall score | 80    | 95    | 75    | 76    | 95    | 67    | 71    | 73    | 75    |

Table 2. Test samples of the improved RBF score prediction model for college female wrestlers.

| Hight (cm) | 167  | 161.8 | 167.5 | 158.9 | 166  | 159.9 | 165.7 | 166.7 | 166.3 | 161.5 |
|------------|------|-------|-------|-------|------|-------|-------|-------|-------|-------|
| Weight (kg)| 59.1 | 58.6  | 59    | 56.5  | 57   | 57.5  | 59.1  | 56.7  | 59    | 57.2  |
| Hemoglobin (g/L) | 116.96 | 165.5 | 104.78 | 152.2 | 121.63 | 163.14 | 138 | 138.83 | 101.82 | 150.05 |
| Blood urea (nmol/L) | 7.13 | 6.87  | 7.99  | 8.74  | 7.4  | 7.01  | 8.83  | 7.52  | 8.16  | 8.62  |
| Testosterone (nmol/L) | 12.49 | 16.69 | 11.23 | 15.32 | 12.97 | 16.45 | 9.76  | 9.67  | 10.92 | 15.09 |
| Serum creatinine (U/L) | 210.99 | 207.98 | 189.02 | 274.56 | 219.42 | 212.25 | 272.51 | 274 | 252.17 | 270.69 |
| Sit-up (times/min) | 63   | 64    | 54    | 64    | 56    | 54    | 63    | 64    | 64    | 54    |
| Push-up (times/min) | 55   | 56    | 56    | 66    | 66    | 63    | 64    | 64    | 56    | 64    |
| Deep squat (kg/weight) | 1.92 | 1.69  | 1.96  | 1.72  | 1.64  | 1.98  | 1.69  | 1.64  | 1.65  | 1.66  |
| Bench press (kg/weight) | 1.98 | 1.97  | 1.72  | 1.98  | 1.64  | 2     | 1.68  | 1.96  | 1.68  | 1.99  |
Figure 4. Comparison of measured results and predicted results of college female wrestlers.

It can be seen from Figure 4 that the comprehensive performance of 10 athletes is predicted by quantitative factor data such as height and weight, and technical data such as sit-up and push-up. The absolute value of the maximum relative error is 12.97%, and the absolute value of the minimum relative error is 0.50%, the absolute value of the average relative error is 5.49%, and 80% of the prediction results are less than 10%, proving that the network has high accuracy. More than 10% of the two athletes are expected to be caused by other abstract factors such as psychological quality and emotional state.

4. Conclusions

In this paper, the improved RBF is used to explore the performance and influencing factors of wrestlers. The improved model is trained with 30 sets of data, and the model is verified with another 10 sets of data. The results show that most predicted results are in good agreement with the real results. The relative error of a small part of the results is more than 10%, which is because the model does not include additional influencing factors and the number of samples used for training is small. In general, the improved RBF neural network has a better ability to predict the performance of wrestlers, which can enrich the teaching and guidance system to a certain extent, enable athletes, coaches and relevant personnel in the industry to better scientifically control the training plan, improve the competitive level, and obtain excellent results.

References

[1] Ye Jun. The importance and practice of manipulation training in wrestling. Theory and Application of Education. 2020, 1:17-20.
[2] Lu Dan, Jia Wei, Yang Yun. The Application of Biochemical Index Monitoring for Excellent Wrestlers [J]. Journal of Changchun Teachers College. 2012, 31(3):117-121.
[3] Liu Jian, Yang Tao, Alex Kun. Analysis on the Partial Indexes of the Physical Fitness of the Male Elite Wrestlers [J]. Journal of Beijing Sport University. 2011, 34(5):136-140.
[4] Wang Xu. A Study on the Effect of Single and Double Leg Strength Activation on Wrestlers’ Five-meter Three-way Running Performance [J]. 2019, 210:18-20.