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The role of deep learning-based variable speed running training method in agility improvement of badminton players

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ABSTRACT

Variable speed running training method is an efficient training method targeting the improvement of athletes' agility. In this paper, 30 male students from two badminton special classes of physical education majoring in a college of 2021 were selected as experimental subjects, and hexagonal ball reaction test, hexagonal jump test, repeated straddle test, standing bench press test, closed-eye in-situ step test, and low gravity center of gravity quadrangular running test were chosen as the evaluation indexes of agility quality. A new high-resolution multi-scale feature fusion network was designed for running stance estimation, and the effects of variable speed running training method and conventional agility training on the agility quality of young badminton players were analyzed. The performance curve of the RHPNet designed in this paper has low convergence difficulty and high recognition accuracy, which tends to 0.83, and performs much better than the LSTM network. The intergroup data after the experiments of the experimental group and the control group show that there are significant differences in the performance of the hexagonal jump test, the 20s repeated straddle test, the hexagonal ball reaction test, and the closed-eye in-situ step test. It verifies the effectiveness of the network designed in this paper in the estimation of athletes' movements during running, and also shows that the training effect of variable speed running training is better than that of conventional agility training.

Keywords: human posture estimation, multi-scale feature fusion, RHPNet, variable speed running training method, athlete agility

1. Introduction

Badminton is one of the key sports programs in China to achieve excellent results in international competitions and improve the influence of Chinese sports. With the rapid development of badminton program, the technology of badminton in China as well as in the world is developing in the direction

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of more rapid and comprehensive, and the competition among countries in the game is more intense, which requires more and more physical and technical requirements for badminton players. In badminton, the new competition characteristics make the athletes' ability to supply energy from the phosphagenic energy supply system become a key factor, and the rules of the new system also emphasize the importance of speed [1-3]. After years of development, Chinese badminton has gradually worked out the Chinese style of badminton, i.e., fast, hard, accurate and alive, which are all very important but not absolutely balanced [4-7]. Among them, fast is the soul of the other three aspects, and the advantages of the other aspects can only be fully utilized under the awareness of fast. If you want to reflect the "fast" in the competition must be mainly through the improvement of speed to realize, see the role of speed in badminton is undoubtedly [8-9]. Therefore, in badminton training, we should pay attention to the quality of speed under the premise of ensuring the overall development of athletes [10-11].

Badminton is different from other sports, because it needs to react in an instant, with sharp stops, sharp jumps, and sharp turns, so it needs good physical fitness as a backup, and it needs to take professional and systematic training methods in order to strengthen the reserve of physical fitness [12-15]. Among the many badminton speed endurance training methods, variable speed running is considered to be a training method closer to specialization than general long-distance running [16-18]. In the context of the digital era, the combination of deep learning technology-assisted training has become an effective method for athletes to make progress, and informatization and systematic training are of great help to the technical and tactical level of athletes as well as the training of physical fitness, so that the students' mastery of specialized knowledge is more comprehensive and specific [19-22].

In this paper, the research object and research methodology were firstly identified, and six different specific agility test items were designed to carry out the research in the direction of the effect of variable speed running training on the development of agility qualities in junior badminton players. A new high-resolution multiscale feature fusion network was designed by integrating HRNet and RFSP modules, which was used for the estimation of running postures of young badminton players during variable speed running training. The network integrates the multiscale method and also combines the spatial pyramid pooling method, which enhances the prediction ability of the posture estimation method designed in this paper for the occluded joints of junior badminton players in running. The significant effectiveness of variable speed running training on agility enhancement of junior badminton players was experimentally verified.

2. Research Objects and Methods

2.1. Subjects of study

The effect of variable speed running training method on the development of sensitivity quality of male students in special badminton classes in colleges and universities was studied.

2.2. Research methodology

2.2.1. Literature method. In the process of research, according to the needs of the research purpose and research content, we used domestic and foreign databases such as CNKI, Wanfang Database, Google Scholar, etc., to search for keywords such as "variable speed running training", "badminton", "agility quality", "Agility", etc., and downloaded relevant literature and materials at home and abroad. At the same time, read books related to badminton and physical training such as Sports Training Science, Badminton Sports Theory and Practice, Speed, Sensitivity and Reaction Training. Through continuous study and in-depth research, combined with advanced theories and practical experience at home and abroad, we provided sufficient theoretical support and practical guidance for the study.

2.2.2. Expert interview method. To ensure the scientificity and reliability of the experiment, the expert interview method was used. First, the outline of the expert interviews was determined by reviewing relevant literature and communicating with the tutor. Subsequently, in-depth interviews were conducted with six experts in the field of badminton and experts in physical training, including those from our university and foreign universities. The main content of the interviews included in-depth exchanges on the views of introducing variable speed running training into badminton, the feasibility of the experiments in this study, the experimental design ideas and the selection of indicators for the detection of sensitivity quality. The valuable suggestions provided by the experts were recorded and summarized to provide theoretical basis and guidance for the subsequent experiments.

2.2.3. Experimental methods. In this experiment, male students of two badminton specialization classes of physical education majors in a college of 2021 were selected as experimental subjects, with a total of 30 persons, divided into two groups of 15 persons each. The location of the experiment was in the badminton hall of their college, and the experiment lasted for 12 weeks, with two training sessions per week, totaling 24 training sessions. Before the beginning of the experiment, the homogeneity test was conducted on the basic conditions and sensitivity quality test indexes of the subjects in the two classes, and the results showed that there was no significant difference, and the experimental and control classes were randomly selected, with the experimental class receiving variable-speed running training, and the control class receiving regular sensitivity quality training.

2.2.4. Mathematical and statistical methods. Relevant data were collected at the beginning and end stages of the experiment. After completing the experiment, the raw data were organized and the resulting data were subjected to mathematical statistics using Excel 2016 and SPSS 26.0 software. Paired samples t-test was performed on the data of the two groups at the beginning and end stages to observe the changes in the performance of junior badminton players before and after their participation in the experiment. At the same time, independent samples t-tests were used for between-group comparisons to compare whether there were significant differences between the experimental and control groups at the beginning and end of the experiment.

3. Experimental design and implementation

3.1. Experimental hypothesis

In the study of this paper, the independent variable is variable speed running training and the dependent variable is sensitivity quality of junior badminton players. The proposed experimental hypotheses are as follows:

Hypothesis 1: The scientific and rational use of variable speed running training can effectively improve the sensitivity quality of young badminton players.

Hypothesis 2: The effect of variable speed running training is better than the effect of traditional training methods of sensitivity quality in developing the sensitivity quality of young badminton players.

3.2. Experimental Test Metrics

In order to understand and select the test indicators, I have read a lot of literature on the measurement and evaluation of agility quality, such as "Speed, Agility and Reaction Training", "Youth Agility and Flexibility Training", "Agility Training", etc., at the same time, in order to take into account the special agility quality of badminton, I have also read books related to badminton physical fitness, such as "Chinese Youth Badminton Teaching and Training Syllabus", "Badminton Sports Physical Training Guide", " Research on the Special Physical Fitness Measurement Indicators and Evaluation Standards of Chinese Youth Male Badminton Players", etc. By organizing and classifying the evaluation indexes about the sensitivity quality that appeared in the reviewed information, the test indexes needed for this study were initially selected. Sensitivity quality is not a single physical quality like strength quality and speed quality, it is a complex physical quality, which is the result of a variety of physical qualities working together, and it is a comprehensive expression of a variety of physical qualities, strength, speed, coordination and other qualities can have an impact on the quality of sensitivity. The complexity of agility determines that if it is measured and evaluated through a single dimension and angle, it will lead to unscientific, unreasonable and unconvincing measurement results. Therefore, through combing the relevant literature, I decided to measure the agility of young badminton players from three aspects: general agility, specialized agility, and coordination and balance ability. Then, a questionnaire for the screening of the evaluation indexes of the sensitivity quality was designed, which was distributed and recovered from the relevant experts and scholars, experienced first-line coaches and other professionals. Finally, taking the experts' suggestions into consideration, this study classified the badminton players' sensitivity quality into three aspects, five dimensions and six test items, and the classification results are shown in Table 1.

Table 1. Indicators of sensitive qualities of badminton athletes

	Test dimension	Test index
General sensitive qualities	Responsive ability	Hexagon ball test
	Change direction	The 20s are repeated across the test, Hexagon test
	transformation	The 20s bench test
Special sensitive qualities	Special sensitive qualities	Lower center of gravity
Balanced balance	Coordination of peace and balance	Close test

3.3. Specific test items

1) Hexagonal Ball Test. Purpose: To evaluate the subject's ability to respond to external signal stimuli.

Equipment: Hexagonal ball, stopwatch.

Methods: Set point A as the starting point, the subject stood in front of point A at a position of 2m, the tester held the hexagonal ball at a height of 2m directly above point A. The subject was ready to grasp the ball in the standard badminton ready position, and the tester held the ball in one hand at a height of 2m. The subject is ready to grab the ball posture using the standard badminton preparatory movements, the tester holds the ball in one hand and pinches the watch with one hand, and pinches the watch at the moment of releasing the hand to drop the ball, and when the ball first falls to the ground and bounces up, the subject needs to grab the hexagonal ball at the fastest speed. The tester stops the timing and records the time at the moment the subject catches the hexagonal ball. Each subject is tested three times and the average of the three scores is calculated as the final result.

2) Hexagonal Test. Purpose: To evaluate the subject's ability to change direction quickly in the lower limbs.

Equipment: Hexagonal agility circle (side length 50cm), stopwatch.

Methods: The six sides of the hexagonal agility circle are marked with letters A, B, C, D, E, F in clockwise direction, and the tester pinches the stopwatch at the moment of issuing the command “start”, and the starting position of the subject is at the center of the hexagonal agility circle at O. After hearing the command “start”, the subject jumps forward with both feet over the edge of the circle. After hearing the command “start”, the subject jumped forward with both feet over the edge line A, then jumped back to the center of the circle with both feet, and then jumped back to the center of the agility circle after jumping the 6 edge lines in clockwise order, and the whole process was counted as one test. Each subject performed 3 tests, and the best score was taken as the final score.

3) 20s repetitive straddle test. Purpose: To evaluate the coordination of the subject's movements.

Equipment: tape measure, chalk, tape, protractor, stopwatch.

Methods: Draw 3 parallel lines on the floor with a distance of 1.2 meters, the subject was in a semi-squatting position, with his/her feet riding across the center line. After hearing the start whistle, start to the right side of the step to move, in accordance with the “center line - right center line - left center line” order to move repeatedly, every time through the touch or across a line, counting once, write down the number of times within 20S through the measurement of the two times, take the best results.

4) 20s push-up. Purpose: To evaluate the subject's ability to change movements.

Equipment: Stopwatch.

Method: The subject stands naturally on the test site. When the tester issued the command “start”, the stopwatch was pinched, the subject heard the command and squatted quickly, with both hands on the ground, legs straight back, into a push-up position, and then withdrew the legs into a squatting position, and then jumped upwards, with both hands through the side of the body in the overhead high-five and then landed on the ground, and the whole movement was counted as a complete push-up. After landing, the next push-up was performed. The tester recorded the number of push-ups performed by the subject within 20 s. The number of push-ups performed by the subject within 20 s was recorded by the tester.

5) Low center of gravity four-corner movement. Purpose: To evaluate the subject's ability to move with specialized footwork.

Equipment: Badminton ball, stopwatch.

Methods: The flow of low center of gravity four-corner movement is shown in Fig. 1, point A and point B are the right and left intersections of the front serve line and the singles sideline, and point C and point D are the left and right intersections of the doubles back serve line and the singles sideline, respectively. Before the start of the test, the subject into a ready position standing in the middle of the badminton court half-court field O point, the tester issued the “start” command instant pinch meter timing, the subject heard the command to use badminton special footwork to move to the A point, and the hand will be located in the A point of the badminton touched down, and then return to the point of the O point using the special footwork, according to this method The remaining badminton balls at points B, C, and D were touched down and returned to point O. Then the next round of movement was continued in the order of OA, OB, OC, and OD, and the return to point O after completing two rounds of movement was counted as one complete test. Each subject performed 2 tests and the best score was taken as the final score.

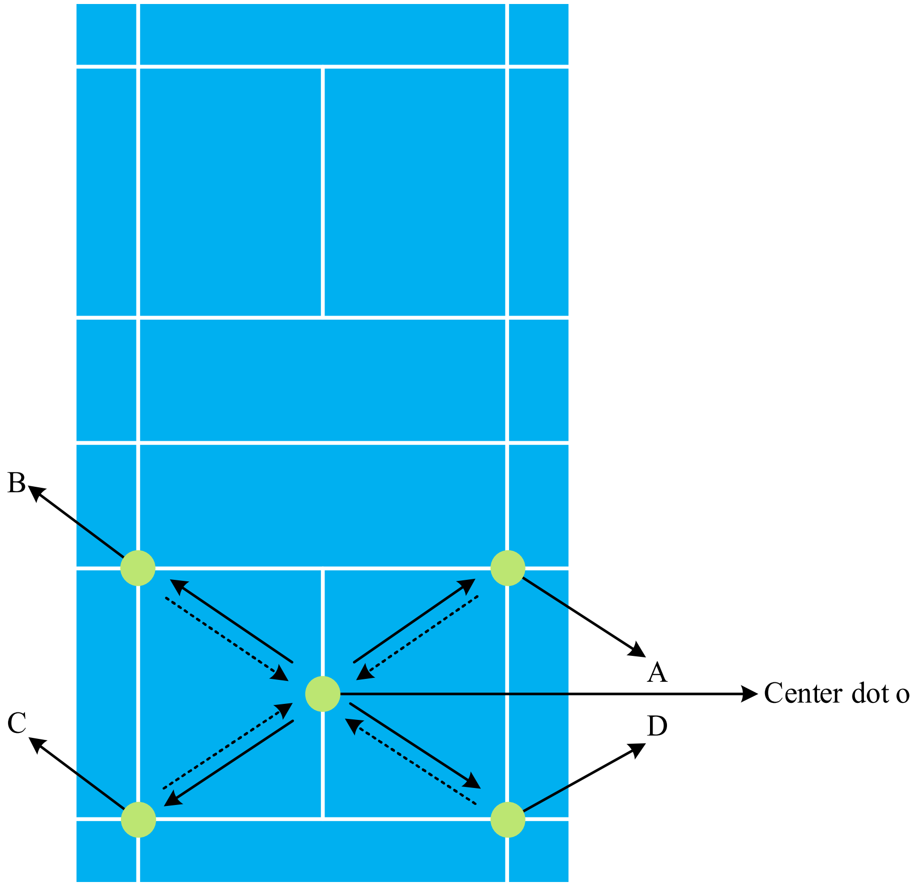

Fig. 1. Low center of gravity four corners moving test diagram

6) Stepping in Place with Eyes Closed. Purpose: To evaluate the subject's ability to balance.

Equipment: Stopwatch.

Methods: The subject stands naturally on the badminton court, the tester pinches the stopwatch at the moment of issuing the “start” command, the subject closes his eyes when he hears the command, raises one foot arbitrarily, crosses the waist with both hands, and maintains the balance with the supporting leg. The test ends when one of the following situations occurs: eyes open, moving the supporting foot, non-supporting foot to the ground. Each subject will be tested 3 times and the best score will be taken as the final score.

4. Deep learning based training recognition method for athletes running at variable speeds

In this paper, we utilize a deep learning approach for posture recognition in variable speed running sports to detect the posture changes of badminton players in variable speed running training.

4.1. Model structure

HRNet is a representative high-resolution multiscale feature fusion network [23], and its direct method of aggregating the final stage features neglects the fusion of shallow features. In order to fully utilize the detail information of the shallow features, this chapter designs an RFSP module, combines it with HRNet, and proposes an improved high-resolution multiscale feature fusion network, RHPNet, which effectively improves the model's localization accuracy for occluded joints and edge joint points.

The internal structure of RHPNet, a pose estimation network for multiple human instances, is shown in Fig. 2. First, the input images are fed into a backbone network consisting of a modified HRNet, and the four stages of the HRNet continuously add high to low resolution sub-networks for repeated multi-scale fusion. Then, refined hybrid features are generated by fusing shallow features from the backbone network with deeper features output from the backbone network. Finally, the hybrid features together with the shallow features are fed into the RFSP module for processing to generate K heat maps, each corresponding to a joint.RHPNet integrates the multi-scale approach and combines with spatial pyramid pooling, which enhances the model's multi-scale feature extraction and fusion capabilities. In addition, the modular design makes it easy to implement and train.

The Receptive Field Pooling Module (RFSP) utilizes the RFB module to simulate the receptive field of human vision and enhance the feature extraction capability of the network. The spatial pyramid pooling method is then used to fuse multi-scale features to enhance the model's prediction of occluded joints.

Population Receptive Field (pRF) is a concept that represents the range of perception of a visual stimulus by a specific neuron in the visual cortex. It utilizes multi-branch pooling of different kernels corresponding to different sizes of the perceptual range. And an inflated convolutional layer is applied to control the eccentricity of the receptive field and finally they are reintegrated to generate the final feature representation.

Spatial Pyramid Pooling (SPP), which takes feature maps with variable scales and converts them to a uniform scale to fuse multi-scale features. The fused feature maps are then subjected to the Spatial Pyramid Pooling module to obtain the final articulated thermal map. In this paper, in order to reduce the number of parameters and improve the computational speed, we choose to use the SimSPPF module.

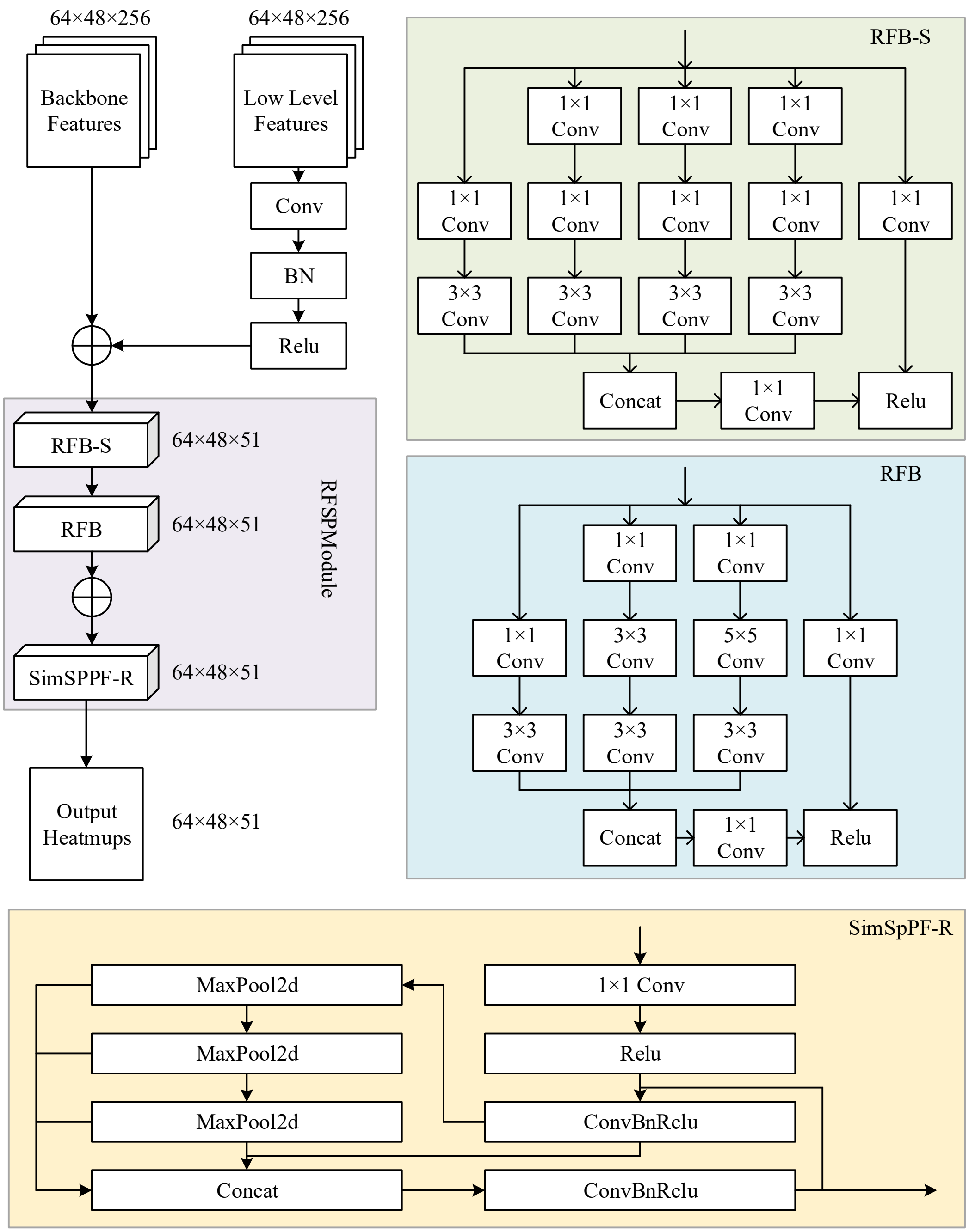

Fig. 2. Overview of the internal structure of the receptive field cisterization module

4.2. *Gaussian heat map and loss function*

In the current mainstream deep learning based pose estimation algorithms [24], the prediction of keypoints is widely used to regress the heatmap rather than directly regressing the coordinates of keypoints. Gaussian Heatmap Representation [25] is a technique commonly used in the field of computer vision party and image processing for detecting and localizing keypoints or targets in an image. It represents the location and intensity of a target by generating a heat map with Gaussian distribution at a specific location on the image. Gaussian heat map representations have been dominant in the prediction of critical points due to their strong localization and generalization capabilities. Many follow-up works have been devoted to continuously improving them, including proposing powerful networks to estimate heat maps more accurately and introducing attention mechanisms into the model. Gaussian heat maps are now widely used for encoding and decoding keypoint coordinates.

In the human pose estimation task, the Gaussian heat map H_i of joint n_i is shown in equation (1):

$$H_i(x,y) = exp\left[-\left(\frac{(x-a_i)^2}{2\lambda^2} + \frac{(y-b_i)^2}{2\lambda^2}\right)\right] \tag{1}$$

where a_i, b_i is the horizontal and vertical coordinates of joint n_i, respectively, and λ is a constant that controls the magnitude of the Gaussian heat value.

Heat map estimation has a better spatial paradigm than coordinate regression because heat maps can model the probability of existence of key points rather than just predicting coordinates. In addition, heat maps are able to capture important connections between key points. Since the network needs to predict the entire heat map during training and not just the coordinates of individual keypoints, it can utilize interactions and constraints between keypoints to improve the accuracy of its predictions.

The loss function we use during network training is the mean square error loss function, which represents the mean of the sum of the squares of the errors of the corresponding points of the predicted and original data, and is commonly used in linear regression problems. Its formula is shown in equation (2):

$$Loss = \frac{1}{\kappa H_w H_h} \sum_i^K \left[H_i^{pred}(x,y) - H_i^{gt}(x,y) \right]^2 \tag{2}$$

where $H_i^{pred}(x,y)$ is the predicted heat map, $H_i^{gt}(x,y)$ is the truth value, and K, H_w, H_h is the number of joints, heat map width and heat map height, respectively.

In the prediction process of the network, the Gaussian thermogram is decoded as the coordinates of the joints as shown in equation (3):

$$\hat{N}_i = argmax(H_i^{pred}) \tag{3}$$

where $\hat{N}_i$ is the location of the peak response in the predicted thermogram.

Equation (2) is the error calculation for the whole picture in heat map mode, the final output of the model is the heat map prediction for each key point of the human body, each coordinate point has a heat value and the place where the value is maximum is considered to be the key point coordinate predicted by the model i.e., $\hat{N}_i$. For the real tagged values, the dataset itself only provides the coordinates of each key point, so the error calculation is performed by using Gaussian function for each key point coordinate to generate a heatmap, and then only the error calculation between the heatmap of the predicted and real values can be performed to get the loss. The loss function measures the L2 distance between the heat map predicted by the model and the heat map generated from the real marker values of the image, and the solution of the model is obtained by minimizing the loss function during training.

4.3. Athlete Training Recognition Performance Analysis

The training parameters were pre-selected prior to the network debugging experiments to serve as the default parameters for the model structure experiments, with the setup parameters shown in Table 2.

Table 2. List of network training parameters

Network parameter	Value
Batch training scale	128
Activation function	ReLu
Optimization algorithm	Adam
Target function	Cross entropy

Comparison experiments are conducted between the multi-resolution multi-scale network and the LSTM network, and the accuracy training results and loss degree curves obtained are shown in Fig. 3 and Fig. 4, respectively. Analyzing the experimental results, it can be seen that the training time cost of the long and short-term memory recurrent neural network is much higher than that of the multi-resolution multi-scale network in this paper, and the performance curve of the LSTM network has a higher convergence difficulty, and the performance of the recognition accuracy rate under the optimal parameter settings is inferior to that of the multi-resolution multi-scale network in this paper, and the recognition accuracy rate in this paper tends to be 0.83. The reason is that the training difficulty of the LSTM network is greatly affected by the length of the sequence. The reason is that the training difficulty of LSTM network is greatly affected by the sequence length. The reason is that the training difficulty of the LSTM network is greatly affected by the sequence length. In summary, the multiresolution multiscale network in this paper is a more efficient and accurate deep learning program for variable speed running action recognition.

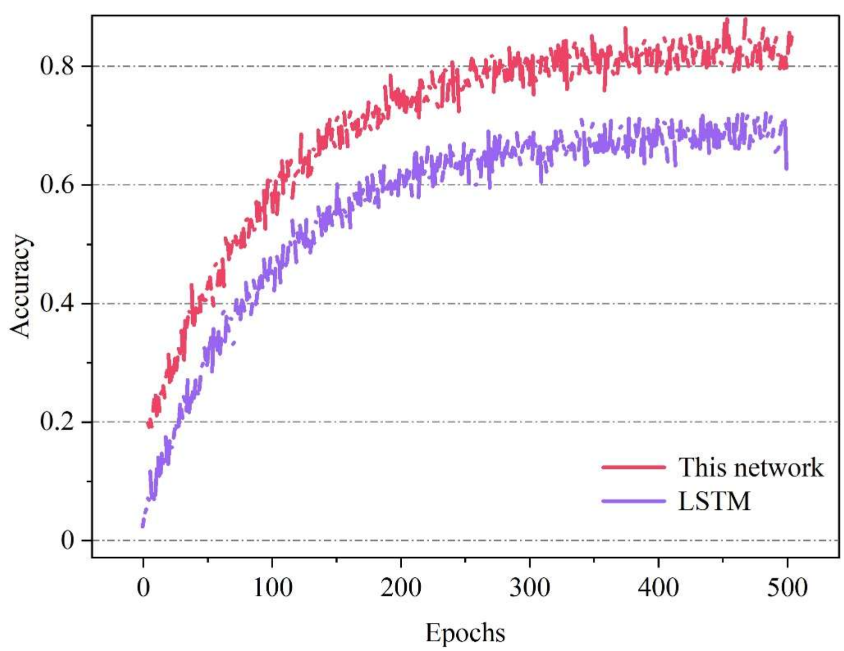

Fig. 3. Accuracy training results

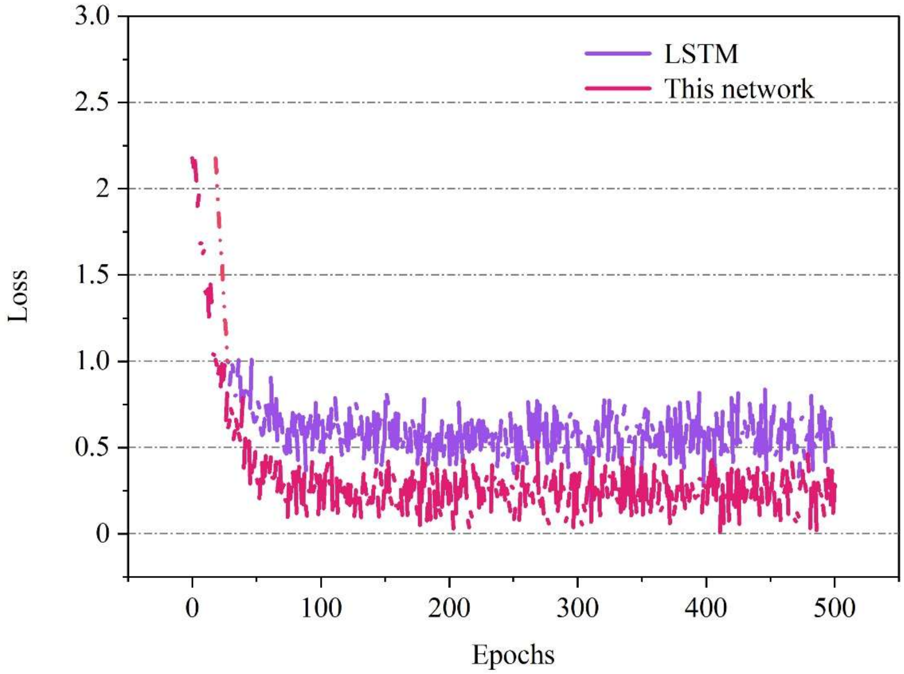

Fig. 4. Loss training results

In the case of uneven distribution of data volume, there is a huge drawback in using only the accuracy rate as an algorithm evaluation metric. In order to more reasonably compare the two action recognition models based on features and based on deep learning, the prediction error metrics used are introduced as follows:

The accuracy rate refers to the ratio of the number of correctly classified samples to the number of all samples, which is calculated from the first-level indicator, so it is called the second-level indicator, and the definition of the accuracy rate is shown below:

$$P = \frac{TP}{TP + FP} \tag{4}$$

For the multivariate classification problem, the accuracy rate indicator can be computed separately for each category by relabeling the current category of interest until and relabeling the other categories as negative. Therefore, the obtained metrics are N-element arrays.

The precision rate is usually used to evaluate the quality of the classification model.

Recall rate, as the name suggests, is the proportion of target categories recalled among the categories of interest. Recall rate is a metric corresponding to precision rate, which is often used to evaluate the completeness of recognition results. The definition of recall rate is shown below:

$$R = \frac{TP}{TP + FN} \tag{5}$$

We want the recognition models to have the highest possible values for both precision and recall, but the two metrics are in conflict.

Models with high recall have low precision, while models with high precision tend to have low recall, and in order to weigh the impact of the two metrics, the two metrics are fused into a single metric, which gives us the tertiary metric F_1 metric. It is defined as shown in the following equation:

$$F_1 = \frac{2TP}{2TP + FP + FN} \tag{6}$$

The following action prediction experiments were conducted by applying a combination of two window segmentation algorithms and two recognition models on the badminton action dataset, respectively.

Using the number of actions as the weight, the performance metrics of each type of action are weighted and averaged, and the precision, recall and F1 metric scores obtained are shown in Table 3. In terms of the experimental results, the precision and recall metrics under several scenarios do not show serious deviations, and the classification results of the model are credible. Further analysis of the experimental results shows that the feature-based recognition scheme in offline mode can achieve higher recognition accuracy and can flexibly adjust the combination of features according to the actual needs. For online action recognition, the neural network algorithm can show robustness to data displacement, in fact, the translation expansion of the dataset rather improves the recognition performance of the network, and does not need to significantly increase the training time, which is only 10.51 min, so the deep learning-based scheme can better work with the simple sliding-window sampling to realize action recognition.

Table 3. Movement recognition performance index record

Scheme	Accuracy rate(%)	Training time(min)	Accuracy rate(%)	Recall rate(%)	F1 index(%)
Event window + feature recognition	97.98	12.15	97.87	97.33	97.6
Sliding window + feature recognition	93.49	91.32	93.21	93.13	93.23
Event window + depth network	95.38	8.75	95.28	95.14	95.15
Sliding window + depth network	96.88	10.51	96.35	96.14	96.18

Examples of accelerometer output curves under two running maneuvers are shown below. Figures 5 and 6 show the accelerometer output curves under variable-speed running and normal long-distance running, respectively, and both curves show a change in acceleration at a sampling point of 150. Such experimental results reflect the fact that the equipment installation solution of fixing the measurement device on a part of the running track, although it can minimize the obstruction to the collector's movement, can also result in the resultant variable-speed running The motion dataset is not sensitive enough to the distinction between running styles, and based on this situation, the installation of the motion acquisition device on the body of a badminton player is a feasible solution.

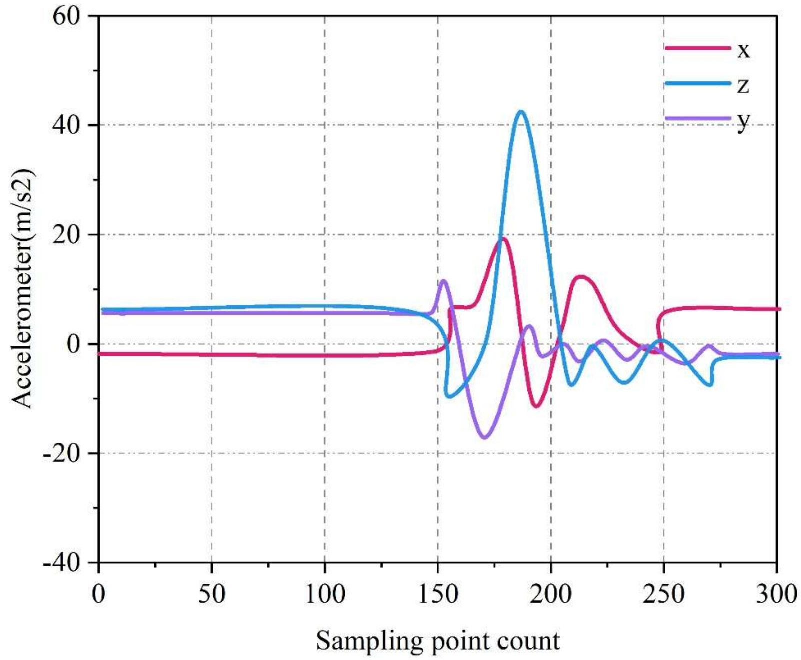

Fig. 5. The acceleration meter output curve of variable speed

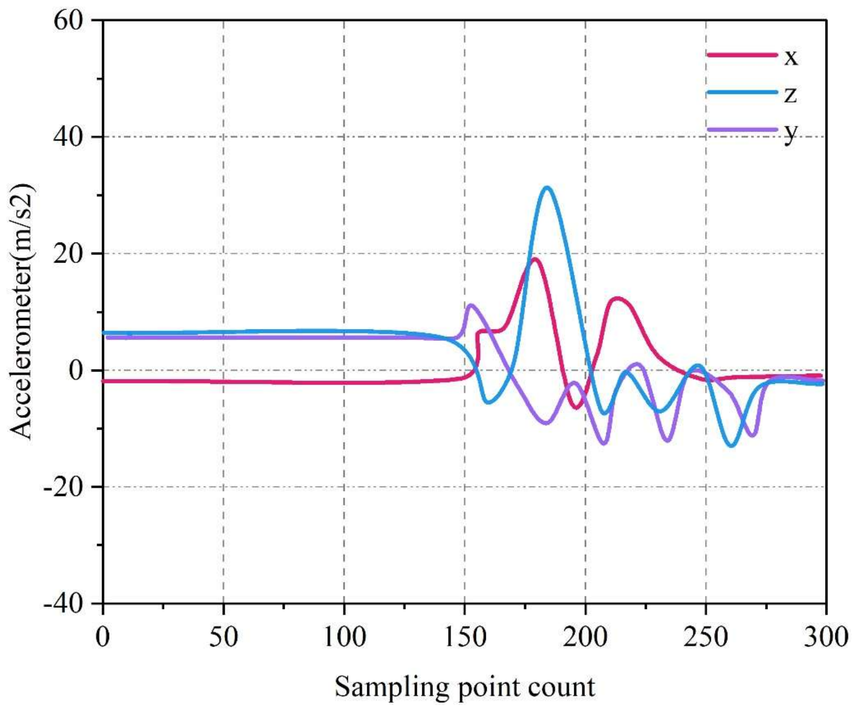

Fig. 6. The accelerometer output curve under a regular long run

5. Analysis of the results of sensitivity quality indicators in the experimental and control groups

5.1. Test of homogeneity of sensitivity quality indicators in the two groups before the experiment

In order to ensure the rationality and rigor of this experiment, homogeneity test was conducted on the experimental subjects' sensitivity quality indexes before the experiment, as shown in Table 4. The P-values of the hexagonal ball reaction test, hexagonal jump test, 20s side step test, 20s push-up test, closed-eye in-situ step test, and low center of gravity quadrangular running test are 0.506, 0.415, 0.627, 1.000, 0.847, and 0.613, respectively.There is no significant difference in the indexes of participating in the present experiment (P>0.05), and the experimental subjects' various sensitive quality test indexes are basically at the same level and can be carried out in subsequent experiments.

Table 4. Two groups of pre-measured sensitive quality indicators (n= 30)

Test index	Experimental group	Control group	T value	P value
Hexagon ball reaction test (min)	11.85±2.011	10.84±1.588	0.674	0.505
Hexagon jumping test (second)	14.36±0.425	14.49±0.318	-0.83	0.415
Second and second of the two years (one)	29.08±1.124	29.25±1.354	-0.492	0.627
The 20s bench test (one)	12.05±0.666	12.25±0.794	0.000	1.000
Standing time test (second)	6.94±2.012	6.80±1.695	0.195	0.847
Low center of gravity test (second)	18.84±2.195	19.22±1.831	-0.517	0.613

5.2. Comparative analysis of data before and after the experiment in the control group

The effect of routine sensitivity training on the subjects' sensitivity quality was explored by analyzing the data on the performance of the control group before and after the experiment in the hexagonal ball reaction test, hexagonal jump test, standing bench press test, repeated straddle test, closed-eye march in place, and low center of gravity quadrangular running test. After 12 weeks of routine sensitivity quality training, we can see that there is a significant improvement in the six data of the control group. According to Table 5, it was found that the P values of the scores of hexagonal ball reaction test, 20s standing push-up test, and 20s repeated straddle test were 0.001, 0.035, and 0.015, respectively, with $P < 0.05$, which were significant differences. The P-value of the improvement in the performance of hexagonal jump test, closed-eye march in place, and low center of gravity quadrangular run were 0.000, $P < 0.001$, with highly significant differences.

Table 5. Data t test before and after the control group(n=15)

Test index	Preexperiment	After the experiment	Rate of change/%	T value	P value
Hexagon ball reaction test (min)	10.84±1.588	11.72±1.374	8.11	-2.725	0.01
Hexagon jumping test (second)	14.49±0.318	13.94±0.274	3.80	10.512	0.000
Second and second of the two years (one)	29.25±1.354	29.67±0.987	1.44	-2.801	0.015
The 20s bench test (one)	12.25±0.794	12.48±0.514	1.88	-2.346	0.035
Standing time test (second)	6.80±1.695	7.73±1.505	13.68	-5.285	0.000
Low center of gravity test (second)	19.22±1.831	16.97±1.004	12.02	8.654	0.000

5.3. Comparative analysis of data before and after the experiment in the experimental group

The effect of variable speed running training on the subjects' sensitivity quality was explored by analyzing the data of the experimental group's scores in the hexagonal ball test, hexagonal jump test, standing bench press test, repeated straddle test, closed-eye in-situ step test, and low center of gravity quadrangular running test before and after the experiment. Table 6 shows the comparison of test scores of the experimental group before and after the experiment, after 12 weeks of training, the experimental group had significant improvement in 6 data. The P values of hexagonal ball reaction test, hexagonal jump test, 20s repeated straddle test, 20s stand-up push-up test, standing and standing in place with eyes closed, and low center of gravity quadrangular running were 0.001, 0.000, 0.000, 0.000, 0.000, and 0.000, respectively, which showed that the scientific and rational use of variable speed running training could effectively improve the agility of young badminton players, and verified Hypothesis 1.

Table 6. Data t test before and after the experimental group(n=15)

Test index	Preexperiment	After the experiment	Rate of change/%	T value	P value
Hexagon ball reaction test (min)	11.85±2.011	13.22±1.704	11.56	-4.725	0.001
Hexagon jumping test (second)	14.36±0.425	12.94±0.574	9.89	13.012	0.000
Second and second of the two years (one)	29.08±1.124	33.67±0.985	15.78	-21.801	0.000
The 20s bench test (one)	12.05±0.666	12.78±0.415	6.06	-4.345	0.000
Standing time test (second)	6.94±2.012	8.83±1.407	27.23	-5.785	0.000
Low center of gravity test (second)	18.84±2.195	16.77±1.454	10.98	6.254	0.000

5.4. Comparative Analysis of Post-Experimental Data of the Two Groups

Table 7 shows the results of the comparative analysis of the post-experimental data of the two groups, and the P-values of the Hexagonal Ball Reaction Test, Hexagonal Jump Test, 20s Side Step Test, 20s Standing Push-Up Test, Closed Eyes In-Place Test, and Low Center of Gravity Quadrangular Running Test were 0.020, 0.000, 0.000, 0.102, 0.041, and 0.445, respectively. Comparison results: the P value of hexagonal jump test and 20s repeated straddle test is less than 0.001, the P value of hexagonal ball reaction test and closed-eye in-situ step test is less than 0.05, all have significant difference. 20s push-up test and low center of gravity four-point running test have P value greater than 0.05, no significant difference. To summarize, conventional agility training has certain limitations, and the improvement is not as good as variable speed running training. Variable speed running training is composed of various forms of multi-directional movement graphic training, rope ladder training, small bar training, cone barrel training, weight training, etc. The young badminton players have a high degree of participation and enthusiasm in training, and they can easily control their own limbs, and the degree of completion of the movement and the degree of proficiency is higher than that of the control group, which shows that in the development of young badminton players' sensitivity qualities, the effect of variable speed running training is better than that of traditional sensitivity quality training. This shows that the effect of variable speed running training is better than that of traditional sensitivity training methods in the development of young badminton players, which verifies the hypothesis 2 of this paper.

Table 7. Two groups of pre-measured sensitive quality indicators (n= 30)

Test index	Experimental group	Control group	T value	P value
Hexagon ball reaction test (min)	13.22±1.704	11.72±1.374	2.115	0.020
Hexagon jumping test (second)	12.94±0.574	13.94±0.274	-5.534	0.000
Second and second of the two years (one)	33.67±0.985	29.67±0.987	8.442	0.000
The 20s bench test (one)	12.78±0.415	12.48±0.514	1.681	0.102
Standing time test (second)	8.83±1.407	7.73±1.505	2.114	0.041
Low center of gravity test (second)	16.77±1.454	16.97±1.004	-0.734	0.445

6. Conclusion

In this paper, a new network model RHPNet is proposed and used to carry out the running posture estimation of athletes in variable-speed running training, and the effectiveness of variable-speed running training on the impact of young badminton players' sensitivity qualities is explored.

The training time cost of LSTM network is higher than that of this paper's network model RHPNet, and the performance curve of this paper's network RHPNet is less difficult to converge, the recognition accuracy of this paper's network performs better than that of LSTM network, and the final recognition accuracy tends to be 0.83. Therefore, it can be concluded that this paper's multiresolution multi-scale network is more suitable to be used for the recognition of athletes' launching poses in the training of variable-speed running.

The P-values of the six items of agility indexes show that the training performance of the experimental group before and after the experiment have significant differences, which verifies the hypothesis 1 proposed in this paper, that is, the scientific and reasonable use of variable-speed running training can effectively improve the agility quality of young badminton players.

Comparative analysis of the data after the two groups of experiments showed that the P-value of the hexagonal jump test and 20s repeated straddle test scores was less than 0.001, and the P-value of the hexagonal ball reaction test and the closed-eye in-situ step test scores was less than 0.05, which were significantly different.The P-value of the 20s vertical push-up test and the low center of gravity four-point running test scores were 0.102 and 0.445, which were greater than 0.05, and there was no significant difference. It shows that the magnitude of the improvement of conventional agility training on the agility of junior badminton players is not as good as that of variable speed running training. It verifies the hypothesis 2 of this paper, that is, the effect of variable speed running training is better than the effect of conventional sensitivity training methods in developing the sensitivity quality of young badminton players.

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