Tropical coastal climate change based on image defogging algorithm and swimming rehabilitation training

Lijun Long 1 · Yanqing Fu 2 · Long Xiao 3

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Abstract
This paper first designs and implements an image defogging algorithm based on FPGA. The hardware design mainly includes SDRAM control module, SD card control module, data transmission control module, and convolution neural network calculation module. The SDRAM control module controls the working state of SDRAM; the SD card control module controls the working state of SD card; the data transmission control module controls the data transmission of reading and writing SDRAM; and the convolution neural network module is responsible for the image defogging algorithm. Based on this point, this paper uses the medium complex ocean atmosphere combination model to estimate the SST diversity and climate characteristics of the tropical coastal Pacific and Atlantic Ocean in recent years, and studies and analyzes the influencing factors of the prediction. The atmospheric part of the coupled model is the global atmospheric circulation model CCM3, and the oceanic part is a simplified gravity model of Zebiak Cane type. In addition, an air filter is added to the coupled model to test the impact of natural noise during broadcasting. Finally, the article investigated the positive effect of swimming rehabilitation training on chronic neck pain symptoms of office workers. Objectives were to study the effect of various swimming rehabilitation trainings on chronic neck pain symptoms of office workers and investigate the effect of different swimming rehabilitation training cycles on chronic neck pain symptoms of office workers. Objective was to provide a theoretical basis for the development of exercise rehabilitation plan to improve the chronic pain symptoms of office workers. The results showed that breaststroke training and freestyle training were effective in treating neck pain of office workers. In this paper, the application of adaptive image defogging algorithm and the correction of coastal climate change in the rehabilitation training research has promoted the healthy development and progress of swimming rehabilitation training.

Keywords
Image defogging algorithm · Tropical coast · Climate characteristics · Swimming rehabilitation training

Introduction
This paper first introduces the basic knowledge of convolutional neural network (CNN), and introduces two kinds of algorithm networks, dehazenet and AOD net, based on CNN in detail. Due to the influence of image input size, dehazenet cannot detect the global image information, and estimate the two parameters that may lead to reconstruction errors (Liang et al. 2016). AOD net algorithm adds the formula of atmospheric diffusion model in the network training process. CNN image defogging algorithm finally obtains the clear image after defogging through shape capture, shape merging, and partial learning input fog image (Morales et al. 2017). Then, the image defogging algorithm designed in this paper is compared with other defogging algorithms subjectively and objectively. The results show that the defogging effect of this algorithm is more significant. Based on this, this paper refines and improves the existing start-up research methods of some tropical coastal climate characteristics, and uses noise filters to minimize the impact of noise in the replication process (Neretnieks and Moreno 2003). The prediction results show that the improved model greatly improves the prediction ability of ENSO. The correlation coefficient of NINO3 index was 0.71 in...
the first 6 months and 0.43 in the first 12 months. The correlation coefficient of NINO3.4 index is 0.75 in the first 6 months and 0.49 in the last 12 months, which reaches the advanced level of ENSO. The predictability of the model for cold and warm ENSO events is much higher than that for conventional events, which can better understand and summarize the structure and trend of cold tongue temperature changes in El Niño and La Niña events (Nguyet and Goldscheider 2006). Therefore, this paper summarizes the function and influence of tropical coastal atmospheric noise filter, which can be used as a simple and effective method to improve the prediction performance of correlation model, and can be used in climate prediction and climate research. It is suggested that further correction of bias and improvement of assimilation method can improve the prediction level of ENSO. Finally, the article carried out a swimming rehabilitation training on the treatment of desk workers. A total of 20 subjects aged between 27 and 49 were recruited. The main symptoms are headache and neck pain, and the pain is recurrent (Obianyo 2019). For workers with a history of more than 3 months and a history of irregular exercise within 6 months, the subjects were randomly divided into breaststroke group and freestyle training group in 8 or 16 weeks of training (Seres-Pirole et al. 2012). The results show that swimming rehabilitation training can effectively improve the blood flow of office workers. After training, the maximum average blood flow to vertebral artery was lower than that before training, which indicated that the blood flow to vertebral artery was improved (Tahershamsi et al. 2018). Breaststroke training is better than freestyle training in terms of blood flow (Seres-Pirole et al. 2012). The assimilation method can improve the prediction level of ENSO. The predictability of the model for cold and warm ENSO events is much higher than that for conventional events, which makes it easier to activate and attenuate the gradient loss effectively. The expression is as follows:

$$ F_i(x) = \max_{p \in [1]} f(\mathbf{W}^1 \mathbf{g}^{1,i}(x) + \mathbf{B}^{1,i}) $$

After the fusion stage, the Relu function is used as the activation function. Compared with sigmoid and Tanh activation functions, the Relu activation function is linear and unsaturated, which makes it easier to activate and attenuate the gradient loss effectively. The expression is as follows:

$$ f(x) = \max(0, x) $$

therefore, the output characteristics of the convolution layer can be expressed as follows:

$$ F_{l-1}(Y) = f(W_l \times F_{l-1}(Y) + B_l) $$

Finally, two sets of $3 \times 3$ convolution kernel deepens the depth of the shape learning process model, improves the mapping ability of the nonlinear network, and estimates the fog-free image. The function of this feature is the same as that of the Relu function, so the feature map of the exit of the convolution layer is as follows:

$$ F_l(Y) = f(W_l \times F_{l-1}(Y) + B_l) $$

where $W_l$ is the convolution kernel of layer $l$, $B_l$ is the offset of layer $l$, $F_{l-1}(Y)$ is the output part of layer $l-1$ exit, and * is the convolution operation.

**Calculation of atmospheric apparent heat source $Q_1$ and apparent water vapor sink $Q_2$**

In order to reveal the cause of atmospheric temperature change and ascending and descending motion, the apparent heat source $\langle Q \rangle$ and apparent water vapor $\langle g \rangle$ are calculated; the calculation formula is as follows:

$$ \begin{align*}
Q_1 &= c_p \left( \frac{\partial T}{\partial t} + V \cdot \nabla T + \left( \frac{p}{\rho_0} \right)^\kappa \frac{\partial \theta}{\partial p} \right) \\
Q_2 &= -L \left( \frac{\partial q}{\partial t} + V \cdot \nabla q + \frac{\partial q}{\partial p} \right)
\end{align*} $$

**Materials and methods**

**Data source**

The materials used in this paper mainly include monthly SST data which are provided by Hadley Centre, UK, with horizontal resolution of $1 \times 1°$; NCEP/NCAR reanalysis monthly data provided by NCEP and NCAR; the horizontal resolution is $2.5° \times 2.5°$. It includes monthly mean wind field and vertical velocity of each layer, surface temperature data, surface pressure, air specific humidity, sensible heat change, latent heat dissipation, near ground light shift, and upper atmospheric luminous flux. The southern network points are Gauss grid points (Tan et al. 2016).

**Image defogging algorithm design**

The dehazing network proposed in this paper is a convolutional neural network composed of eight convolution layers (Zhang et al. 2020). There are only convolution layers in the network, and the shape of the output image of each convolution layer is the same as that of the input image. In order to ensure the same size of the input image, the global view is zero filled in the convolution process. The activation function of convolution layer function uses maxout, so that the output part of the first convolution layer can be expressed as follows:

$$ F_1(x) = \max_{p \in [1]} g^{1,i}(x) $$

$$ g^{1,i}(x) = W_1^{1,i} \times I + B_1^{1,i} $$

where $W_1$ is the convolution kernel of layer 1, $B_1$ is the offset of layer 1, $F_1(x)$ is the output part of layer 1 exit, and * is the convolution operation.
Swimming rehabilitation training effect research

A total of 20 subjects aged between 27 and 49 were recruited. The main symptoms are headache and neck pain, and the pain is recurrent. For workers with a history of more than 3 months and a history of irregular exercise within 6 months, the subjects were randomly divided into breaststroke group and freestyle training group in 8 or 16 weeks of training.

The 20 subjects were randomly divided into two groups by drawing lots: breaststroke group (n = 10) and freestyle group (n = 10); According to the training time, they were divided into 8-week breaststroke training group (3), 16-week breaststroke training group (3), 8-week freestyle training group (6), and 16-week freestyle training group (4). All the above are not empty control group, and the test data are shown in Table 1.

Table 1. Comparison of general information of subjects in each group

| Gender | Average age (unit: year) | Average weight (unit: kg) | Average course of disease (unit: month) |
|--------|--------------------------|---------------------------|---------------------------------------|
| Male   | 34.70±5.70               | 66.10±7.19                | 13.50±5.87                            |
| Female | 40.20±6.91               | 63.60±9.14                | 14.10±9.17                            |
| Male   | 30.00±2.65               | 72.00±4.36                | 10.00±3.46                            |
| Female | 39.0±6.25                | 66.50±7.19                | 14.25±6.65                            |

Results

Relationship between tropical ocean circulation and coastal climate change

In order to more directly describe the spatial distribution of the two types of SST anomalies and the corresponding circulation anomalies, the coincidence coefficient consistent with SST anomalies is given in Figure 1. If the IEM is in the positive phase, the SST in the tropical Pacific has a negative and positive structure. The center of thermal anomaly is located at 180° The center of cold anomaly is located at 130° E and 90° W. There are obvious anticyclone circulation anomalies in these two regions near. SST A is negatively correlated in most areas of the ocean (Fig. 1a). If the Lepn is in a positive phase, the SST dipole distribution of the tropical Pacific presents a “negative in the West and positive in the East” dipole distribution, and the center of the thermal anomaly is located at 100° W. The distribution of SST anomaly is located at 100° W. The distribution of SSTA in the ocean is also different under the condition of IEPN, i.e., “positive West negative East” (Fig. 1B). This variability has a specific impact on the SSTA safety description events in the tropical Pacific.

The mean vertical circulation in the equatorial region (5° S−5° N) is compared with IEM. IEPN has different characteristics (Fig. 2).

Different SST distribution models will produce different atmospheric pressure anomalies, and different atmospheric pressure anomalies will also affect SST distribution. This paper analyzes the relationship between the obvious abnormality of air heat source and SSTA EM and EPN transportation modes (Fig. 3). Since the distribution of water vapor in the tropics is consistent with the above figure, only the < Q1 > anomaly is analyzed here. The apparent heat source distribution and index show that if the LEM is in a positive phase, there is a significant positive correlation in some parts of the South China Sea, and its regional center is located at 160° W.
indicating that the air in this area is gradually heated. In addition, there is a significant negative zone connecting the South China Sea, southwest Sumatra, Banda, and Arafura seas, where the air is adiabatically cooled (Fig. 3a). If LM is in a positive phase (Fig. 3B), the sea level is still positive in the north and negative in the south. However, compared with EMI > 0, there is a significant positive correlation in the west east direction in the tropical Pacific, which corresponds to the anomalous circulation shown in Fig. 2b.

The coefficients related to the temperature anomaly at 2 m above the ground and IEM and IEPN also show significant differences between the oceanic continent and the Pacific. The spatial model of temperature anomaly above 2 m surface corresponding to EM index is “negative plus minus.” The two negative centers are located in the marine continental region and 90° W in the east of tropical Pacific; the positive center is located in the center of tropical Pacific, close to 165° W (Fig. 4a). The spatial distribution of EPN index of 2-m surface temperature anomaly corresponds to “negative positive” in the east of MC area, while negative anomaly is detected in the center from the east of tropical Pacific to the west of tropical Pacific (Fig. 4b). This distribution is consistent with that of SST anomaly.

**Prediction results analysis of tropical coastal climate change characteristics**

Figure 5 compares the anomalous correlation coefficients with the two experimental predictions and the overall observed typical OSH. The estimation results after eliminating the meteorological noise in the experiment are much better than those before the experiment, which shows that it has strong forecasting ability.

After understanding the forecast skill level of Atlantic tropical SST, the performance of different seasonal forecasts will be compared. Figure 6 shows the correlation coefficients between the predicted STA index and the observed anomalies starting at different times. First of all, the difference between this prediction and ENSO prediction is noticed, that is, the current prediction value of STA region is relatively low. In addition to the forecast that started in April, the current forecast dropped rapidly in the first 6 months.

It is necessary to continue to evaluate the impact of OSH forecasts on seasonal precipitation models after obtaining a high level of expertise in Osh forecasting. Figure 7 compares the relative skill of the control experiment and the noise filtering experiment with the rainfall forecast from March to May. Obviously, the effect of the noise filtering experiment is much
better than that of the precipitation prediction experiment in a certain area of Brazil.

Figure 8 shows the time-dependent variation of SST anomaly coefficients for filter air test, flux test, and control test, noise filter test, and continuous prediction and observation. This kind of experiment applies the same initial conditions, but the noise filter is applied to different variables, so the effect of noise filter can be obviously compared. As can be seen from Figure 8, although the noise filtering in the process of air pressure and heat dissipation can improve the prediction effect, it is obvious that the improvement effect of noise filtering is mainly for heat flux. Compared with the control experiment, there is no obvious improvement in the prediction technology of air pressure noise. Consistent with this result, it can be understood that noise filtering can increase the coupling and feedback effect between the heating surface of STA and SST, thus improving the prediction ability of SST. The noise caused by wind stress can affect the ocean dynamics through the SST changes affecting the response, but it plays a secondary role in the prediction of the region.

Through this experiment, we can test the upper prediction limit of the model under the assumption of “complete prediction of thermocline change.” Figure 9 compares the prediction methods of the “ideal thermocline” test (prediction I) and the noise filtering test (prediction b) with the NINO3 and STA indices. The “ideal thermocline” experiment shows that it can predict ENSO period very well for a long time, which means that the variation of thermocline depth plays an important role in ENSO prediction. In contrast, compared with the previous “ideal thermocline” STA test in the noise filtering experiment, its prediction skills are not improved, but decreased. The results emphasize that there are significant differences between the dynamic factors of STA and ENSO. The latter is controlled by sea-air coupling dynamic reaction mechanism, while the former is controlled by thermodynamic feedback.

Factors affecting the prediction results of climate change characteristics in tropical coastal areas

Figure 10 shows the comparison between the “ideal thermocline” experiment (prediction F-1, F-2) and the initial prediction experiment (prediction C). It can be seen that the model has high competitiveness in long-term prediction when the thermocline change is determined, which indicates that the model has a reasonable thermocline change SST mechanism; However, the SPB still exists even when the actual
Fig. 3  The distribution of correlation coefficients between the anomaly of atmospheric apparent heat source \(< 0\) and IEM (a) and IEPN (b) in summer.

Fig. 4  The distribution of correlation coefficient between temperature anomaly at 2 m above ground and index IEM (a) and IEPN (b) in summer.
The prediction skill of “ideal thermocline” noise filtering test (F-1 prediction) decreased significantly from April to May, and the overall coverage was wider. The “ideal thermocline” unfiltered noise test (F-2 prediction) shows that it is more seriously affected by SPB.

Then, the thermocline depth field is analyzed. Figure 11 shows the main modes of empirical orthogonal function (EOF) of internal heat dissipation of GFDL ODA in RGO model and the depth anomaly of simulated thermocline. Figure 11 b and c show the simulation results under different wind fields, and are observed for RGO and SST models. Figure 11 b uses ECWMF to observe the wind field and heat flux to drive the ocean model, while Figure 11 c uses ccm3-rgo coupling model, where the air and thermal conductance of the wind field are provided by the atmospheric model.

In order to study the influence of wind stress on ENSO simulation, the proposed ENSO model is compared with the wind ECMWF model and ccm3-rgo model (i.e., pressure variation coefficient) in Fig. 12, and it is found that there are obvious differences in this model. The maximum positive value of air pressure observed in ENSO region is in NINO3.4 region near the Pacific equatorial daily line, which reflects the warming effect of equatorial wind anomaly in Pacific ENSO. The negative regions outside the eastern Pacific and the equator are more vulnerable, and the NINO3 SST effect is only 1/3–1/4 in the positive region (Fig. 12a). In the simulated ENSO zonal wind stress, the area of the equatorial Pacific is smaller and the center moves eastward. Negative values also appear in the ITCZ region outside the equator, indicating that the east wind anomalies outside the equator and at the equator are more closely related to the ENSO thermal phase (Fig. 12b). In other words, if the ENSO phase is warm, the equatorial sea temperature of the eastern Pacific is positive, and the wind speed vector indicates a strong easterly wind.

Figure 13 shows the simulated calibration results in the g-1 test field. Compared with Figure 12, the model-corrected gas field output exceeds the excess wind
deflection to the east of ITCZ region (Figure 12b) and is compared with the observation field. The model is very similar to the observation field (Fig. 12a), and the variation amplitude is relatively small.

Figure 14 shows the first two main EOF modes of the simulated anomalous thermocline in the adjoint mode after air field correction. Compared with Figure 11, the simulated thermocline without correction (Figure 12b) is closer to the observed characteristics (Figure 12a). The first EOF-corrected eigenvector thermocline field method shows the East-West inverse variation, and the variance contribution is 47.7%. The second method changes the East-West trend, and the variance contribution is 18.3%. Therefore, the correction of MOS in wind field needs additional adjustment.

**Swimming rehabilitation training effect analysis**

Table 2 shows ROM evaluation results of joint range of motion before and after training in 8-week breaststroke group and 8-week freestyle group.
There was no significant difference in neck joint range of motion between breaststroke group and freestyle group after training ($P > 0.05$); There was no significant difference in ROM between breaststroke group and freestyle group after training and their own neck joints, $P > 0.05$.

Results: the average blood flow rate of right vertebral artery in breaststroke group was significantly different from that in freestyle group after training, $P < 0.05$, and the average blood flow rate in breaststroke group was lower than that in freestyle group after training.

Table 3 shows the test results of each index of breaststroke group before and after 16-week training.

The test results of each index before and after 16-week training in freestyle group are shown in Table 4.

Discussion

The influence of swimming rehabilitation training on joint range of motion

In this study, two styles of breaststroke and freestyle were selected. The effects of these two swimming postures on neck,
shoulder, and arm muscles are different, especially in breathing and stroke. First of all, breaststroke is the slowest of all swimming methods. This method uses lift breathing, bending legs to produce propulsion; breaststroke is the most labor-saving of the four swimming methods. During swimming, the only part related to neck movement is the process of breathing (Baazi et al. 2020). The ratio of breathing to kicking is not 1:1. In order to save energy, the rhythm is usually 2–3 times, and the breathing between kicking is once. Therefore, the neck is static most of the time, and the impact on neck joint.

**Fig. 10** Variation of correlation coefficient of Nino3 index anomaly with forecast lead time

**Fig. 11**

- **a** Upper layer heat content of GFDL ODA.
- **b** The first two EOF modes and time coefficients of the thermocline depth $h$ anomaly simulated by wind-driven RGO.
- **c** CCM3-RGO coupling were observed

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activity is low. Secondly, compared with breaststroke, freestyle consumes more energy on the body, and its forward speed is also the fastest. It is necessary to use both feet to draw water quickly to obtain the initial force, and at the same time, it is necessary to use the same hand to draw water alternately (Bailey et al. 2013). The way of breathing is to rotate to the left or right. Skilled swimmers often only use the same direction for breathing, and the breathing rhythm is the same as breaststroke. Freestyle, due to the changing position of legs and hands, the body is in a high position in the water, and the body undulation is small, so that the spine remains in a stable position (Chen 2014). Therefore, breaststroke and freestyle exercise the deep stability of the spine to a certain extent, so in this experiment, the range of motion may not change.

Although some domestic literatures have reported that neck pain intervention can increase joint range of motion after intervention, this intervention is based on common exercise methods, such as aerobics, Taijiquan, and coordinated flexible exercise (Dewaide et al. 2016). The sample is small and concentrated, so it is not representative. In view of the small number of subjects in the 16-week training group in this study, it is impossible to determine the effect of exercise intervention on joint mobility, so more research is needed.

Fig. 12  a ECMWF  b Regression coefficient of wind stress simulated by CCM3-RGO to observed NINO3 index

Fig. 13  a Latitude after MOS correction simulated by CCM3-RGO. b Regression coefficient of meridional wind stress (test g-1) to observed NINO3 index
Effect of swimming rehabilitation training on neck dysfunction index

The results showed that there was no significant difference in the neck joint activity before and after the training, no matter 8 weeks or 16 weeks of training, breaststroke training, or freestyle training. If the 10 elements of neck function index (NDI) were compared longitudinally, the scores of pain intensity, headache, and sleep were higher before training, but most of the subjects showed a downward trend after training (Elbaz et al. 2018).

The subjects recruited in this study were all patients with neck pain grades I–II. In the disability index statistical table, only one subject’s disability level was in the middle, the disability index was 22%, and the other 19 subjects’ disability index was lower than 20%. Due to the small fluctuation of data, it is necessary to further expand the sample and test population to observe the progress of obstacle improvement.

The effect of swimming rehabilitation training on the number level of pain

NRS is a simple and convenient method widely used in clinical research to evaluate the disease degree of patients, and its effectiveness and reliability have been widely proved.

The training used in this study is a way of training in the water so the subjects will touch and rub the water. It can be seen from previous studies that contact and friction can bring certain massage and relaxation effects to skin and body. In addition, due to the specific temperature changes between water temperature, room temperature, and body temperature, the human body needs a certain degree of heating and heat dissipation to keep the body temperature constant (Estabragh et al. 2014). The self-regulation ability of body temperature depends on the skin, muscle, and blood vessels to a certain extent. Through the regulation mechanism of microcirculation, it can speed up the metabolism of the body, relieve skin and muscle tension, promote muscle relaxation, and

Table 2. The results of joint range of motion of breaststroke group and freestyle group before and after training for 8 weeks

|                      | Breaststroke group (n=10) | Freestyle group (n=10) |
|-----------------------|---------------------------|------------------------|
|                       | 0 week        | 8 weeks   | 0 week       | 8 weeks   |
| Bend forward          | 46.90±8.05    | 43.60±10.07 | 46.80±8.08   | 46.80±9.14 |
| Back stretch          | 60.10±10.04   | 71.10±14.37 | 68.20±11.93  | 64.10±14.11 |
| Lean to the left      | 40.00±2.71    | 39.60±7.63  | 35.00±7.51   | 32.80±9.60  |
| Lean to the right     | 39.80±4.05    | 40.40±6.83  | 35.40±5.44   | 34.30±6.78  |
| Rotate to the left    | 64.10±10.19   | 56.70±7.39  | 60.50±10.24  | 60.10±13.44 |
| Rotate to the right   | 61.70±9.04    | 64.80±9.75  | 61.80±8.53   | 61.90±11.54 |
further reduce neck pain. Research shows that participation in sports has an impact on the effect of pain intervention. Higher participation has a positive impact on pain, but long-term randomized clinical trials may reduce exercise participation, and the effect of pain intervention may be lower than expected. Different training cycles have different intervention effects on neck pain.

In this study, no matter breaststroke or freestyle, no matter 8-week training, or 16-week training, there were significant differences in NRS index ($P < 0.05$), and the NRS score decreased significantly after training, indicating that different styles of swimming training have obvious effect on the treatment of neck pain. After a long period of training, breaststroke is still effective in relieving neck pain. After 16 weeks of training, there was a significant difference in NRS between before and after training ($P < 0.05$), and there was a very significant difference between 8 weeks of training and before training ($P < 0.01$). There was no significant difference between 16-week training and 8-week training. This result may be due to the self-body adjustment of the subjects, reducing the neck pain, so there is no obvious change between them. Therefore, for beginners and patients with severe pain, it is recommended to choose breaststroke as contact stroke. If the physical fitness of the subjects has reached a certain standard, they should choose more intense freestyle, which is in line with the principle of gradual movement.

Whether it is 8 weeks of training or 16 weeks of training, breaststroke training or freestyle training, can be used as the treatment of neck pain exercise intervention method. However, considering that the subjects in this study are in the non-acute stage of neck pain, we should find relevant supporting materials and appropriate examination and evaluation before exercise intervention in clinical practice (Goldscheider et al. 2008).

| Table 3 | Results of index test before and after 16-week training
| breaststroke group |
|-------------------|--------|--------|
|                  | 0 weeks | 8 weeks | 16 weeks |
| Bend forward      | 45.67±4.04 | 44.67±5.03 | 36.67±10.41 |
| Back stretch      | 57.33±15.53 | 76.00±6.93 | 54.00±12.17 |
| Lean to the left  | 41.33±1.15 | 47.33±1.53* | 34.67±5.03 |
| Lean to the right | 37.67±6.81 | 40.67±6.03 | 30.00±7.21 |
| Rotate to the left| 59.67±4.33 | 63.00±1.53 | 56.33±6.33 |
| Rotate to the right| 55.00±2.88 | 67.00±2.00 | 55.67±8.10 |
| NDI               | 8.00±10.58 | 7.33±0.95 | 8.67±13.31 |
| LVm (cm/s)        | 54.67±9.29 | 42.67±6.11 | 38.00±4.16 |
| RVm (cm/s)        | 50.00±18.36 | 47.00±5.29 | 50.33±5.77 |
| NRS (points)      | 3.33±1.53* | 2.33±1.53* | 0.00±1.00*  |
| Muscle endurance (s)| 117.33±124.34 | 116.66±33.70 | 77±34.77 |

| Table 4 | Results of index test before and after 16-week training
| freestyle group |
|----------------|--------|--------|
|                  | 0 weeks | 8 weeks | 16 weeks |
| Bend forward      | 50.50±7.37 | 44.00±14.17 | 51.75±6.24 |
| Back stretch      | 75.75±11.79 | 62.50±11.90* | 58.50±6.03 |
| Lean to the left  | 35.75±10.90 | 29.75±11.32 | 29.75±3.69 |
| Lean to the right | 38.50±3.87 | 34.75±4.99 | 32.00±2.45* |
| Rotate to the left| 69.00±7.39 | 53.25±10.93 | 52.25±13.96 |
| Rotate to the right| 54.50±10.66 | 57.25±8.38 | 55.00±13.64 |
| NDI               | 6.50±7.56 | 5.50±6.40 | 3.00±3.46 |
| LVm (cm/s)        | 45.50±10.60 | 44.00±12.11 | 42.50±11.70 |
| RVm (cm/s)        | 52.25±6.70 | 45.50±3.11 | 46.75±6.95 |
| NRS (points)      | 3.50±1.29 | 2.25±1.71 | 1.50±1.29 |
| Muscle endurance (s)| 106.50±72.96 | 100.92±39.95 | 57.10±22.50 |
The influence of swimming rehabilitation training on vertebral pulse blood flow

In this study, there was a significant difference in the maximum blood flow of left vertebral artery between breaststroke training for 8 weeks and breaststroke training for 16 weeks. Compared with before training, the maximum mean blood flow to vertebral artery decreased. Especially after 8 weeks of training, breaststroke compared with freestyle, vertebral artery blood flow is much lower than freestyle. The above results show that swimming training can affect the blood status of neck; breaststroke training can help to improve the blood flow status of neck. And there is no significant difference between 8-week training and before training (Huan et al. 2015). After 16 weeks of training, the maximum average blood flow to vertebral artery was much lower than that before training. Therefore, the improvement effect of 16-week exercise is more obvious than that of 8-week exercise. The reason for this result may be related to the flow path of vertebral artery in the neck. According to the anatomical position, the vertebral artery starts from the subclavian artery, passes through the foramen magnum, and enters the cranial cavity through the transverse foramen at the height of the sixth cervical vertebra. The basilar artery was formed between the inferior edge of pons and the other side of vertebral artery. The first part of the vertebral artery rises backward between the longus cervicis and the anterior scalenus, and enters the inferior thyroid artery after the common carotid artery and the vertebral vein. The velocity of vertebral artery is closely related to the tension of surrounding tissue. In breaststroke training, because it is necessary to raise the head to inhale and exhale, the muscles that complete the head movement exert force, and the antagonistic muscles act on the superficial muscles of the head and neck (sternocleidomastoid muscle, scalene muscle, trapezius muscle, etc.) and the deep muscles (longus cervicis, longus capitis, anterior rectus capitis, lateral rectus capitis, posterior occipital muscle, suboccipital muscle, etc.). It includes muscle tension relaxation and continuous relaxation caused by continuous head movement, which can activate relatively weak muscle groups and relieve tension when tightening muscle group joints. Similar to the initiation process of proprioceptive neuromuscular rehabilitation therapy, it can also be realized in swimming training (Hussain and Abed 2019). During the training, the head of the subjects is in a relatively neutral position, which is different from the head position when they work on the table. At this point, the deep muscles of the spine are more active to maintain posture stability, while the superficial muscles are relaxed. In addition, the skin gets the effect of water massage, leading to the skin fascia also has a relaxing effect, so to a certain extent, it can promote blood circulation and make blood flow to the neck.

Effect of swimming rehabilitation training on neck endurance

In this study, whether breaststroke or freestyle, whether 8-week training or 16 week training, there was no significant difference in neck extensor strength between or within groups. Different from the results of muscle strength or endurance improvement in previous studies at home and abroad, this result may be due to the fact that the subjects will continue to work at desk for a long time in the office in addition to swimming training for two consecutive times. It is well known that the body needs time to rest after fatigue, to recover or over recover. However, people who work at the desk for a long time in the office keep the same body posture every day, and the posture will not change or adjust with the passage of time, resulting in the aggravation of muscle fatigue. When the body gives work instructions, it often does not reach the proper posture level, resulting in physical discomfort, leading to more and more serious pain (Khosronejad et al. 2016). Therefore, in work, rest is necessary.

In swimming training, even though the physical properties of water can make the body relaxed, and aerobic exercise can improve the subjects’ cardiopulmonary activities and physical fitness, swimming needs the coordination of the whole body posture. In breaststroke, the legs carry the main function of driving force. In the process of learning and using the action mode, if the subjects use the wrong force or the action range is not in place, when swimming, if the leg force mode is not correct or the strength is insufficient, the arm, shoulder, back, and even head can be used to compensate for the forward movement. Long-time local tissue compensation will lead to other problems, which leads to the need for more physical support in the process of swimming training. In breaststroke, the subjects rely on their arms to gather strength to paddle, and the arm muscles and neck muscles are closely connected through the skin fascia. If the body does not relax and recover in time after training, the body will accumulate fatigue. After a period of training, the body of the subjects has adapted to the characteristics of water, and the massage relaxation effect of water cannot reach the initial level, resulting in no significant difference in muscle endurance. In this study, in order to minimize the experimental error, the 8-week training plan was the same as the 16 week training plan. But the relaxation plan after training is not strengthened, so it is easy to lead to the accumulation of fatigue, which leads to the decline of muscle endurance. This is in line with the need to improve the rehabilitation plan in the process of rehabilitation. We need to adjust the rehabilitation training plan according to the changes of the subject’s body during the disease, based on different seasons and combined with the different states of the subject (Koestel and Larsbo 2014). After reaching a certain degree or certain conditions, we can adjust the rehabilitation treatment plan according to the situation of the subject.
Conclusion

In this paper, the ENSOEP index is defined according to the ENSO Modoki index proposed by Ashok et al., and the newly defined EMI index is used to calculate CP and EPENSO index. According to the research results of Kao and Yu, the IOBM of the Indian Ocean is simulated, and the previous ENSO signal is filtered to obtain the updated IOBM index. The relationship between the northern hemisphere IOBM and the summer climate anomaly in MC area is studied to explore the possible mechanism. Finally, the paper makes a part of research on swimming rehabilitation training. Research shows that the sense of participation in sports has a significant impact on pain intervention. Higher participation has a positive impact on pain intervention, but longer randomized trials reduce participation in exercise, resulting in the effect of pain intervention may not be as expected. In this study, the subjects are not allowed to carry out other long-term swimming training and other sports activities and treatments in the process of the experiment, which will affect the participation enthusiasm of the participants, thus affecting the experimental results to a certain extent. At the same time, according to the analysis of breaststroke and freestyle, it is best to keep the head in a neutral position when swimming, but in the neck endurance test, the head should be tilted back as far as possible, and exert force in different positions to activate muscle fibers. There may be differences between different subjects, which will also affect the judgment of whether swimming training can improve neck muscle strength. No matter what the reason is, the neck endurance of the subjects is not significantly improved or even decreased, which is worthy of further investigation.

Declarations

Conflict of interest The authors declare no competing interests.

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