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Research Article

A Neural Network Model for the Correlation between Sprinters' Pre-competition Anxiety and Competition Performance

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Abstract: Sprint is an important sporting event in track and field competition, in which, athletes' pre-competition anxiety will greatly affect them in bringing into play their competence, which will then influence their final performance in the competition. For this reason, to study the correlation between sprinters' pre-competition anxiety and their competition performance is of great significance in predicting athletes' performance under difference anxiety state. After having analyzed domestic and foreign research achievements related with sport anxiety and sport performance, the study further applied CSAI-2 (1994) questionnaire to investigate athletes' anxiety in sprint competition of a university sports meeting in Changsha. Moreover, based on neural network model, the study also constructed related models concerning athletes' pre-competition anxiety and their competition performance. In addition, related curves concerning athletes' pre-competition anxiety and specific performance are also formulated.

Keywords: Correlation, neural network model, pre-competition anxiety, specific anxiety, sprinter

INTRODUCTION

Track and field competition has always been regarded as "mother of sports", for it is the foundation for the other sporting events (John and Paul, 1993). What's more, sprint is a fundamental event in track and field sports, with very significant meaning and role to the training of other sporting events (Mangan, 2009) Sprint is one of the oldest sporting competition events. In competitive sports, the sport level of a country's sprinter can event represents its development level in track and field sports (Malliaropoulos *et al*., 2006). Sprint belongs to stamina explosive competition. Before the competition, athletes' mental state will greatly affect their stamina explosion, which will then influence the final competition performance. Good and positive psychological states are helpful for athletes to outdo their normal competence, so as to take on very strong explosive force. By contrast, the psychological state of anxiety could affect the normal bringing into play of athletes' competence, leading to unsatisfying result (Hanton *et al*., 2004). The correlation between athletes' pre-competition anxiety and performance is being widely studied by Chinese sports researchers in recent years (Yi-Chieh and Tsung-Min, 2010). Many domestic scholars have conducted explorations with different methods and from different aspects. By drawing support from document literature method and psychological scale measurement method, Zhao (2012) has studied the interrelation between competitors' competition anxiety and their performance in martial arts competition of China's National Games. With the Sport Competition Anxiety Investigation Form (CSAI-2) compiled by Fu (1997, 1999) has conducted a series of researches concerning the relationship between Chinese university athletes' pre-competition anxiety and competition performance, as well as the correlativity between high-level athletes' pre-competition anxiety and competition performance (Fu, 1997, 1999). Gao (2010) applied CSAI-2 Questionnaire to survey university racers' anxiety in heel-and-toe walking race. On this basis, she studied the correlation between anxiety state and sport performance. These researches generally adopt the form of anxiety questionnaire, which have collected plenty of valuable data. However, none of them have adopted the mature correlativity model, so that the result obtained is inadequate to construct the function for quantizing athletes' pre-competition anxiety and competition performance. Based on neural network model, Yuan (2008) further researched the relation between the world's outstanding male high jumpers' physical quality and their specific performance, as well as the functional relation between athletes' physical quality, training level and their specific performance (Yuan, 2008). Moreover, he also drew the correlation curve between quality training level and specific performance, which provided reference for further

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researches concerning the relationship between athletes' pre-competition anxiety and their specific performance. With the aforementioned literatures as the basis, by applying CSAI-2 Questionnaire (Zhu, 1994) and by drawing support from neural network model, the study quantitatively analyzed the correlation between sprinters' pre-competition anxiety and their sport performance. The research obtained is helpful to sprinters, in keeping a good pre-competition psychological state, as well as in scientifically training athletes' psychological quality.

SPORT ANXIETY

Anxiety refers to a sort of nervous and fear emotion formed by frustration of self-esteem and self-confidence, or increasing of the sense of failure and guilty, which is resulted by the threat from being unable to achieve goals or to overcome obstacles (Akbar *et al*., 2011). Normally, anxiety emerged in sports is called sport anxiety. This term is designed to describe athletes' worries or the tendency to worry about current or predicted possible threats in trainings and competitions (Annemarie and Roland, 2011).

Sport anxiety can be divided as cognitive state anxiety, body state anxiety and state self-confidence.

- Cognitive state anxiety refers to athletes' subjective worries on the danger or threat from a certain entity that they consider to be unidentified in competition or before competition. Such anxiety is mainly caused by athletes' unconfident about their ability, or athletes' negative reaction and expectation on competition result. Normally, it is reflected by worrying about failure, fearing of low ability, so as to do negative self-hint in sub-consciousness.
- Body state anxiety refers to athletes' abnormal feeling about the reaction of their nerve system in competition, before competition or even after competition. As for this, they may subjectively consider one organ or one part of their body is abnormal. For example, compared with ordinary state, athletes may involuntarily increase their breath frequency, with cold hands and feet, as well as wet palm. Some of them may even feel ill in their stomach, leading to vomit and other symptoms.
- State self-confidence refers to athletes' un-confidence about their state in competition or before competition. Under normal state, their may become obviously unconfident about themselves, distrusting their eyesight, easily giving up the competition, or being of low fighting-will in competition.

Although sport anxiety is a reaction of human body, there are still many ways to measure sport anxiety. Normally, athletes are required to narrate (rating scale method) the anxieties they are aware of. Such cognation reaction based measurement method would firstly compile a standard questionnaire and then test the reliability and validity of the question with psychological measurement method. Questionnaires for measuring anxiety are comprised by trait anxiety measurement scale, including Taylor's Manifest Anxiety Scale (MAS), Spielberg's State-Trait Anxiety Inventory (STAI) and Martens' Sports Competition Anxiety Scale (SCAI); state anxiety measurement scale, including Taylor's Activation Deactivation-Adjective Check List (AD-ACL), Spielberg's State Anxiety Inventory, Martens' Competitive State Anxiety Inventory-II (CSAI-II), as well as SR Anxiety Questionnaire in basketball context.

Measuring the changing of anxiety level via questionnaire is actually conducting evaluation through the two dimensionalities of cognation change and physiological reaction. Its advantages: it is fast and easy for implementation and is easy for analysis, with open-and-shut result. Its disadvantages: the method is easily affected by sample size. As for this, larger sample size is a necessity to complement its validity. This in return increases the testing difficulty in sports teams or smaller sports groups. Another disadvantage is that, it may be affected by some expectation effect in society. For example, athletes may complete the questionnaire following the coach's intention, or coaches and athletes may take non-cooperative or perfunctory actions to disguise athletes' practical anxiety level, which will inevitably influence the validity and reliability of the survey.

NEURAL NETWORK

Neural network has no unified definition. Its normally definition goes like this: artificial neural network refers to a sort of wide and parallel-connected network comprised by simple units with adaptability (Qingsong *et al*., 2012). Its organization enables it to simulate biological nerve system's interactive reaction to the real material world. Its structure and working principle are actual the abstraction of human nerve's learning process, based on human's nerve structure (Li *et al*., 2011). Accurately speaking, it is a mathematic model for distributive and parallel information processing, by simulating the behavioral features of animals' neural network. Relying on the complexity of system and by adjusting the interconnected relation among large amounts of internal nodes, such network can realize the function of information processing. Artificial neural network has self-learning and self-adaptive ability (Xuefei and Chen, 2012). As for this, based on a group of mutually-matched input-output data, it may analyze the potential rules among the two parties, so as to master these rules and to predict the output result with newly input data. The basic model of neural network is comprised by artificial neuron model and network model (Yasser and Nora, 2012).

Artificial neuron model: The universal model of neuron is demonstrated in Fig. 1. In the diagram, P1, P2, P3 are the input data, while α is the output, so that a stands for the summation of P1, P2, P3, as is shown in Formula 1:

$$a = f(\sum_{i}^{\Re} WiPi - \theta) \quad (1)$$

Network model: According to the feedback direction of input and output, artificial neural network can be divided into feed-forward network and feedback network. Feed-forward network is function mapping, mainly used in functional approximation and mode identification. In the analysis for figuring out the correlation, multi-layered forward network is often adopted to construct the input-output relation between objects (Mantzaris *et al*., 2011), which can be described as follows:

$$net_{i,k} = \sum_{j=1} W_{i,j,k} O_{j,k-1} - \theta_{i,k} \quad (2)$$
$$O_{j,k} = f(net_{i,k})$$

The frequently applied response functions include:

- **Threshold unit:**

$$\sigma(s) = \begin{cases} 1 & s \geq 0 \\ 0 & s < 0 \end{cases} \quad (3)$$

- **Linear unit:**

$$y = \sigma(s) = s \quad (4)$$

- **Nonlinear unit is sigmoid function:**

$$\sigma(s) = \frac{1}{1+e^{-s}} \quad (5)$$
$$\sigma(s) = \tanh(\beta s)$$

In the formula,

$O_{j,k}$ = The output of Neuron i in the layer of k
$net_{i,k}$ = The corresponding input
$W_{i,j,k}$ = The link weight
$\theta_{i,k}$ = The threshold value
$f(net_{i,k})$ = The response function, which is normally linear function or sigmoid function

BP neural network: When having constructed the above network model, neural network learning shall then be performed (Hojjat and Ashif, 2009). What's more, the most important learning algorithm is error back propagation, i.e. the so-called BP algorithm. It is actually a multi-layered network that has generalized the rules of W-H learning, so as to conduct weighted training over nonlinear differentiable function (Chauhan *et al*., 2009). BP network has four features:

- Parallel relation between input and output of the model
- In the input and output of computation network, there is normally no fixed method for computation of weighted value
- The intelligence of network will increase along with learning
- The hidden layer of network can improve the simulation accuracy of network. More hidden layers lead to high precision degree.

When the input and output of network is limited between 0 and 1, there has to be S-typed activation function in the output layer. Under normal situation, S-typed activation function is often adopted by hidden layers, while linear activation function is normally applied in output layers.

The most frequently used learning method in BP neural network is supervised learning method, with processes shown in Fig. 2:

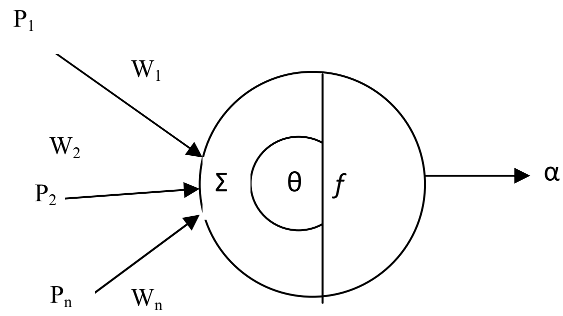

Fig. 1: Universal artificial neuron model (1)

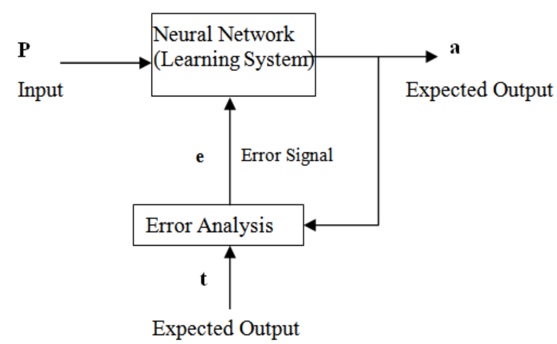

Fig. 2: Supervised learning

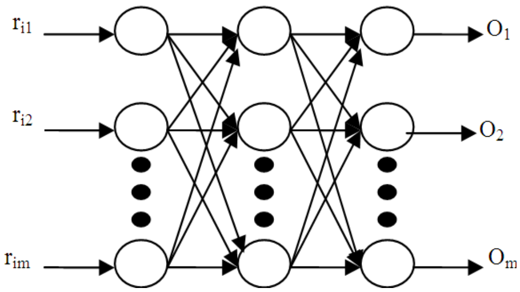

Fig. 3: Multi-layered BP network

Multi-layered BP network: Multi-layered BP Network refers to neural networks with three or more than three layers (Du, 2010). Each layer is comprised by many neurons, as is shown in Fig. 1 and 2. In multi-layered neural network, left and right neurons are interconnected. However, there is no connection relation between upper and lower neurons, as is shown in Fig. 3.

The messaging method of BP network is supervised learning method, i.e., learning method with teachers. Neural information is transmitted via input layer-middle layer-output layer. The output layer responds according to neurons' corresponding input mode (Daniel *et al*., 2006). As BP network transmits layer by layer, so that it is habitually referred to as error back propagation training. With this mode being continued, the network's response accuracy to input mode will also be improved gradually. The middle position is the hidden layer of BP network. As for this, through continual learning, BP network can also identify nonlinear modes.

The general algorithm of BP neural network would firstly establish a random network with n nodes, while the feature of each node is of the sigmoid type (Mohamed, 2012). Appoint the network with only one output y and the output of any node i is O_i. Assuming that there is N samples (x_k, y_k) (k = 1, 2, 3,…, N), for a certain input x_k, the network output shall be y_k and the output for node i shall be O_{ik}. The output of node j shall be the function demonstrated in Formula 2. Based on Formula 3, we are to define $E_k = (yk\ yk)^2$ and $O_{jk} = f(net_{jk})$, so that for a certain input x_k, the corresponding network output capacity shall be y_k. The output of node i is O_{ik} and the input of node j shall be:

$$net_{jk} = \sum_i W_{ij} Q_{ik} \tag{6}$$

Defining the error function to be:

$$E = \frac{1}{2}\sum_{k=1}^{N}(y_k - y_k)^2 \tag{7}$$

In the above equation, y_k is the practical output of the network; defining that:

$$E_k = (y_k - y_k)^2,\ \delta_{jk} = \frac{\partial E_k}{\partial net_{jk}} \text{ and } O_{jk} = f(net_{jk}) \tag{8}$$

Hereby,

$$\frac{\partial E_k}{\partial W_{ij}} = \frac{\partial E_k}{\partial net_{jk}} * \frac{\partial net_k}{\partial W_{ij}} = \frac{\partial E_k}{\partial net_{jk}} * O_{jk} = \delta_{jk} O_{ik} \tag{9}$$

When j is the output node, $O_{jk} = \hat{y}k$, so that:

$$\delta_{jk} = \frac{\partial E_k}{\partial \hat{y}_k} * \frac{\partial \hat{y}_k}{\partial net_k} = -(y_k - \hat{y}_k) f'(net_{jk}) \tag{10}$$

If j is not the output node, then:

$$\delta_{jk} = \frac{\partial E_k}{\partial net_{jk}} = \frac{\partial E_k}{\partial O_{jk}} \frac{\partial O_{jk}}{\partial net_{jk}} = \frac{\partial E_k}{\partial O_{jk}} f'(net_{jk}) \tag{11}$$

$$\frac{\partial E_k}{\partial O_{jk}} = \sum_m \frac{\partial E_k}{\partial net_{jk}} \frac{\partial net_{mk}}{\partial O_{jk}} = \sum_m \frac{\partial E_k}{\partial net_{jk}} \frac{\partial}{\partial O_{jk}} \sum_i W_{mi} O_{ik} = \sum_m \frac{\partial E_k}{\partial net_{mk}} \sum_i W_{mj} = \sum_m \delta_{mk} W_{mj} \tag{12}$$

Thus,

$$\begin{cases} \delta_{jk} = f(net_{jk}) \sum_m \delta_{mk} W_{mj} \\ \dfrac{\partial E_k}{\partial W_{ij}} = \delta_{mk} O_{ik} \end{cases} \tag{13}$$

RESEARCH OBJECT AND METHOD

Research object: The research objects were selected from track athletes participated in the competitions of men's 100 m, 200 and 400 m, respectively in sports meeting of 2011 that hosted by an unnamed university in Changsha. The questionnaire adopted is China Norm Scale (CSAI-2) revised by Zhu (1994) according to Sport Anxiety Scale compiled by Martens from the US University of Illinois. The major surveying contents in the measurement scale are cognitive scale anxiety, body state anxiety and state self-confidence, totally 27 questions, with 4 score for each question. Two weeks before the sports meeting, 10 randomly extracted athletes from three events who had been primarily chosen by their departments were arranged to undergo two psychological inspections. Furthermore, during the sports meeting, the performances of these athletes were recorded as well.

Research method: By analyzing the collected data, the neural network model for the correlation between sprinters' three pre-competition presentations (cognitive state anxiety, body state anxiety and state self-confidence) and their specific performance was constructed. The correlation between the two parties was figured out, with corresponding correlation curves formulated.

CONSTRUCTION OF NEURAL NETWORK MODEL

According to the construction procedures of ordinary neural network model, the neural network model constructed in this study was implemented via two steps: the first step is to determine the structure of neural network mode; the second step is to learn sprinters' pre-competition anxiety training samples with dynamic back propagation algorithm, so as to figure out the final connection weight between pre-competition anxiety and specific performance.

Neural network structure: The structure of neural network model adopted in this study is shown in Table 1.

Sigmoid function is adopted to be the transfer function of neurons in hidden layers, while linear function is used to output transfer function of neuron. The correlation degree and correlation coefficient between three presentations and specific performance are shown in Table 2.

Neural network learning: The three presentations from three different sprint events are taken as the training samples. Please see Table 3 for the data of training samples. In the table, the input samples are of one-point system, higher points lead to lower anxiety. The final data is the athletes' average score. The final performance is the average score of 100 m for all athletes, with the unit of s, while the order numbers 1-3 separate represents 100, 200 and 400 m, respectively.

After having been normalized, the above data will then be learned via the neural network tool in MATLAB and with dynamic back propagation algorithm. After learning 1.26S, the dynamic learning process curve for dynamic back propagation algorithm is figured out, as is shown in Fig. 4:

In the meanwhile, the connection weight table in construction of the neural network model is formulated, as is shown in Table 4.

Neural network fitting precision analysis: By comparing the result predicted via the model for the correlation between athletes' pre-competition anxiety and their performance with the practical result obtained after the competition, we will be able to get the correlation between practical result and predicted result, shown in Table 5.

By performing error analysis on the prediction result, it can be seen that, the error rate between predicted performance and practical performance is lower than 3%, indicating that the correlation between athletes' pre-competition anxiety and their specific performance predicted via neural network based analysis is reliable. Compared with the sport performance under normal state, cognitive state anxiety, body state anxiety and insufficient state self-confidence can all affect athletes in fully bringing into play their normal level. Higher anxiety degree leads to lower performance. Moreover, by comparing the predicted performance and the practical performance in their 3rd item, we may also find that, under a certain anxiety

Table 1: Neural network structure

Items	Volume	Remarks
Input neuron	3	Corresponding to 3 anxiety presentations
Output neuron	1	Specific performance
Hidden layer	1	Hidden layers of neural network
Hidden neuron	8	-

Table 2: Correlation degree and correlation coefficient

Presentation index	Correlation coefficient	Correlation degree
Cognitive state anxiety	0.9978	0.9725
Body state anxiety	0.9989	0.9857
State self-confidence	0.9847	0.9965

Table 3: Training samples

	Input sample			
Order	Cognitive state anxiety	Body state anxiety	State self-confidence	Output sample
1	0.89	0.95	0.95	16.8
2	0.87	0.96	0.86	16.7
3	0.86	0.92	0.83	16.4

Table 4: Connection weight

	Input neuron			Output neuron
Connection weight	1	2	3	1
Hidden neuron	0.1256	0.1005	0.0804	0.8926
	0.1548	0.1238	0.0991	0.4586
	-0.2684	-0.2147	-0.1718	0.1545
	0.6354	0.5084	0.4067	-0.7856
	0.2153	0.1722	0.1378	0.3641
	-0.2546	-0.2037	-0.1629	-0.6421
	0.1235	0.0988	0.0790	0.3671
	0.2452	-0.1962	0.1569	0.2361

Table 5: The correlation between practical result and predicted result

Predicted Specific Performance	Practical Performance	Error Rate
16.8	17.4	3.45%
16.7	16.2	3.09%
16.4	16.9	2.96%

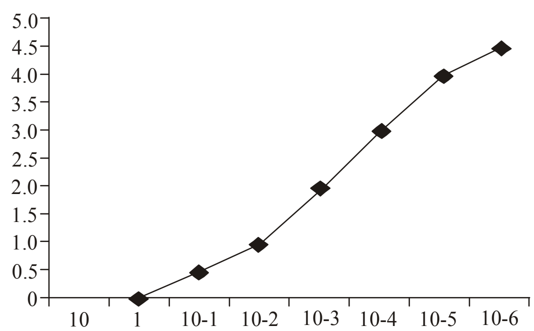

Fig. 4: Dynamic learning process

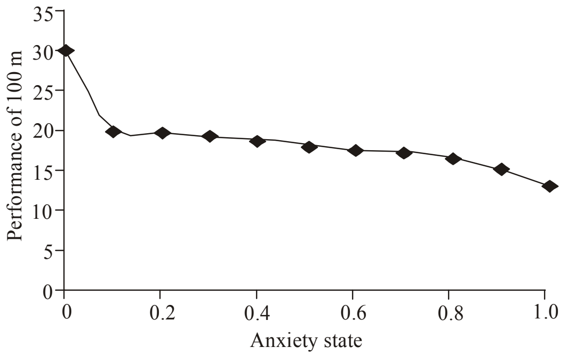

Fig. 5: Curve of correlation between cognitive state anxiety and sport performance

state, proper anxiety is helpful to athletes in bringing into player their level, so as to achieve a better performance.

Neural network model application analysis: After constructing the neural network model for the correlation between sprinters' pre-competition anxiety and specific performance, we will be able use the model to predict athletes' sprint performance under different anxiety states. Figure 5 shows the correlation curve between cognitive state anxiety and sport performance.

Similarly, we may as well draw the curve for the correlation between body state anxiety, insufficient state self-confidence and specific performance. With these curves, athletes and coaches may better understand sprinters' performance under different anxiety state. As for this, coaches may organize corresponding trainings according to athletes' psychological state, to avoid anxiety and to improve athletes' performance to the largest extent.

CONCLUSION AND SUGGESTION

Sport anxiety has obvious influence on sport performance. Sprint is explosive competition, in which, athletes' anxiety state will greatly affected athletes in bringing into play their competence, so as to affect the finial specific performance. By studying the correlation between athletes' pre-competition anxiety and their performance, we will be able to organize customized trainings to help athletes get to know themselves and to overcome anxieties. In this field, neural network model has superior advantages and has been widely applied by scholars domestic and overseas. This study has applied CSAI-2 (1994) Questionnaire to investigate sprinters' anxiety in university sports meeting. Moreover, the study has constructed the neural network model for the correlation between sprinters' pre-competition anxiety and their specific performance. On this basis, this model was applied to predict sprinters' performance under different anxiety states. By comparing the predicted performance with practical performance, the model was proved with high precision, which can perfected predict athletes' specific performance under different anxiety states. The three factors were also demonstrated with high correlation degree with athletes' performance. The curve of correlation between specific performance and cognitive state anxiety plays some positive roles in promoting customized trainings to improve athletes' pre-competition psychological quality, as well as in regulating athletes' pre-competition psychological state.

Shown by the research in this study, worse anxiety state often leads to lower specific performance. In routine trainings, trainings concerning athletes' anxiety state should be attached with great importance. Apart from routine trainings, we may as well consciously create difficulties to trigger athletes' pre-competition anxiety, so as to take corresponding adjustment and measure according to their anxiety state, so as to turn anxieties into power and to make better performance.

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REFERENCES

Akbar, J., H. Talebi, S.S. Seed, S. Khalil and Z. Ghasem, 2011. The relationship between sport orientation and competitive anxiety in elite athletes. Proc. Soc. Behav. Sci., 30: 1161-1165.

Annemarie, S.D. and S. Roland, 2011. Extra-curricular sport participation: A potential buffer against social anxiety symptoms in primary school children. Psychol. Sport Exer., 12(4): 347-354.

Chauhan, N., V. Ravi and D.K. Chandra, 2009. Differential evolution trained wavelet neural networks: Application to bankruptcy prediction in banks. Exp. Syst. Appl., 36(5): 7659-7665.

Daniel, W.C., J. Ho and J. Lam, 2006. Global exponential stability of impulsive high-order BAM neural networks with time-varying delays. Neural Netw., 19(10): 1581-1590.

Du, K.L., 2010. Clustering: A neural network approach. Neural Netw., 23(1): 89-107.

Fu, M., 1997. Research on the relation between university student athletes' pre-competition anxiety and competition performance. China Sports Sci. Technol., 48(5): 45-47.

Fu, M., 1999. A study of the variation pattern of track athlete's pre-competition anxiety and relationship between pre-competition anxiety and competition performance. China Sports Sci. Technol., 35(3): 106-108.

Gao, Z., 2010. Research on the correlation between high-level race-walkers' competition anxiety and competition performance. Master, 17(4): 74-76.

Hanton, S., O. Thomas and I. Maynard, 2004. Competitive anxiety responses in the week leading up to competition: The role of intensity, direction and frequency dimensions. Psychol. Sport Exer., 5(2): 169-181.

Hojjat, A. and P. Ashif, 2009. A probabilistic neural network for earthquake magnitude prediction. Neural Netw., 22(7): 1018-1024.

John, S.R. and E.T. Paul, 1993. Anxiety and performance in track and field athletes: A comparison of the inverted-U hypothesis with zone of optimal function theory. Personal. Indiv. Differ., 14(1): 163-171.

Li, W., Z. Qinghua and W. Pei, 2011. Ultimate boundedness of stochastic hopfield neural networks. Neurocomputing, 74(17): 2967-2971.

Malliaropoulos, N., E. Papacostas, A. Papalada and N. Maffulli, 2006. Acute lateral ankle sprains in track and field athletes: An expanded classification. Foot Ankle Clin., 11(3): 497-507.

Mangan, M., 2009. Dietary intake of senior athletes participating in the 2008 southeastern masters track and field meet. J. Am. Diet. Assoc., 109(S9): A24.

Mantzaris, D., G. Anastassopoulos and A. Adamopoulos, 2011. Genetic algorithm pruning of probabilistic neural networks in medical disease estimation. Neural Netw., 24(8): 831-835.

Mohamed, C., 2012. Output feedback direct adaptive neural network control for uncertain SISO nonlinear systems using a fuzzy estimator of the control error. Neural Netw., 36(12): 25-34.

Qingsong, S., L. Xibin and Z. Xiangmo, 2012. Short-term traffic flow and hourly electric load forecasting algorithm based on echo state neural networks. JDCTA, 6(4): 166-172.

Xuefei, W. and X. Chen, 2012. Cluster synchronization of nonlinearly coupled neural networks with hybrid time-varying delays and stochastic perturbations via pinning control. JCIT, 7(6): 101-111.

Yasser, F.H. and H. Nora, 2012. Hybrid system of PCA, rough sets and neural networks for dimensionality reduction and classification in human face recognition. Int. J. Intell. Inform. Process., 3(1): 16-24.

Yi-Chieh, C. and H. Tsung-Min, 2010. Effects of pre-competition cognitive anxiety on attention and emotion during archery performance. Int. J. Psychophysiol., 77(3): 268.

Yuan, L., 2008. Construction of recurrent neural network model for relationship between specific performance and physical fitness of top high jumpers in the world. J. Beijing Sport Univ., 31(2): 201-204.

Zhao, Q., 2012. Correlation analysis of competition state anxiety and sport results of high-level wushu routine athletes. J. Shenyang Sport Univ., 31(3): 132-135.

Zhu, B., 1994. Competitive state anxiety inventory (CSAI-2 Questionnaire) China norm revisions. Psychol. Sci., 17(4): 358-361.