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Retraction

Retracted: Nontarget Suppression in Ball Sports Multitarget-Tracking Task

Mathematical Problems in Engineering

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] M. Li and L. Zhang, "Nontarget Suppression in Ball Sports Multitarget-Tracking Task," *Mathematical Problems in Engineering*, vol. 2022, Article ID 6848195, 8 pages, 2022.

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Research Article

Nontarget Suppression in Ball Sports Multitarget-Tracking Task

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In order to solve the problem of large interference caused by nontarget tasks on the ball sports field, the author proposes a method for multitarget-tracking tasks. By changing the movement speed of the athletes in the expert group, the novice group, and the control group, we investigate the performance of visual attention tracking and neural oscillatory characteristics in ice hockey players. Experimental results show that the main effect of speed was significant ($F = 120.58$, $P < 0.01$, $\eta_P^2 = 0.81$), and post hoc comparison results showed that the faster the movement speed, the lower the tracking accuracy. The main effect of speed was significant ($F = 31.96$, $P < 0.01$, $\eta_P^2 = 0.53$). Post hoc comparison results showed that the faster the movement speed, the lower the ERSP value of the high-frequency alpha rhythm. It proves the influence of speed on the inhibitory effect of nontarget tasks, which is beneficial for athletes to suppress more interference information brought by opponents or the court in the game and plays an important role in improving sports performance and developing the scientific level of sports.

1. Introduction

In daily life, we often need to pay attention to multiple objects at the same time and track for a period of time to obtain information. For example, when we drive a car, we should not only pay attention to the vehicles passing by but also pay attention to the pedestrians at all times to avoid accidents. Multiobject tracking plays an important role in sports, especially ball games. For example, ice hockey players need to always pay attention to and track multiple moving objects on the field; when dribbling and passing the ball, the player with the ball will allocate resources to different key areas in the sports scene, and players need to always pay attention to the position of teammates who are sliding at high speed and flexibly change direction and also need to pay attention to the position and movement of the opponent's players; in other cases, other players should always pay attention to the position of the ball and the movement information of related players and track multiple moving objects for a period of time to collect information on the field [1]. The ability to notice and continuously track multiple moving objects in a sports scene is a prerequisite for an athlete to make a reasonable tactical strategy. Therefore, the author proposes a related research on the multitarget-tracking task of ball sports and further studies its inhibitory effect on nontarget tasks. The multitarget-tracking task corresponds to the player's own ability to actively judge the ball, and the detection rate of detection stimuli in different regions corresponds to the athlete's ability to screen the opponent's true intention information, and the nontarget inhibition amount corresponds to the player's own ability to inhibit the court information, as shown in Figure 1. Athletes not only need their own subjective judgment and the ability to accept information but also more importantly, they need to know how to judge the opponent's intention, how to accept the opponent's information, how to screen a lot of information, and how to suppress interfering information [2]. Athletes suppress the interference information brought by their opponents or the stadium, such as the interference of the audience, the opponent's fake moves, and the opponent's tactics,, and then can judge the opponent's true intentions, screen out the opponent's true intentions, and correct them; it plays an important role in improving sports performance and developing the scientific level of sports.

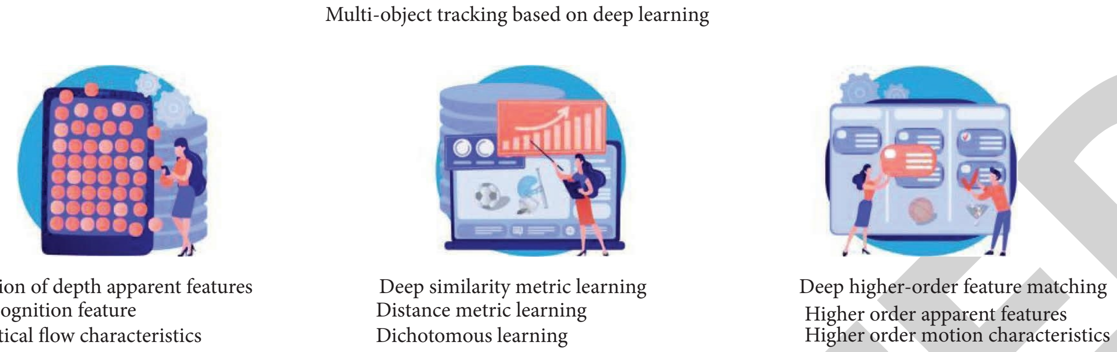

Figure 1: Multitarget-tracking tasks.

2. Literature Review

In response to this research problem, the multiobject tracking paradigm ("MOT" for short) proposed by Esghaei et al. is a common paradigm to study the visual attention processing mechanism in dynamic scenes [3]. This paradigm has become one of the main methods to explore the laws of dynamic visual attention and perceptual processing. The study by Suleimenova et al. found that compared with the novice group of the basketball team, the expert group performed better than the novice group in the multiobject tracking task, and there was a significant difference [4]. These studies show that athletes in collective ball sports such as basketball can receive a large amount of complex temporal and spatial information more frequently than ordinary people, so their dynamic visual attention has been developed. The resource sharing model theory also believes that the proficiency of cognitive operation tasks affects its operation effect, even in the same ball sports; due to the different division of labor on the court, long-term competition and training will lead to different cognitive characteristics of athletes [5]. A study of professional football players by Garcia-Fernandez and others found that the multitarget-tracking performance of defenders is better than that of forwards [6]. However, some studies have come to different conclusions; for example, Silva-Gago et al. used multitarget visual tracking to examine the visual attention of different groups of people and found that the performance of athletes and ordinary people in completing multitarget-tracking tasks was significantly different, see significant differences in Ref. [7]. He et al. took ice hockey players of different sports skill levels (expert group and novice group) as the research object and found that ice hockey players of different sports skill levels did not show significant differences in the multitarget-tracking task [8]. Sharma and Chaurasia studied the visual search features of ice hockey players of different levels and found that the gaze trajectories of the players were relatively concentrated, and in complex tasks, the way athletes get information is mainly based on the relationship between the opponent and the position of the field, while the novice group mainly observes the racket and the racket arm [9]. Similar experiments have also been confirmed in sports such as basketball, volleyball, tennis, table tennis, and short track speed skating. The reason for this result may be the difference in the multitarget-tracking task load or the difference in the sports skill level of the selected athletes.

According to the above research results, the author adopts a multitarget-tracking task by changing the movement speed of the athletes in the expert group, the novice group, and the control group and explores the performance of visual attention tracking and neural oscillation characteristics in ice hockey players [10]. Through experiments, it was observed that the movement speed increased, whether it can reduce the individual's tracking performance and enhance the degree of neural oscillations, thereby reducing the inhibitory effect on nontarget tasks.

3. Research Methods

3.1. Research Objects and Methods

3.1.1. Research Objects. A total of 68 subjects (Table 1) were selected and divided into expert group, novice group, and control group according to their ice hockey training experience. The expert group had a national first-level athlete or above who should have been in sports for more than 4 years, and the training frequency is 6 times/week, about 3 hours each time; the athletes in the novice group had a sports level of the national second-level athlete and below, and the training period was not more than 3 years, and the training frequency was 6 times/week, about 2–3 hours each time; and the control group was ordinary college students who had not received team ball training. The subjects had normal vision or corrected vision, were right-handed, voluntarily participated in the experiment, and also signed the informed consent.

3.1.2. Test Design. A mixed design of three groups (expert group, novice group, and control group) × 3 speed levels (slow, medium, and fast) was used. Group is the between-subject variable, and speed is the within-subject variable. The dependent variable is the tracking accuracy rate, and the EEG indicator is the ERSP value of the high-frequency alpha rhythm, as shown in Figure 2.

3.2. Test Equipment and Materials

3.2.1. Test Equipment. The experimental program was compiled in the Psych Toolbox toolbox in Matlab software, and a 23.8-inch DELL desktop computer (screen resolution

Table 1: Basic information of the subjects.

Category	Expert group	Novice group	Control group
Number of people	22	23	23
Gender: Male/female	10/12	11/10	10/13
Age	20.59 ± 2.55	19.5 ± 3.2	20.68 ± 1.97
Training years	5.56 ± 1123	1.75 ± 0.80	—
Training frequency/(times/week)	6	6	—
Training time/(h/time)	3	2 ~ 3	—
Sport class	7 national athletes	National level-2 athletes 10	No sports rating

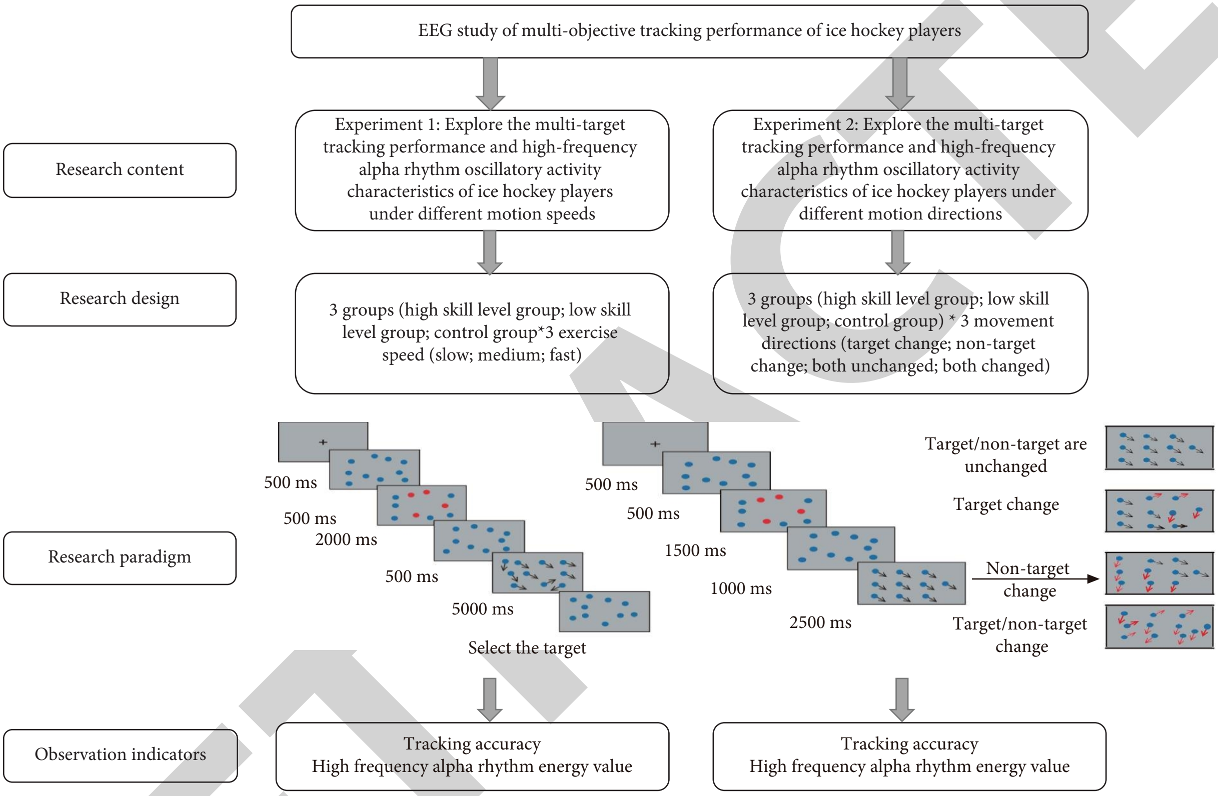

Figure 2: Technology roadmap.

of 1920 × 1080 pixels and refresh rate of 60 Hz) was used to present the stimuli in the experiment and record the behavioral data of the subjects.

3.2.2. Stimulus Material. The stimulus material is 10 blue balls with a size of 0.9 degree.

3.3. Test Tasks. The subject's head was fixed with a bracket, and the distance between the subject's eyes and the center of the screen was about 57 cm. The screen background is gray. A black fixation point "+" appeared in the center of the screen, and after 500 ms, 10 blue balls appeared. The initial positions of the 10 blue balls are randomly distributed, and the distance between each ball is greater than the diameter of the ball, and the distance between the initial position of the ball and the border of the tracking area is not less than 2 times the diameter of the ball [11]. After 500 ms, four blue balls turned red, the red balls were marked as target stimuli, and the remaining six blue balls were interference stimuli, and the marking time was 2000 ms. After 2000 ms, four red balls turned blue, and after 500 ms, 10 blue balls moved randomly on the screen for 5000 ms. The movement speed of each trial is randomly presented, and during the movement, the balls do not block each other. When the ball collides with the edge of the tracking area, the ball will randomly change its movement direction. When the distance between the balls is smaller than the diameter, the balls randomly change the direction of movement. After 5000 ms, the movement of the ball stops, and the tested mouse selects the previously marked targets in turn; after selecting, press the space bar to enter the next trial. The specific test process is shown in Figure 3.

There are three speed conditions: the slow speed is 3(°)/s, the medium speed is 4(°)/s, and the fast speed is 5(°)/s. These three speed s were randomly presented, with 30 trials for each speed condition, for a total of 90 trials. After every 15 trials, the subjects rested for 1 min. Before entering the

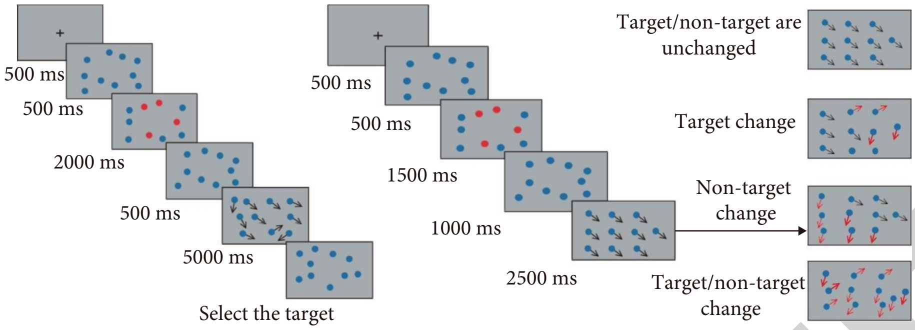

Figure 3: Test flow chart.

formal test, let the subjects practice six times to ensure that the subjects are familiar with the test process. The whole test process is about 50 min.

3.4. EEG Recording. EEG data were recorded using the ERP recording system produced by Brain Products, Germany, the 64-lead electrode cap (Brain Products GmbH, Munich, Germany) extended by the international 10–20 standard system was used, and the electrodes were Ag/AgCl electrodes. The reference electrode point was FCz, and the ground electrode point was AFz; horizontal electro-oculography was placed 1 cm lateral to the subject's right eye, and vertical electro-oculography was placed 1 cm below the subject's left orbit. The contact impedance between the scalp and the electrode was less than 5 kΩ, and the sampling frequency was set to 1000 Hz/conduction.

3.5. Data Processing

3.5.1. Behavioral Data. SPSS 25.0 software was used to perform arc sine function transformation (ARSIN) on the tracking accuracy rate, and then the arc sine transformation value of the tracking accuracy rate was three groups (expert group, novice group, and control group) × 3 speed conditions (slow, moderate, and fast) repeated measures ANOVA.

3.5.2. EEG Data. The data were preprocessed with the BP analyzer. The average potential of both ear mastoids (TP9 and TP10) was used as the rereference electrode, and the FCz electrode was reduced. The rereferenced EEG data were filtered with a high pass of 1 Hz, a low pass of 30, and a slope of 24 dB/oct. Segmentation was performed according to three speed conditions, and the segmented data were baseline corrected, and the baseline time ranged from (−1 000 ms) to (−500 ms). The electro-oculogram artifact was removed by the semiautomatic mode in principal component analysis, and the data with amplitude exceeding ±80 μV were automatically removed. Finally, the preprocessed data were exported. The preprocessed data was subjected to time-frequency analysis in lets wave.7 software, and the data were subjected to wavelet transform in lets wave according to the gain model, and the transformed data were subjected to event-related spectral perturbation analysis (ERSP). The data were subjected to continuous wavelet transform to calculate the event-related power spectrum for each trial. The mother wavelet short is set to cmor1 ~ 1.5, the low frequency is set to 1 Hz, the high frequency is set to 30 Hz, and the output format is set to the power value. Then for each frequency, the event-related spectral power for each time-frequency bin was divided by the average spectral power of the same frequency in the baseline period before stimulation. The percent ERSP (ERSP%) is log-transformed, and by definition, the log-transformed unit is the decibel (dB) calculated as follows:

$$ERS(f,t) = \frac{1}{n}\sum_{k-1}^{n}\left|F_k(f,t)\right|^2. \tag{1}$$

Among them, *Fk* is the wavelet value of trial *K* at frequency *f* and time *t*, and n is the number of trials:

$$ERSP\% = \frac{ERS(f,t)}{\mu_B(f)}. \tag{2}$$

Among them, $\mu_B(f)$ is the average value of ERSP in the baseline range at frequency f, and in order to make the distribution of ERSP values tend to be more normal, logarithmic transformation of ERSP is performed:

$$\mathrm{ERSP}_{Jog}(f,t) = 10\log_{10}\left[\mathrm{ERSP}_{si}(f,t)\right]. \tag{3}$$

When completing the multitarget-tracking task, the brain activation areas of the subjects were concentrated in the occipital and parietal regions; according to the distribution of brain topographic maps and previous literature, the occipital (Oz), parietal (Pz), and parieto-occipital (POz) regions were selected. Of the electrode points, calculate the ERSP average of the high-frequency alpha rhythm (10 ~ 13 Hz) of the three electrode points, and perform a 3 × 3 repeated measures ANOVA [12]. During the analysis, when the statistic did not satisfy the spherical test, the degrees of freedom and *P* values were corrected by Greenhouse Geisser's method, and Bonferron's method was used for post hoc comparisons.

4. Analysis of Results

4.1. The Effect of Exercise Speed on the Tracking Performance of the Three Groups of Subjects. As shown in Figure 4, the main effect of speed was significant ($F = 120.58$, $P < 0.01$, $\eta_P^2 = 0.81$), and the post hoc comparison results showed that

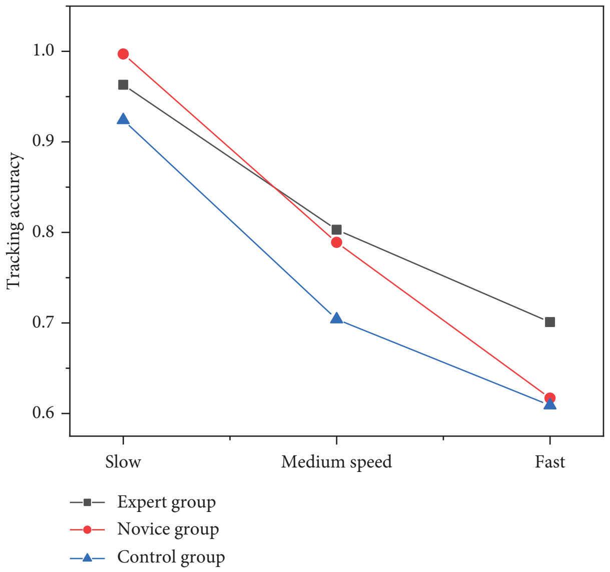

Figure 4: Differences in the tracking accuracy of the three groups of subjects under different speed conditions.

the faster the movement speed, the lower the tracking accuracy. The tracking accuracy rate under the slow speed condition was significantly higher than that of the medium speed condition ($P < 0.01$) and the fast condition ($P < 0.01$). The tracking accuracy rate under the medium speed condition was significantly higher than that of the fast condition ($P < 0.01$). The main effect of the group was significant ($F = 3.39$, $P < 0.05$, $\eta_P^2 = 0.10$), and post hoc comparison results showed that the tracking accuracy rate of the expert group was significantly higher than that of the control group ($P < 0.05$), and there was no significant difference between the expert group and the novice group ($P > 0.05$), and the tracking accuracy rate between the novice group and the control group was marginally significant ($P = 0.061$). The interaction between group and speed was significant ($F = 2.63$, $P < 0.05$, $\eta_P^2 = 0.082$). Further simple effect analysis found that under the slow speed condition, there was no significant difference in the tracking accuracy among the three groups ($P > 0.05$). Under the medium speed condition, the tracking accuracy of the control group was significantly lower than that of the expert group ($P < 0.01$) and the novice group ($P < 0.05$), and the tracking accuracy rate of the expert group under the fast condition was significantly higher than that of the control group ($P < 0.05$). Under the fast condition, there was no significant difference in the tracking accuracy between the novice group and the control group ($P > 0.05$), and the tracking accuracy of the expert group was higher than that of the novice group but did not reach a statistically significant level ($P > 0.05$). The above results show that with the increase of movement speed, the accuracy rate of multitarget-tracking of ice hockey players shows obvious advantages. Under medium speed conditions, the ice hockey player group (expert group and novice group) is significantly better than the control group. Under fast conditions, the multitarget-tracking performance of the expert group athletes still has an advantage.

Table 2: Statistical table related to high-frequency alpha precepts and behavioral performance.

		Variable	r	P
High skill level group	Slow	Tracking accuracy	−0.396	0.094
	Medium speed	Tracking accuracy	−0.536	0.018
	Fast	Tracking accuracy	−0.478	0.039
Low skill level group	Slow	Tracking accuracy	−0.427	0.053
	Medium speed	Tracking accuracy	−0.570	0.007
	Fast	Tracking accuracy	−0.547	0.010
	Slow	Tracking accuracy	−0.397	0.092
Control group	Medium speed	Tracking accuracy	−0.445	0.046
	Fast	Tracking accuracy	−0.516	0.024

4.2. The Effect of Motion Speed on Neural Oscillations of High-Frequency Alpha Rhythms. As shown in the statistics in Table 2, the main effect of speed was significant ($F = 31.96$, $P < 0.01$, $\eta_P^2 = 0.53$), and post hoc comparison results showed that the faster the movement speed, the lower the ERSP value of high-frequency alpha rhythm. Specifically, the ERSP values of high-frequency alpha rhythms under slow conditions were significantly higher than those in moderate ($P < 0.01$) and fast conditions ($P < 0.01$). The ERSP values of high-frequency alpha rhythms in the moderate speed condition were significantly greater than those in the fast condition ($P < 0.01$). The main effect of group was significant ($F = 5.1$, $P < 0.01$, $\eta_P^2 = 0.15$), and post hoc comparison results showed that the ERSP value of high-frequency alpha rhythm in the expert group was significantly higher than that in the control group ($P < 0.01$), and there was no significant difference in the ERSP values of high-frequency alpha rhythms between the expert group and the novice group ($P > 0.05$), and the ERSP values of high-frequency alpha rhythms in the novice group were slightly larger than those in the control group and marginally significant ($P = 0.061$). The interaction between group and speed was significant ($F = 3.01$, $P < 0.05$, $\eta_P^2 = 0.097$). Further simple effect analysis found that under the slow condition, there was no significant difference in the ERSP value of high-frequency alpha rhythm among the three groups ($P > 0.05$). Under the condition of moderate speed, the ERSP value of the high-frequency alpha rhythm of the control group was significantly lower than that of the expert group ($P < 0.01$) and the novice group ($P > 0.05$). Under the fast condition, the ERSP value of the high-frequency alpha rhythm of the expert group was significantly greater than that of the control group ($P < 0.01$), and the ERSP value of the high-frequency alpha rhythm of the expert group was greater than that of the novice group but did not reach a statistically significant level ($P > 0.05$). There was no significant difference in the ERSP values of high-frequency alpha rhythms between the novice group and the control

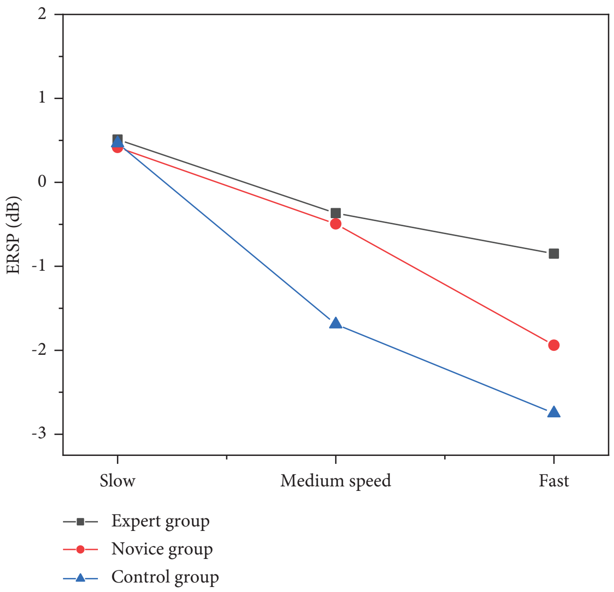

Figure 5: ERSP values of high-frequency alpha rhythms of the three groups of subjects at different speeds.

group ($P > 0.05$). The above results (Figure 5) show that as movement speed increased, hockey players had lower levels of oscillations in high-frequency alpha rhythms compared to controls. Under the moderate speed condition, the oscillation level of the high-frequency alpha rhythm of the ice hockey player group (expert group and novice group) was significantly lower than that of the control group. Under the fast condition, the oscillation level of the high-frequency alpha rhythm of the expert group players was significantly lower than that of the control group.

5. Discussion

The author adopted the multitarget-tracking paradigm combined with EEG technology and explored the visual attention tracking performance and neural oscillation characteristics of ice hockey players under different speed loads, and the results show that movement speed reduced the multitarget-tracking performance and enhanced the oscillation level of high-frequency alpha rhythm. The differences in multitarget-tracking performance and high-frequency alpha rhythm oscillation between the expert group hockey players, the novice group ice hockey players, and the control group were mediated by the movement speed.

5.1. Movement Speed Affects Multitarget Tracking Performance of Ice Hockey Players. With the acceleration of the exercise speed, the tracking performance of the expert group ice hockey players, the novice group ice hockey players, and the control group decreased significantly, which is consistent with the previous research results: Visual attention tracking performance degrades with faster motion [13]. The researchers proposed the flexible resource theory to explain the reasons for the impaired tracking performance, arguing that there is a "resource pool" in the brain of the resources which needed to track the target, and the attentional resources required to track each target determines the number of targets that can be tracked simultaneously. When the object moves fast, tracking one target will consume most of the attention resources in the "resource pool," and the subjects can only accurately track one target, lose or confuse other targets, resulting in impaired tracking performance [14]. Under moderate speed conditions, compared with the control group, the expert group hockey players and the novice group hockey players have superior visual tracking performance, which indicates that the multitarget-tracking ability of the hockey players is better than that of the nonathletes, which supports the results of some previous studies; that is, athletes have advantages in multitarget-tracking performance compared to nonathletes [15]. Under the fast condition, the expert group hockey players still had an advantage in visual tracking performance compared with the control group, and there was no significant difference in tracking performance between the novice group hockey players and the control group. This shows that as the speed of movement increases, the expert group hockey players still maintain the advantage of multitarget-tracking performance, while the tracking performance of the novice group hockey players and the control group is impaired. The authors verified from the behavioral level that the increase of exercise speed will reduce the tracking performance, which is in line with the flexible resource theory and found that with the increase of exercise speed, the multitarget-tracking performance of ice hockey players is better than that of the control group, and the higher the skill level, the better the tracking performance, the more obvious the advantage.

5.2. Movement Speed Affects the Level of Neural Oscillations in Ice Hockey Players. In order to effectively track multiple targets, certain attention resources need to be invested, so when completing multitarget-tracking tasks at different speeds, there may be differences in the degree of neural oscillations of the expert group ice hockey players, the novice group ice hockey players, and the control group. Oscillation levels of high-frequency alpha rhythms were assessed using the ERSP values of high-frequency alpha rhythms. Note that the more the focus on a certain task, the smaller the ERSP value of the alpha rhythm, and the higher the oscillation of the alpha rhythm [16]. Under the fast condition, the oscillation intensity of the high-frequency alpha rhythm of the expert hockey players was weaker than that of the control group, while the oscillation intensity of the high-frequency alpha rhythm of the novice group and the control group was not significantly different. This shows that under the fast task load, compared with the control group, the ice hockey players in the expert group can complete the tracking task with less attention resources, reflecting the characteristics of attention resource saving [17]. This revealed that under conditions of high task load, the expert group ice hockey players exhibited a lower degree of oscillation of high-frequency alpha rhythms and had more efficient use of attentional resources. This supports the ability to perform specific tasks or cognitive tasks related to specific tasks and that athletes in the expert group have more obvious characteristics of resource consumption saving [18]. Research indicates that athletes may have higher neural efficiency and less attentional resource consumption during multiobject tracking tasks. When performing multitarget-tracking tasks, compared to nonathletes, ice hockey players showed lower alpha rhythm oscillation levels and more efficient attentional resource utilization, and the higher the skill level, the more obvious the advantage of saving attentional resources [19]. Combining the tracking accuracy and the high-frequency alpha rhythm oscillation, under moderate speed conditions, the tracking performance of the ice hockey players was better than that of the control group, and the high-frequency alpha rhythm oscillation level was lower than that of the control group. Under the fast condition, the expert group ice hockey players showed a tracking advantage and less attentional resource consumption, and the novice group ice hockey players and the control group showed no significant differences in tracking performance and the degree of high-frequency alpha rhythm oscillations [20].

6. Conclusion

The author proposed a multitarget-tracking task based on and by changing the movement speed of the athletes in the expert group, the novice group, and the control group, explored the visual attention tracking performance and neural oscillation characteristics of ice hockey players, and used the multiobject tracking paradigm combined with EEG technology to observe the performance of different exercise loads, differences in multitarget-tracking performance, and the degree of oscillation of high-frequency alpha rhythms between expert hockey players, novice hockey players, and control groups, revealing their inhibitory effect on nontarget tasks, and the specific performance is that as the movement speed increases, the multitarget-tracking performance of ice hockey players is better, the degree of neural oscillation is lower, and the higher the skill level, the more obvious the effect, and it has a strong inhibitory effect on nontarget tasks.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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