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POMS and eye movement: Two indicators for performance in athletics

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ABSTRACT

Background: Regularly and scientifically participating in athletics is beneficial for physical and mental health. Mood or emotions are important component of psychology and a major indicator of physical and mental health. Positive and negative mood or emotions can have a strong impact on physical responsiveness. The aim of the present study was to explore whether mood or emotional state influence performance in athletics.

Methods: Mood, analyzed by Profile of Mood States, and emotional state, reflected by eye movement (looking at times and length), were used to predict track or field performance in training and competition.

Results: 1. The profile of track training (except 3rd week) resembled an iceberg profile (highest vigor scores) and the profile on the 3rd week resembled a "melting" iceberg profile, in which positive mood (vigor and self-esteem) was decreased and negative mood, particularly depression and anger, was significantly increased. The profile of field training almost overlapped, with the exception of depression decreasing markedly on the 3rd and 4th weeks. 2. Positive mood overpowered negative mood, particularly following a track competition; positive emotions exceed negative emotions following track and field competition. 3. The results of the regression analysis showed that an improvement in track performance was negatively correlated with a rise in total mood disturbance (TMD), and field performances were positively correlated with positivity of emotion, as tested by eye movement. 4. Good performance in track events appeared to be associated with decreased vigor and increased fatigue during 3rd and 4th track training; decreased depression and fatigue, and increased vigor as well as low observe length of watching negative emotional pictures (NEPs) before track competition. A good performance in field events appeared to be associated with anger decrease and confusion increase, increased fixation counts of watching positive emotional pictures (PEPs), and decreased fixation and observe counts of watching NEPs before field competition.

Conclusions: The present study proved that different indicators appeared to measure different sport performances: More indicators of Profile of Mood States inclined to predict track performance, while more eye movement indicators could predict field performance. Mixed methods could provide a better understanding of performance than a single approach alone. These findings provided theoretical support and supplementary data for practical applications in the design of comprehensive training programs.

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1. Introduction

Athletics refers to track or field sports, such as running, jump and throwing [1,2]. Generally speaking, track events happen on playground ring, field events happen inside playground ring. Technically speaking, track events are measured by time and field events by distance, while performance is measured in seconds, minutes or hours, as well as meters [3].

Athletics originated from the survival instinct of humans to adapt to the environment, is the foundation of many physical exercises. Regularly and scientifically participating in athletics can promote the metabolism, improve the regulatory function of the nervous system and internal organs, and reduce the incidence of depression and anxiety [4,5], and possess a more positive mental health compared with individuals who are less physically active [6,7].

Through the teaching and training of track and field sports, college students can comprehensively develop their physical fitness (speed, strength, endurance, etc.), improve their sports skills and performance [8]. Successful performance and good mood are usually linked [9,10], which is why it's important to maintain a good mood of the athletes before a competition [2]. Across many different individual and team sports and measures of performance, successful athletes exhibit a mood profile slightly more positive than that of less successful athletes [11–13]. Some successful athletic performance is closely associated with mood, which combines high vigor with low tension, depression, anger, fatigue and confusion scores, as suggested by the iceberg profile (the mean scores of the normative group represent the water line beneath which most scores fall) [14]; athletes with a debilitated performance are characterized by below average scores for vigor and above average scores for tension, depression, anger, fatigue and confusion as inverse iceberg profile reported. The inverse iceberg profile is characterized by below average scores for vigor and above average scores for tension, depression, anger, fatigue and confusion [15]. Therefore, psychological monitoring during training may be useful in predicting performance [16], and athletes possessing positive psychological states and traits are usually predicted to be more successful. It is in the athlete and coaches' best interest to increase positive moods as much as possible prior to a competition [16,17]. Competitions are not only used as a model for challenges, but are also profound physiological and psychological stressors [3]. Modern competitive sports have stricter requirements for psychological ability rather than physical fitness. Athletes need to overcome both physical and psychological hurdles to achieve the goal.

Athletes, coaches, and psychologists generally believe that mood state is useful for predicting the performance of athletes [18], monitoring mood states during training and competition provides a great possibility for preventing athletes from excessive fatigue, detecting their adaptation to training plans, and predicting sports performance [19,20]. Mood was defined as a set of feelings, ephemeral in nature, varying in intensity and duration, and usually involving more than one emotion [21,22]. Profile of Mood States (POMS) is a self-reported questionnaire for mood state [23,24]. This questionnaire is the most widely used tool to study the relationship between mood state and physical exercise, and an effective tool for evaluating athletes' potential and a good means of predicting sports performance [25]. It has been used in several studies to predict athletes' performance on the basis of their mood [15, 22,26].

Determining whether self-evaluations are valid has been a longstanding problem for a variety of reasons: different understanding ability: (different individuals have different language comprehension abilities of the scale); conceptual differences (the definition of concepts varies among individuals); social expectations (even completely anonymous scale can be influenced by societal expectations) [27,28], and cooperation (participants may be unwilling and or unable to provide accurate self-evaluation) [29]. One method of increasing self-evaluation validity was eye movement [30], physiological correlations between the autonomic nervous system (e.g., eye movement variation) and emotional status have been reported [31]. Emotions are the dynamic interplay between individuals and their environments, and the duration and timing of emotions are often due to the duration and timing of the eliciting stimuli [32]. Such objective recognition of emotions through eye movement detection of participants while they look at emotional pictures before and after a competition could be useful in psychological studies. The viewing time and counts might reveal important information about cognitive and affective information processing [31], thus revealing a positive or negative emotional state.

In the present study, with the aim to explore characteristics of mood changes during training, whether mood or emotional state influence performance in athletics, and different indicators appeared to measure different sport performances, so mood states measured by POMS and emotion status reflected by eye movement characteristics of perception of PEPs and NEPs were examined. Through the above experiments, the following problems were explored: (1) monitor mood during training could predict performance in the competition; (2) compare mood states measured by POMS and emotional status measured by eye movement before and after competition; (3) clarify the association between positivity of TMD and dwelling on emotional pictures with performance; (4) determine whether mood or emotional changes before a competition influence performance; and confirm certain parameters of POMS and eye movement test that can predict good or bad performance in the competition.

2. Materials and methods

2.1. Participants

All experimental protocols and methods were approved by Psychology and Education Research Ethics Committee (**No.** 2021-04-01). This study was designed to reach a convenience sample of adults ($\geq$18 years) currently in university. A written informed consent document was obtained from all participants. All of them had visual acuity of more than 1.0 with or without glasses/contact lenses, and normal color vision. Only male college students were the participants list, and the basic information was shown in Table 1. The data were collected volunteers who participated only one kind of track or field training and competition according to their willing,

regardless of their experience in sports activities or their motor experience in the track and field events. The track events included 100, 200, 400, 800, 1500, 3000, 5000 m; and field events included high jump, long jump, triple jump, shot-put, discus, and javelin. For our power calculation, we wanted the capability to show a difference of 10. With $\alpha = 0.05$, two-tailed and a power of 80%, we needed 26 participants. After the experiment was completed, considering the uniformity of college students before and after training or competition, defect in any one test (foul, absence, unfinished task) and invalid data (out range of scale scores) were excluded. Using these criteria, the sample was reduced to 57 track participants, 45 field participants.

2.2. General design

In this study, a 4-week training period before competition days was chosen.

The training program for the collegiate track and field participants included a routine training: warm-up and stretching for 10min, training (aerobic or resistance training) for 60min, post-training stretching and cool down for 10min. The earliest data on measures of mood states within 1 week before the training were elected for the baseline and then they performed different 4-week training periods, and completed the POMS one time every 7 days. Finally, each participant completed eye movement tests and POMS before and after competition day. The competition performance with reference to the performance of training evaluated personal performance good or bad (competition performance better than training = good performance; competition performance not better than training = bad performance), which reflected whether effort was expended and mastery achieved in training. All participants were familiar with the testing procedures (Fig. 1) used in the present study.

2.3. Instruments

2.3.1. Profile of mood states

One of the tools used to study of mood state is POMS (revised by Peili Zhu) [33], which could be used to study the relationship between mood state and exercise effectiveness [24,34], and had high reliability to measure psychological pressure. The scale composed of 40 adjectives measures 5 negative affect scales: tension, anger, fatigue, depression, confusion, as well as 2 positive affect scale: vigor and self-esteem [35]. Participants rated each item on a 5-point response scale where: 0 = Not at all, 1 = A little, 2 = Moderately, 3 = Quite a bit and 4 = Extremely. The reliability of the scale ranges from 0.62 to 0.82 [33]. The scale can also be used to assess TMD. TMD was calculated by deducting the total score of the 2 positive emotions from the total score of the 5 negative emotions and then adding 100 points [35,36]. The higher the TMD score is, the more obvious the negative emotion is.

2.3.2. Eye movement test

Tobii T120 eye tracker (Tobii Technology AB) was used to record eye movement and analyze perception of visual information for interactive applications according to the user manual of Tobii Studio 2.X.

The study on emotional pictures was assessed in three aspects: valence, arousal and dominance [37], under which the internal consistency reliability coefficients of the score results of 46 subjects on the pictures were 0.982, 0.979 and 0.980 respectively. It indicates that the consistency of participants' scores is high under the same aspect, and the results are reliable. The standardized stimulus materials come from Chinese Affective Picture System [38]. Random 8 pairs of PEPs and NEPs were elected according to the research needs (Fig. 2A). All the original emotional pictures were processed with Photoshop CS5, and the final experimental material was a random cross-combination of the emotional pictures (positive and negative) x screen positions (left and right). The size of the experimental material pictures is 960 × 720 pixels, and gray-white image. All pictures were presented using a 17-inch TFT monitor with resolution of 1280 by 1024 pixels, and refresh rate of 120 Hz. Observers sat 55–65 cm from the monitor.

Preparation: eye movement was calibrated with 5 points for each participant's eyes through tracking green moving ball on the screen. Otherwise, they needed to re-calibrate. Then the participants were ready to start the experiment, they were asked to sit in a comfortable position, and show the pictures one by one on the computer lasted about 1 min, and asked the subjects to browse the different emotional pictures in turn and look at them according to their normal habits.

Formal experiments: The screen will show "Please watch the following pictures carefully". Each picture is presented for 5 s. When he gaze points are displayed once between pictures, the eye tracker begins to record the data. After the pictures display, the eye tracker stops recording. The chart of experiment is shown in Fig. 2B.

Based on the needs of the present study, the following 4 parameters are determined: fixation length (FL), the sum of fixation time in the region of interest; observation length (OL), the total time of the participants' gaze at the region of interest, including gaze time and saccade time (the length of eye gaze from one interest region to another interest region); fixation count (FC), the number of fixation times from the participants gazed at the region of interest until they keep the eyes away from the region; observation count (OC), the number of times the participants looked back in the region of interest.

Table 1
Basic information of participants.

	Sample Size	Age (years)	Height (cm)	Body mass (kg)
Track events	57	21.76 ± 1.36	171.74 ± 5.05	57.34 ± 5.98
Field events	45	21.93 ± 1.85	173.25 ± 6.47	58.29 ± 7.12

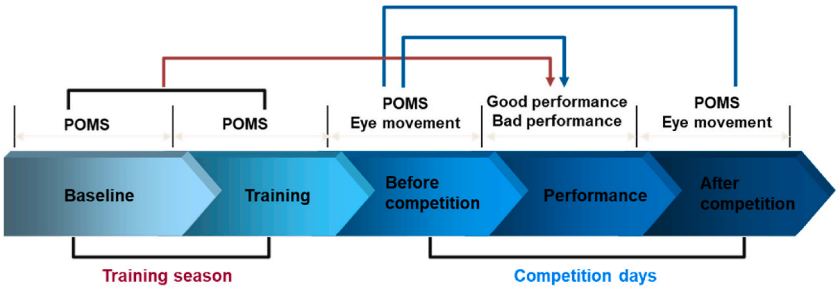

Fig. 1. The general schedule of the study. Red arrow: whether training mood predict competition performance; Blue arrow: whether mood or emotion before competition predict performance; Blue line: compare POMS or eye movement before and after competition. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

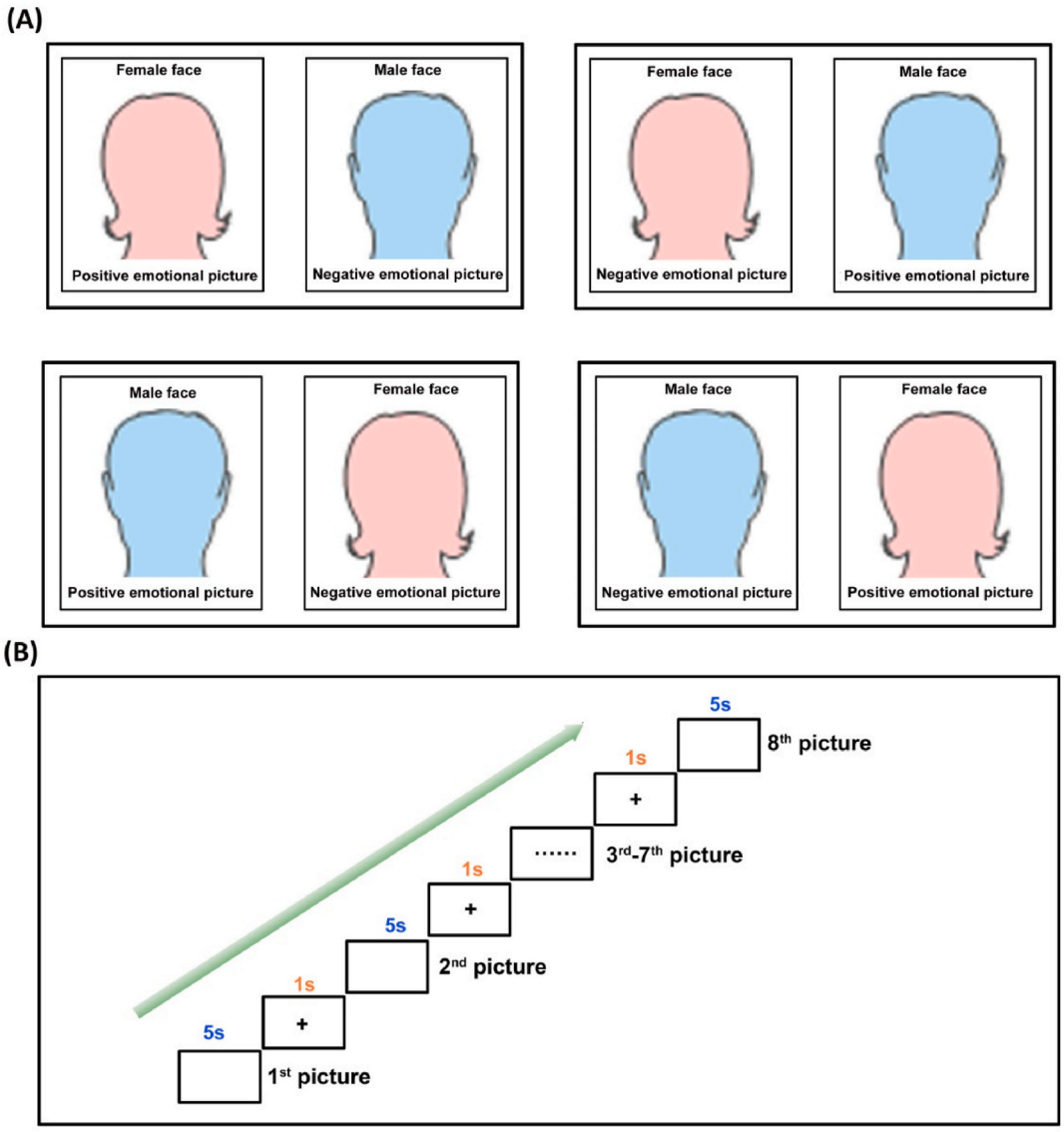

Fig. 2. (A) The four examples of emotional picture pairs and (B) the procedure of the eye movement test. The emotional pictures are classified as positive or negative, as well as female or male. These picture pairs were randomly selected from Chinese Affective Picture System (CAPS) during the study.

2.4. Statistics

All data are presented as mean ± SD and performed through SPSS 22.0 (IBM Corp.). Each participant' mood during training was compared across two conditions using repeated measures one-way ANOVA at 4 time points. Where ANOVA were significant, post-hoc comparisons were made using LSD (Least Significant Difference) tests. Statistical significance of eye movement (FL, OL, FC, OC) were conducted 2 mood (positive, negative) x 2 condition (before and after competition) ANOVA (Analysis of variance). $P < 0.05$ was considered significant. Correlations were calculated with GraphPad Prism, reporting bivariate correlation coefficients and results of two-sided significance testing at a level of 0.05. Student t-tests were used to compare participants' moods and emotions of track and field events in which they performed successful and less successful.

3. Results

3.1. Changes in mood state during training

Fig. 3A shows that across the entire track training, tension, depression, anger, vigor, and self-esteem, fatigue, confusion detected by POMS like an iceberg profile except the 3rd week, where negative affect scales increased, and positive affect scales decreased than baseline. The profile on the 3rd week was characterized by a relative increase in negative mood, indicated by tension, depression, anger, confusion and vigor scores, combined with higher fatigue scores. The curves of increased negative mood and decreased positive mood like the phenomenon of iceberg melting, where the mountaintop descends while the mountain slopes raise, which suggesting a "melting" iceberg profile. One-way ANOVA showed that the feeling of tension [$F(1, 285) = 2.036$, $P < 0.05$] and depression [$F(1, 285) = 2.371$, $P < 0.05$] differed between the baseline and training on the 3rd week.

As shown in Fig. 3B, participation in field training was associated with a clear positive mood change. The tension, confusion and vigor scores revealed an increased trend, peaking on the 4th week. One-way ANOVA showed that the feeling of depression differed between the baseline and training on the 3rd [$F(1, 225) = 1.654$, $P < 0.05$] and 4th [$F(1, 225) = 1.138$, $P < 0.05$] weeks. In addition to a large decrease in depression ($P < 0.05$ on the 3rd and 4th weeks, as compared to the baseline), there was a slight increase in the mean vigor score, and a modest decrease in the mean anger score, although the difference was not significant.

These revealed differences in mood state changes and curve trends as track and field training progressed. Field training was associated with a more positive mood than track training.

3.2. Changes in mood state and eye movement parameters before and after the competition

3.2.1. Significantly increased mood state changes after track competition

As shown in Fig. 4A and B, track participants after the competition were found to be less tense ($P < 0.05$), depressed ($P < 0.05$) and fatigued ($P < 0.05$), and had more vigor ($P < 0.05$), while other mood (anger, self-esteem and confusion) were less impacted. The field groups exhibited a substantial decrease in feelings of confusion ($P < 0.05$), and increases in self-esteem ($P < 0.05$) after the competition, while other mood were only slightly influenced.

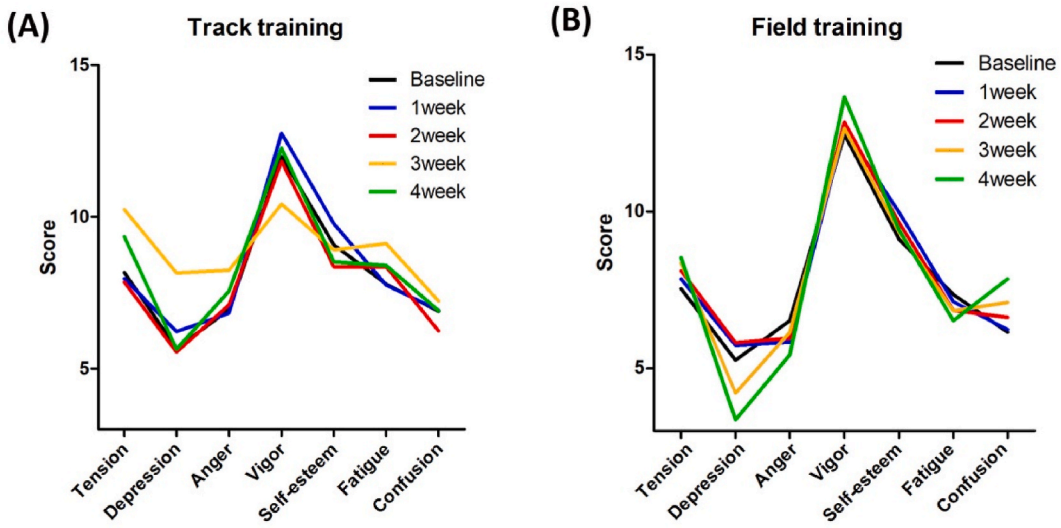

Fig. 3. POMS for tension, depression, anger, vigor, self-esteem fatigue, confusion over (A) track and (B) field training. POMS, Profile of Mood States.

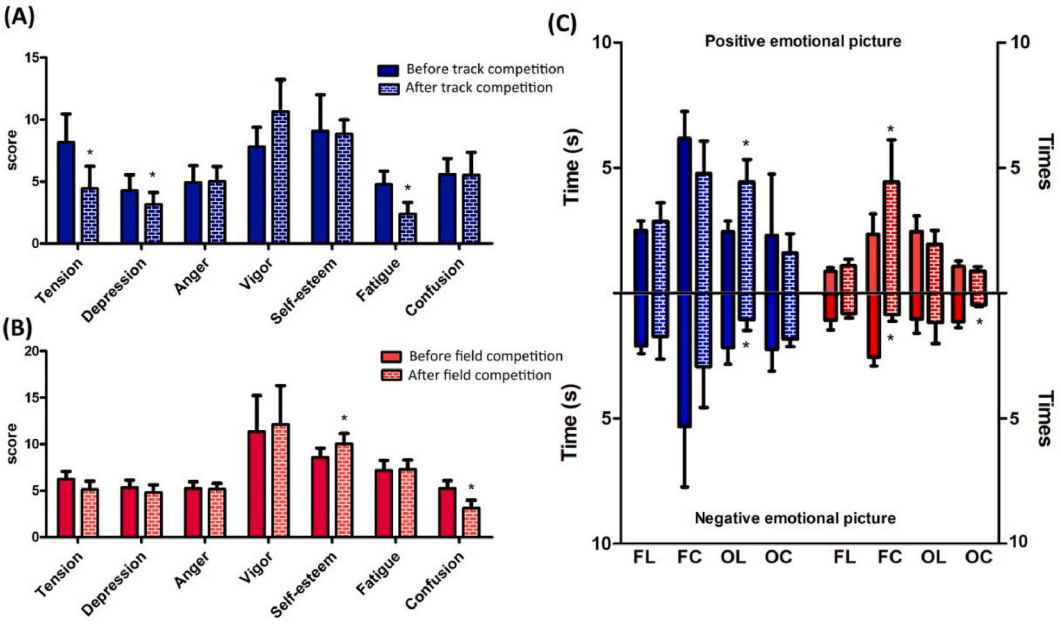

Fig. 4. Different mood state and eye movement before and after the competition. Tension, depression, anger, vigor, self-esteem fatigue, confusion measured by POMS before and after track (A) or field (B) competition. (C) FL, FC, OL, OC measured by eye movement in PEPs (upper) or NEPs (below). *P < 0.05 before vs. after match. FL, fixation length; FC, fixation count; OL, observation length; OC, observation count.

3.2.2. *More significant eye movement parameters after the field competition*

In Fig. 4C and Table 2, the OL results revealed significant main effects of mood, [$F(1, 1818) = 29.625$, $P < 0.001$, $\eta_p^2 = 0.025$] and condition $F(1, 1818) = 0.184$, $P < 0.05$, $\eta_p^2 = 0.017$] and significant mood × condition interaction, [$F(1, 1818) = 0.811$, $P < 0.05$, $\eta_p^2 = 0.05$]. Simple effect analysis was used to analyze the interaction between mood x condition, with college students after a track competition tending to watch PEPs intensely [$F(1, 1818) = 10.956$, $P < 0.05$].

The results showed that the OL of watching PEPs after a track competition were significantly increased as compared with that before the track competition. The higher the OL value, the longer the gaze time in the region of interest. This showed that students were more inclined to watch PEPs. PEPs make people happy and joyful, and the subjects were willing to spend more time appreciating them.

The FL and OL of watching PEPs or NEPs after the field match were increased, as compared with those before the match, but the difference was not significant. The FC results revealed significant main effects of mood [$F(1, 1436) = 6.160$, $P < 0.05$, $\eta_p^2 = 0.02$] and condition [$F(1, 1436) = 0.124$, $P < 0.01$, $\eta_p^2 = 0.01$], and a significant mood × condition interaction, [$F(1, 1436) = 0.274$, $P < 0.05$, $\eta_p^2 = 0.001$]. The results of OC revealed significant main effects of mood, [$F(1, 1436) = 3.612$, $P < 0.05$, $\eta_p^2 = 0.01$] and condition [$F(1, 1436) = 0.064$, $P < 0.05$, $\eta_p^2 = 0.01$], and a significant mood × condition interaction [$F(1, 1436) = 0.504$, $P < 0.05$, $\eta_p^2 = 0.001$]. Simple effect analysis was used to analyze the interaction between mood and condition, and the results showed that college students after a field competition tended to watch PEPs for a significantly longer time [$F(1, 1436) = 1.515$, $P < 0.05$] and NEPS for a significantly shorter time [$F(1, 1436) = 0.358$, $P < 0.05$].

Table 2
Eye movement changes before and after track or field matches.

Conditions	EM							
	Positive emotional pictures				Negative emotional pictures			
	FL	FC	OL	OC	FL	FC	OL	OC
Before track match	2.53± 0.38	6.15± 1.08	2.54± 0.43	2.3± 0.85	2.08± 0.31	5.30± 2.41	2.15± 0.65	2.23± 0.87
After track match	2.88± 0.73	4.78± 1.29	4.45± 0.89[a]	1.61± 0.77	1.73± 0.91	2.94± 1.62	1.06± 0.43[a]	1.83± 0.31
Before field match	0.93± 0.14	2.38± 0.81	2.46± 0.63	1.1± 0.23	1.04± 0.38	2.52± 0.36	1.01± 0.57	1.12± 0.23
After field match	1.10± 0.26	4.45± 1.67[a]	1.95± 0.56	0.90± 0.16	0.81± 0.19	0.85± 0.27[a]	1.17± 0.84	0.46± 0.07[a]

[a] $P < 0.05$ before vs. after the match. FL, fixation length; FC, fixation count; OL, observation length; OC, observation count; EM, eye movement.

3.3. Positive or negative mood (emotion) predict performance

3.3.1. Decreased TMD predicts good track performance but not field performance

A significantly negative correlation was identified between ΔTMD (post-match TMD - mean of training TMD) and improved track performance (competition performance - mean of training performance) ($r = -0.3609$, $P < 0.01$) as shown in Fig. 5A and Supplementary Table 1: a lower ΔTMD and a more positive mood state, was associated with a higher performance improvement. There was also a negative correlation between ΔTMD and improved field performance ($r = -0.1891$, $P = 0.1979$), although it was not significant (Fig. 5B and Supplementary Table 2). These data showed that a decreased TMD is an indicator of better track performance.

3.3.2. Positivity of eye movement predicts a better field performance than track performance

In line with the above results, a positive correlation was also identified between eye movement positivity [FL + FC + OL + OC of PEPs - (FL + FC + OL + OC of NEPs)] and improved track performance ($r = 0.1470$, $P = 0.2753$), and a significant positive correlation was identified between eye movement positivity and improved field performance ($r = 0.4274$, $P = 0.0024 < 0.01$) (Fig. 5C and D). These data indicated a moderate and significant association between positive mood changes tested by eye movement and competition performance improvement, particularly in the field competition.

Generally speaking, ΔTMD was negatively correlated with improved track performance, but eye movement positivity was positively correlated with an improved field performance. A similar but very slight association was observed in improved field performance with ΔTMD, and improved track performance with eye movement positivity.

3.4. Different parameters predict performance in different sports

A better-than-training performance during the competition days was considered a successful performance (good performance), otherwise, it was a failed performance (bad performance), which appeared to be associated with certain parameters on scales.

3.4.1. Fatigue increase and vigor decrease during training predicts good track performance

Over the track training time, before the 3rd week (Fig. 6 A, B, C), there were no obvious mood state profile changes between good and bad performance; in the 3rd and 4th week (Fig. 6 D, E), the mood between good and bad performance participants in the competition gradually separate, fatigue increased ($P < 0.05$), vigor decreased ($P < 0.05$) significantly.

On the contrary, from the beginning to the end of field training, for those who succeed or fail in field competitions, the mood changes were not significant and do not change with time and the accumulation of training. Only confusion and fatigue decrease, but

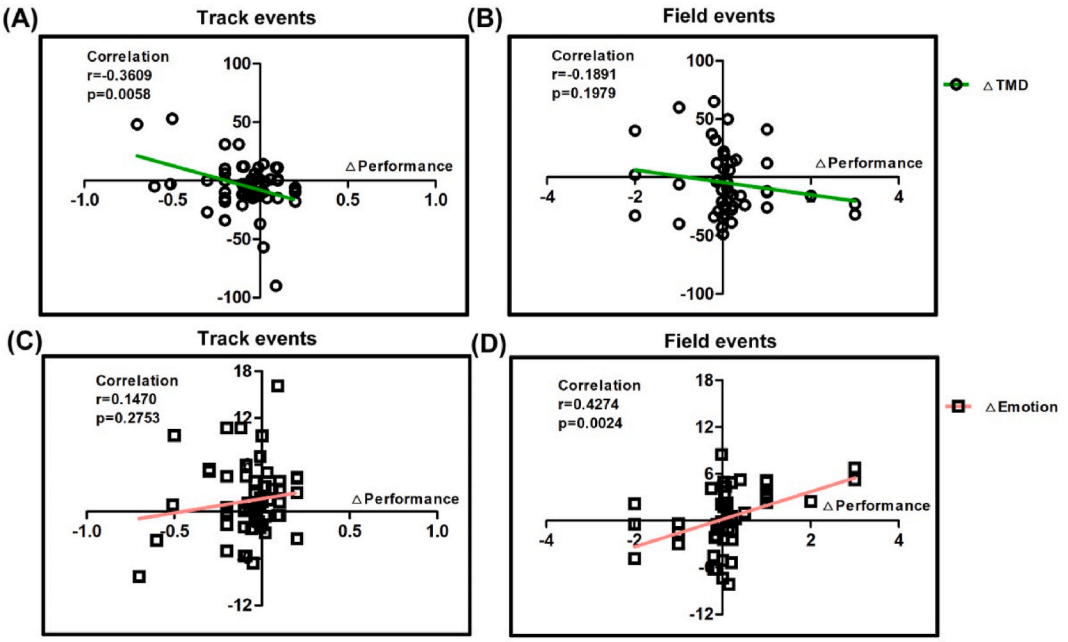

Fig. 5. Correlation between performance and mood or emotional state. (A) Correlation between track performance changes and TMD changes; (B) Correlation between field performance changes and TMD changes; (C) Correlation between track performance changes and emotional changes; (D) Correlation between field performance changes and emotional changes.
ΔPerformance = competition performance - training performance, ΔTMD = TMD after competition - TMD mean of training, Δ Emotion = after competition Δ (positive-negative) - before competition Δ (positive-negative), Δ (positive-negative) = positive (FL + FC + OL + OC) - negative (FL + FC + OL + OC)]. TMD, total mood disturbance; FL, fixation length; FC, fixation count; OL, observation length; OC, observation count.

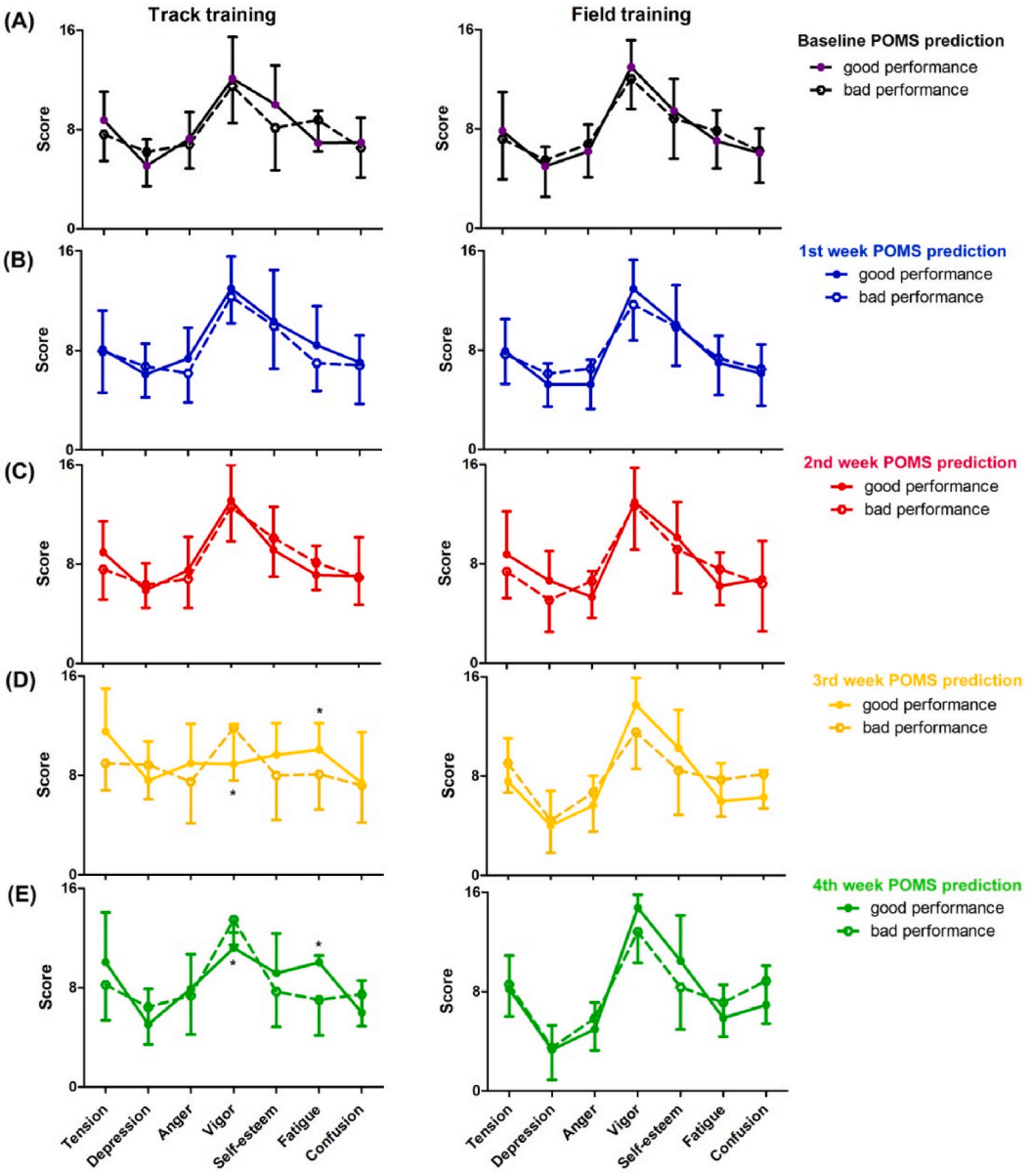

Fig. 6. Different mood profile during training between different performances (good or bad performance). The impact of mood changes (tension, depression, anger, vigor, self-esteem fatigue, confusion measured by POMS) after different training periods (A: baseline; B: 1st week; C: 2nd week; D: 3rd week; E: 4th week) on competition performance (good or bad performance in track or field).

there was no significant difference (Fig. 6).

3.4.2. Fatigue and depression decrease, vigor increase before competition as indicated by POMS predicts good track performance

The mood profile of good track performance groups was not relatively flat and showed higher scores except depression as well as fatigue, a significant increase in vigor, as compared to that of not good track performance groups (Fig. 7A).

To allow for simultaneous comparisons across different mood states in track training, post-hoc tests revealed significant differences between good and bad performance groups for depression ($P < 0.05$), vigor ($P < 0.05$) and fatigue ($P < 0.05$), with the good performance group having higher scores in vigor, lower scores in depression and fatigue, but no difference in tension and anger as compared to the bad performance group.

3.4.3. Decrease in anger and increase in confusion before competition facilitates successful field performance

Using a better-than-training performance in the field match as the criteria for a successful performance, it was found that a successful performance was accompanied by with higher POMS scores (except for depression and anger). Changes in anger and confusion

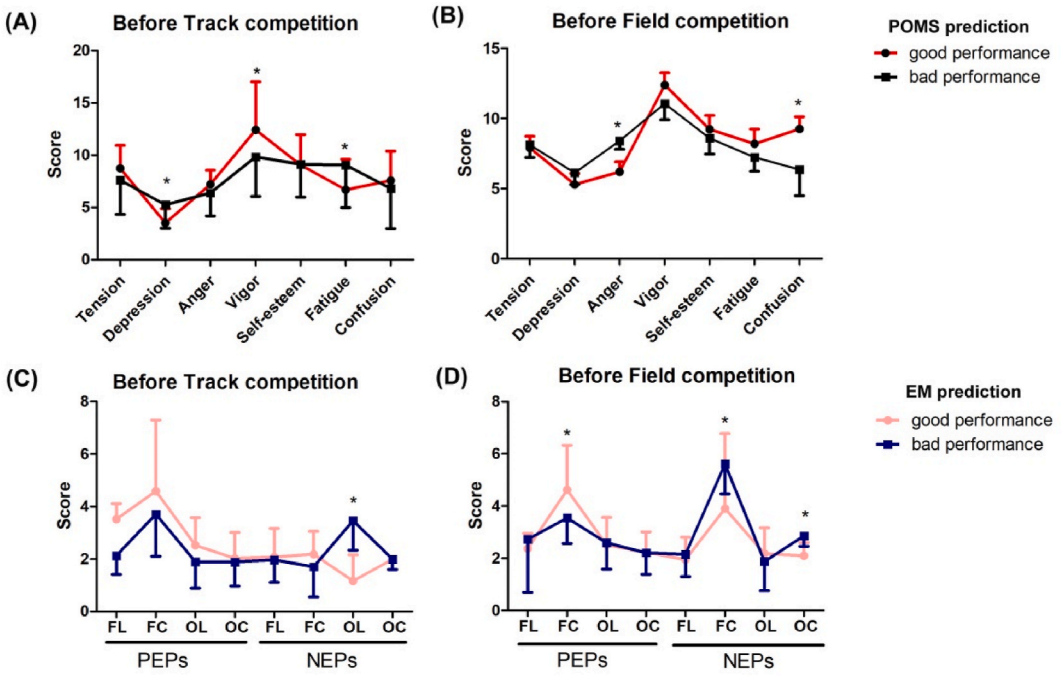

Fig. 7. Differences in mood state and eye movement between different performances (good or bad performance). Differences in tension, depression, anger, vigor, self-esteem fatigue, confusion measured by POMS between good or bad performance in track (A) or field (B) event; differences in FL, FC, OL, OC measured by eye movement in PEPs (left) or NEPs (right) between good or bad performance in track (C) or field (D) event.*P < 0.05 good vs. bad performance. PEP, positive emotional pictures; NEP, negative emotional pictures; EM, eye movement.

during a successful performance in field match were significantly decreased (P < 0.05) and increased (P < 0.05). There was no difference in vigor, self-esteem, and fatigue in field events for both the successful and less successful groups (Fig. 7B).

3.4.4. A lower OL of NEPs is indicator for good track performance

Participants whose performance was good in a competition spent a longer time and fixation counts looking at PEPs, though no significance was identified. Participants spent similar amounts of time and fixation counts looking at NEPs, and differences in the OL of NEPs were evident across successful and less successful performances in the track match; the line chart was relatively stable. The trend to watch more PEPs and less NEPs, which presents positive mood, was associated with a successful track performance, as shown in Fig. 7C.

3.4.5. A higher FC for PEPs, and lower FC and OC for NEPs, are linked to a good field performance

The results revealed no significant differences in FL, OL and OC for PEPs between good and bad performances during the field match, and the FC of the good performance group remained elevated above that of the bad performance group. Precompetitive emotions tested by eye movement were linked to field performance, and a decreased pattern of results was observed for dwelling time of NEPs: the FC and OC of NEPs of the good performance group was significantly decreased, as compared with that of the bad performance group (Fig. 7D).

4. Discussion

College students are an important component of society, have a special social status, the quality of college students has always been a hot topic of social concern. During the process of participating in athletics, student s' physical strength and endurance can be increased, which can promote further improvement of psychological development and ensure their mental health [39]. Through scientific and planned athletics, physical and mental health can be effectively regulated [40]. In track and field teaching in universities, only physical fitness training is emphasized, while the impact of psychological changes on physical fitness among college students is ignored [41]. The present study explored the psychological changes of college students during track and field training, as well as the impact of changes in college students' mood or emotions before competitions on competition results. It attempts to find effective training to promote college students' mental health and hopes to find some indicators that can predict performance.

Training effects before the competition days appeared to differ between sports, and probably between levels of participation [42]. Data from the present study showed that mood varied during training in track and field events. Specifically, participants reported higher levels of tension and depression on the 3rd week after track training, but lower levels depression on the 3rd and 4th weeks after

field training. In particular, during the 3rd week, the relative lack of positive mood changes for track-training participants may indicate that track training does not produce the same euphoric feeling as field training. The participants had a decrease vigor distribution in the middle of the training during intensive training, which then improved toward the end of the training, when the training became lighter. These POMS changes were fairly consistent throughout the literature, that is, that mood states decline or change from the baseline to the halfway point, and then slightly improve from the halfway point to the end of training [43].

The effects of mood during training differed between the track and field events on the competition day, only mood in the track training could predict the outcome of the competition. Track training had a more negative influence on mood than field training. These findings might be explained by participants in the track training experiencing some negative mood states instead of having better performance to truly enjoy the activity, which may due to aerobic work capabilities of athletes varying more extensively during the training season for runners with low fitness levels [44]. In addition, the incongruent results could be attributed to the difference between the competitive nature of a track and field competition and the noncompetitive nature of training, as well as adequate training time.

The present study attempted to explore the impact of an athlete's mood and emotion before competition on performance. College students participating in the competition days were selected to examine the association between precompetitive mood or emotion and performance. The way to reduce the temporal proximity between mood or emotion and performance is to access as close to competition as possible (e.g. within 1 h) [26]. Before the competition, the track participants who reported higher levels of vigor, tension, but lower depression and fatigue tended to be more successful in competition; the field participants who reported higher levels of confusion and lower anger more inclined to perform better in competition. In general, the training and pre competition mood had an opposite impact on competition performance.

The mood states measured by POMS using self-reported information should be supplemented with other objective types of data to reflect mood or emotion states before and after track and field events. The eye movement test results were beyond the scope and depth of POMS, and covered other aspects: the eye movement test provides objective and quantitative data on where, at what frequency, and for how long people look at stable emotional pictures [45]. This cannot be inferred with certainty from the data collected from POMS. Therefore, the researchers could test whether the athletes' performance in the competition was attributed to their emotional state. Data from the present study found that a better performance was negatively correlated with increased TMD and positively correlated with an increase eyes settled in PEPs. This suggested that positive mood or emotional states were associated with successful performance; however, external factors such as from referee and fitness to the competition place were not excluded. Furthermore, more POMS indicators were used to predict track performance, while more indicators of eye movement were used as an indicator for predicting field performance. Of note, mood, the feeling states for a period of time, (tested by POMS) was an indicator of track performance that lasted for 12 s - 17 min in this study. On the other hand, emotional state, the transient feeling states, defined as a set of feelings, ephemeral in nature detected by eye movement, was an indicator of field performance, which lasted for $<$30 s, but was measured by distance. There may be an association between the duration of sports events and length of feeling states. In addition, depression, vigor and fatigue as measured by POMS predicted track performance, and the FC for PEPs, FC and OC for NEPs as measured by eye movement predicted field performance. These results appeared to be in accordance with the literature: depression score facilitated cross-country performance; depression and anger were associated with weight lifting performance, anger and vigor were associated with baseball performance [26]. Fixation appeared to have a discriminatory emotional effect in pleasant and unpleasant stimulus. The first fixation and first fixation duration for both emotional stimuli were not significantly different, but fixation length and fixation count were significantly different between pleasant and unpleasant stimuli [34].

Training teaches athletes the importance of improvement, trying hard and following a coach's training plan, whereas a competition makes athletes more competitive and enhances their self-esteem [45,46]. Compared to the relatively short competition times, the duration of training is usually much longer. Accordingly, coaches and athletes should, become aware of a range of effective control strategies to assist in controlling negative affective responses during training. This may help maintain effort and performance in subsequent training sessions and matches.

5. Conclusion

Mood changes across the training season provide coaches with the opportunity to better know and monitor athletes; ensure they are appropriately trained to maximizing performance. It would enable them to use strategies to make them aware of their mood and how it influences their performance and prevent possible negative effects, so as to optimize success rates.

Through the present study it was found that POMS and eye movement are two indicators for monitoring mood and emotions which, along with other physical variables, can predict performance in athletic events, since the physical aspect is a very important factor for athletes to perform well.

6. Limitation and future research

The present study was not without its limitations. First, although the purpose of this study was to target male individuals who were good at track or field events, it excluded individuals who were female. Thus, a generalizing of these findings based on individual mood or emotion measures as predictive for future performance may be limited. Secondly, the data of the present study was collected from the participants' self-reports (POMS) and from objective detection (eye movement); however, as the emotion changes were dynamic over time, the detection indicators at different time periods after the competition may not necessarily reflect real emotional changes. Finally, it is necessary to collected more individual data from more types of exercise in the future to provide a more solid basis for

further research.

Research has suggested that the link between mood and performance may draw upon variables such as the duration of the event, sport type, or even the place of the match [40]. The study extended previous research by demonstrating that changes in mood or emotions are associated with sports categories and duration or distance in sports. Certain changes may have a number of different consequences. If sorted by duration, the range of duration of track events was very large: track events usually lasted between 12 s and 17 min. In fact, the duration of short-distance track events (100 or 200 m; e.g. <1 min) was higher than that of the field events (e.g. <10 s). The long-distance track events (800, 1,500, 3000 and 5000 m) lasted between 2 and 18 min in the present study. If sorted by distance, the distances of field events were <100 m, considerably shorter than those of track events. Although track events are measured by time, and field events by distance, the order of sorting by duration or distance was that field events precede track events. If the data had been analyzed by cluster analysis, the outcome could have been very different; therefore, further investigation is required.

A better understanding of these has clear practical applications in the design of comprehensive training programs, according to event duration, sport type, or even the "distance" of the game of competition. It has been suggested that more qualitative and sophisticated research is warranted to determine the contributions of mood or emotion changes in performance in other sports measured by time or distance, in order for the conclusion of this study to be fully confirmed.

Declarations

Ethics approval and consent to participate: All experimental protocols and methods were approved by Psychology and Education Research Ethics Committee (**No.** 2021-04-01), and Experimental research Ethics Committee in College of Physical Education, as well as the informed consent from all subjects was obtained for publication in an online open-access publication. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Availability of data and material

All data generated or analyzed during this study are included in this published article.

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Author contribution statement

Liang Pang: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper. Xinyi Xie; Yigang Lin: Contributed reagents, materials, analysis tools or data.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of competing interest

We declare that we have no financial and personal relationships with other people organization that inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the manuscript entitled ''POMS and eye movement: two indicators for performance in athletics".

Abbreviations

POMS	Profile of Mood States
PEPs	positive emotional pictures
NEPs	negative emotional pictures
TMD	Total Mood Disturbance
FL:	fixation length
OL:	observation length
FC	fixation count
OC	observation count

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e17860.

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