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Review Article

Leveraging Artificial intelligence (AI) for Stress Management in Peak Athletic Performance: An Integrative Review

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About Article

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ABSTRACT

Athletes often experience stressors that can impede their performance and well-being. Lack of coping resource or poorly regulated stress can undermine physical output, decision making and well-being. Effective stress management is crucial for achieving peak performance. This paper synthesize evidence on stress management strategies in sports psychology as well as AI powered stress management strategies using an integrative approach. The findings are presented narratively and organised into emerging themes. These strategies are categorized into cognitive-behavioural strategies, mindfulness-based strategies, relaxation strategies, biofeedback and technology-based and social support, and team-based strategies. AI powered stress management strategies were classified in the study as; AI powered wearable monitoring, virtual therapy and chatbot counseling, predictive analytics for stress forecasting, AI guided biofeedback training, AI enhanced injury and recovery support, AI supported cognitive behavior training, and integration of AI with human support systems. The following benefits are derived from the integration of AI in stress management for athletes; Improved performance, enhanced well-being, continuous and objective stress monitoring, all round support for athletes, Injury prevention, early detection and intervention, personalised training and recovery, confidentiality and stigma reduction. Advances in AI for stress management should focus on refining AI-powered injury prevention models, improving biometric sensing capabilities, advancing edge AI for real-time data processing, and integrating wearables sweat analysis to provide feedback, among others. This paper recommends that multimodal, specific interventions should be integrated into regular athletic training, warm-up and recovery process of athletes in order to attain peak performance and enhance overall well-being. Also that a hybrid approach adopted by sport psychologist integrating AI to support stress management among athletes will lead to a faster and positive outcome in stress management.

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1. INTRODUCTION

Athletic performance is the product of an intricate interaction between physical skills, tactical awareness and psychological readiness. Among the numerous psychological determinants, effective stress management stands a crucial factor that influence performance outcomes. Stress is defined as a situation that occurs when psychological demands are perceived (consciously or unconsciously) by an athlete to exceed his or her coping resources. Stress is inherently part of competitive sports. Athletes encounter plethora stressors, which emanate from different sources. These are based on personal, competitive and organizational stressors, which include performance pressures and expectations, injuries and the balancing of sport with other life demands (Arnold & Fletcher, 2021, Fletcher *et al.*, 2012).

Stress can manifest as competitive anxiety, the pressure to perform, fear of failing and external expectations from coaches, peers and audiences (Cox *et al.*, 2003). Moderate stress is facilitative and can enhance performance by increasing arousal, focus, alertness and motivation, while excessive stress is debilitating, often results in performance decline, disrupt motor coordination, impair decision-making, increased risk of injury, and mental exhaustion (Jaiyeoba, 2021; Fletcher & Sarkar, 2012). Inability to effectively manage these stressors can negatively affect athletes' performance and well-being (Arnold & Fletcher, 2021; Jaiyeoba, 2017). To effectively manage stressors in order to improve and achieve optimal performance and improved well-being, it is essential for athletes to master diverse range of stress management strategies.

Technology is emerging as an avenue to manage human endeavors. The rapid advancement of digital technologies has transformed how individuals interact with devices such as computers, tablets, and smartphones, reshaping daily activities and performance optimization strategies (Omokhabi, 2021). Its scope continues to broaden, with diverse tools and usage patterns rapidly reshaping how people live and work (Omokhabi, 2023). People now use technology in every sphere of existence.

Artificial intelligence is emerging as a refined way to enhance athletic performance. A new way of managing stress in now through the use of technology and predominantly through Artificial intelligence. In recent years, AI has emerged as a powerful tool across various fields, including education (Ojokheta & Omokhabi, 2023), healthcare Omokhabi *et al.* (2025) and more recently, sports. These technologies are widely applied across various aspects of human activities to simplify operations. The integration of AI into sports is not only transformating how athletes train and compete but also how they manage stress and maintain good mental health. Within the context of sports, these technological innovations provide the foundation upon which artificial intelligence (AI) is being leveraged to support stress management and mental well-being among athletes.

AI tracks athletes movement, position body signals to give feedback that may prevent circumstances that affect the well-being of the athletes like injury. Biofeedback technology which uses electronic devices with electrodes and sensors to assess, monitor and relay psychophysiological information back to the individual is gaining recognition as a comprehensive tool for enhancing athletes performance and psychological well-being (Jaiyeoba, 2022). Wearable devices are now gaining prominence for early detection of fatigue and stress in athletes and timely intervention which ensures that athletes maintain peak performance. By leveraging AI strategies, athletes can easily manage stress and achieve peak performance. AI therefore offers a proactive approach to stress management with emphasis on prevention rather than cure. Within this technological evolution, mental health remains a critical dimension, as it influences how individuals including athletes respond to stress, regulate emotions, and make decisions (Omokhabi, 2025). Past studies have shown that athletes' performance and well-being are influenced by a range of physical and psychological factors. For instance, nutrition plays a vital role in shaping athletes' health outcomes (Jaiyeoba, 2016) as well as physical exertion like injury. However, broader participation in sports has been linked to social inclusion and personal development (Jaiyeoba & Oguntuase, 2019), hence participation in sport is a necessity for an athlete. Furthermore, the psychological strain faced by athletes particularly during transitions such as retirement can negatively impact their mental health and quality of life (Jaiyeoba & Ogunsanya, 2021). Leveraging AI-powered strategies such as predictive analytics, personalized biofeedback, and virtual therapy offers a promising pathway to address these challenges, ensuring peak athletes maintain resilience, manage stress effectively, and sustain long-term well-being.

Previous studies have focused largely on AI applications in sports psychology but little have specifically proffered strategies for stress management among peak athletes. This study therefore intends to examine AI powered stress management strategies that can be adopted for peak athletes. This study further intend to find out the benefits of AI powered stress management as well as future directions in AI integration for stress management.

1.1. Research questions

i. What are the stress management strategies that could be adopted for peak athletes?

ii. What are the AI powered stress management strategies that can be utilised for peak athletes?

iii. What are the benefits of AI in stress management for athletes?

iv. What are the future directions in AI integration in stress management?

2. LITERATURE REVIEW

2.1. Theoretical Foundations of Stress in Sports

The understanding of stress within sport settings has undergone a profound transformation over the past few decades. Sport psychology draws upon several robust theoretical frameworks that illuminate the complex processes through which athletes perceive, experience and respond to stressors. These foundations provide essential direction for research and practice.

2.2. The transactional model of stress

Transactional model of stress propounded by Lazarus and Folkman (1984) posits that stress is not merely a response to an external event, but rather a dynamic transaction between the

individual and environment, heavily influenced by cognitive appraisal. That is, stress arises from how athletes evaluate the significance of a situation (e.g., a championship final, a critical penalty kick) as threatening or challenging, which in turn affects the stress response and the coping strategies employed. Primary appraisal evaluates threat level, while secondary appraisal assesses coping capacity.

2.3. Biopsychosocial model

Biopsychosocial model states that stress is influenced by the complex interplay of biological, psychological and social factors (Engel, 1977). Biological factors include physiological reactivity to stress (e.g., activation of the sympathetic nervous system (SNS) and hypothalamic-pituitary-adrenal (HPA) axis), genetic predispositions, neurochemistry, physical fitness, injury status and recovery processes. Chronic stress leads to dysregulation (e.g., elevated cortisol and impairing performance) (McEwen, 2021). Psychological factors encompass cognition (appraisal, beliefs, attention, self-efficacy), emotion (anxiety, fear, excitement), motivation, personality traits and learned behaviours (coping styles). Social factors include coach-athlete relationships, team dynamics, social support, organizational culture, fan/media pressure, cultural expectations and socioeconomic factors. Negative social interactions or lack of social supports are potent stressors (Adelusi *et al.*, 2023; Fletcher & Sarkar, 2012).

2.4. Theory of challenge and threat states in athletes (TCTSA) (Jones *et al.*, 2009).

The theory of Challenge and Threat States in Athletes builds upon transactional model of stress and biopsychosocial model. This theory posits that athlete's perception of competition as either a challenge or threat considerably depends on athlete's interpretation of the situational demands and their available resources. These states elicit distinct physiological, psychological and behavioural responses that significantly impact performance. Challenge and threat are motivational states that impact the manner in which athletes involve in competition and includes cognitive, affective and physiological characteristics (Blascovich & Mendes, 2000).

2.4.1. Psycho-physiological effects of stress

Stress is unavoidable in sports. It influences athletes' mental states, physical readiness and overall well-being. Moderate stress can serve as motivational driving force by sharpening the focus and stimulating the energy, while excessive poorly managed stress exerts psycho-physiological consequences.

Psychologically, athletes frequently experience stress in the form of performance anxiety, fear of failure and cognitive disruption. Elevated stress can reduce self-confidence, interfere with concentration and foster maladaptive thought patterns such as self-doubt and catastrophizing (Fletcher & Sarkar, 2012). During intense competition, athletes may struggle with impaired decision-making and attentional control, leading to decreased tactical execution and situational awareness. Over time, chronic psychological stress increases the risk of burnout, characterized by emotional exhaustion, reduced accomplishment and sport devaluation (Jaiyeoba, 2018; Gustafsson *et al.*, 2017). Furthermore, persistent stress exposure may predispose athletes to clinical concerns such as depression and anxiety disorders, which may threaten their long-term involvement in sport.

Physiologically, stress activates the hypothalamic pituitary adrenal (HPA) axis and the sympathetic adrenal medullary system, which results in elevated cortisol and adrenaline secretion (Kudieka & Wust, 2010). These responses are adaptive in the short-term, preparing the body for "fight or flight" demands. However, prolonged arousal produces detrimental outcomes. Increased heart rate, blood pressure, muscle tension and rapid respiration compromise motor coordination and fine skill execution. Sustained cortisol exposure also weakens immune function, delays recovery and increases the likelihood of overtraining, illness and musculoskeletal injury (Crewther *et al.*, 2011). In addition, stress-induced sleep disturbances impair memory consolidation, learning and energy restoration, which exacerbate both physical and cognitive fatigue.

3. METHODOLOGY

An integrative review of major database, peer review journal, articles official publication and other electronic database was conducted. Keywords used for the search were " Artificial intelligence in sports/Athletes, machine learning in sports/ sport psychology, stress management, stress management strategies, predictive analytics/sport analytics, smart Sports psychology, technology based strategies". These key words were at some instances joined with and, OR before the search. The search yielded a lot of publications from which the researcher purposively selected relevant studies. The inclusion criteria of the study is as follows:

Studies included must be a peer review article or official publication or any other relevant electronic source in English language and having the Keywords stated earlier and must be a recent study from 2015 till date. This review will include both empirical and position papers as well as systematic and integrative studies. The selected studies must also contribute to the understanding of the topic under review. Only titles and abstract that are relevant to the study was selected.

The study will exclude all articles or journals that does not satisfy the inclusion criteria.

Search strategy includes:

i. Identification of related studies through electronic search of major databases and other sources which yielded over 1000 studies i.e n = 1330. The duplicates removed are 210. The more recent studies were given preference over older ones. A total of 1120 publication were left after removing the duplicates.

ii. Screening of the publications abstract and titles for relevance. The 1120 publication left was therefore reduced to 225 after screening and the exclusion of 895 studies.

iii. A total of 225 publications were assessed for eligibility and 151 studies were further excluded because they did not focus on AI or stress management, had methodological weaknesses, not directly related to athletes or peak athletes, not peer review and not English language publication with corresponding values of n = 81, 32, 22, 10 & 6 respectively. The studies remaining and included are 74, hence n = 74.

Key information were extracted from the study and refined in the researcher's language. The researcher therefore identified

the strategies for AI integration for Athletes, summarised the benefits and documented any future research potentials suggested by the studies. The information once extracted was grouped into themes for easy understanding and to identify common patterns, trends and insights across different purposively selected publications.

3.1. Expected outcomes

This study aims to provide insight into AI driven strategies for stress management among athletes. This study will inform the development of other technology driven strategies in different areas of sport psychology. This study will enlighten stakeholders on the modern ways of managing stress for optimal output. This study will reveal interventions that will further strengthen stress management in the field of sport psychology.

3.2. Implications

This study will be relevant to sport psychologist, policy makers, technology developers and other stakeholders. This study will map out AI driven strategies for stress management among athletes. This study will reveal the benefit of AI in stress management for athletes. This study will also reveal future directions in the integration of AI for stress management among athletes.

4. RESULTS AND DISCUSSION

4.1. Stress management strategies in sport

Stress management refers to the environmental, physiological, cognitive and behavioural techniques employed by an individual to cope with the factors and components that underlie the experience of stress (Owen *et al.*, 2009). The main goal of stress management in sport is to allow the athletes to effectively regulate competition associated demands to enhance performance as well as overall well-being. Effective stress management is essential for peak athletic performance. Stress management is multidimensional which requires interventions that target cognitive, emotional and physiological systems. The strategies discussed in this paper are evidence-based and are adaptable to individual athletes and sport-specific demands.

4.1.1. Cognitive-behavioural strategies

Cognitive-behavioral strategies are among the most researched and effective methods for managing stress in sports. These strategies aim to identify and modify maladaptive thoughts, emotions and behaviours that contribute to performance-related stress and anxiety (Dozois & Beck, 2023).

i. Cognitive restructuring: Cognitive restructuring, a key component of cognitive behavioural therapy (CBT), helps athletes to identify and challenge irrational thought patterns and replace them with more positive and adaptive ones (Haney, 2004). This technique involves identifying cognitive distortions like catastrophizing, all-or-nothing thinking, and negative self-talk, replacing them with more adaptive thoughts. Studies have indicated that cognitive restructuring reduced competitive anxiety, stress, depression and improved confidence, self-efficacy and athletic performance of athletes (Williams & Krane, 2021; Jaiyeoba, 2018; Haney, 2004)

ii. Thought stopping: Thought-stopping entails training the athlete to actively handle intrusive negative thoughts from further occurrence. This technique involves training athletes to break negative thought cycles using verbal or physical cues, then replacing them with positive or neutral thoughts (Thompson & Sherman, 2014). The process typically evolves from using external cues from sport psychologists or coaches to developing internal self-regulation strategies. A systematic review by Rumbold *et al.* (2012) revealed that thought stopping is effective in managing stress, anxiety, enhance well-being and sport performance. Purposefully and consistent practicing of thought stopping is associated with its effectiveness.

iii. Self-talk: Self-talk refers to statements that athletes used to address themselves. This might involve automatic verbalizations or more conscious forms of speech. It encompasses statements said aloud or inwardly, as a silent or quiet voice in one's mind aimed at achieving particular outcomes in sport context (Hardy & Olivier, 2014). Self-talk can be instructional or motivational. Instructional self-talk focuses on technique and strategy, whereas motivational self-talk increases effort and boosts confidence. Self-talk has been found to improve performance, buffer pressure, manage stress maintain motivation (Hardy & Olivier, 2014; Tod *et al.*, 2011).

4.1.2. Mindfulness-based strategies

Mindfulness-based strategies have gained significant attention in sports psychology due to their effectiveness in reducing stress and enhancing performance. Mindfulness, defined as a state of consciousness that occurs from paying attention to the present moment, without judgement and being fully aware of the unfolding of each experience moment by moment (Kabat-Zinn, 2003). Various mindfulness-based interventions have been designed to reduce stress, improve performance and well-being. These include Mindfulness-Based Stress Reduction (MBSR) (Kabat-Zinn, 1982), Mindfulness-Acceptance-Commitment (MAC) (Gardner & Moore, 2007), Mindfulness Sport Enhancement Program (MSPE) (Kaufman *et al.*, 2009) Mindfulness Meditation Training for Sport (MMTS) (Baltzell & Aktar, 2014), Performance Enhancement Awareness and Knowledge (mPEAK; Haase *et al.*, 2016) among others.

Mindful breathing strategies form a fundamental component of mindfulness-based interventions. These practices involve focusing attention on the breath while observing thoughts and sensations without attachment or judgment. Body scan meditation is another core mindfulness practice, involves systematically directing attention to different parts of the body to develop awareness of physical sensations and tension patterns. This strategy helps athletes to identify early signs of stress and tension, which enables proactive stress management. Mindful movement practices, such as mindful walking or sport-specific mindful practice, integrate mindfulness principles with physical activity. These strategies have shown to be effective in reducing anxiety, coping with stress and setbacks, enhancing self-efficacy, psychological resilience, emotion regulation, well-being and performance (Oguntuase & Sun, 2022; Holguin-Ramirez *et al.*, 2020; Jones *et al.*, 2020).

4.1.3. Relaxation strategies

Relaxation is a deliberate psychological strategy used by sport

performers to aid management of stress-related emotions and physical symptoms during intense situations. These strategies help athletes to achieve a calm and focused state before, during or after competition. Common strategies include deep breathing, progressive muscle relaxation (PMR), guided meditation and visualization.

Deep breathing, also known as diaphragmatic breathing is a simple yet powerful strategy, which involves slow, deliberate inhalation that fully expand the lungs, engaging the diaphragm, followed by controlled exhalations (Russo *et al.*, 2017). This strategy improves oxygen exchange, reduces muscle tension and calm the nervous system. Progressive muscle relaxation (PMR) encompasses the processes of tensing and releasing of different muscle groups to achieve a state of deep relaxation (Jacobson & McGuigan, 2020), which provide significant benefits to athletes both before and after a performance. The implementation of PMR typically involves a structured progression from longer sessions focusing on all major muscle groups to short versions that can be used in competitive settings. Visualization and guided imagery techniques combine relaxation with mental rehearsal of successful performance. These approaches involve creating detailed mental images of an event in an athlete's mind while in a relaxed state. These various relaxation strategies have proven too be effective in reducing tension, anxiety, stress, improving sleeping quality, calmness, well-being, performance and developing confidence (Morris *et al.*, 2020; Kudlackova, *et al.*, 2013).

4.1.4. Biofeedback and technology-based strategies

Biofeedback constitutes an effective and non-invasive procedure, whose basic operating principle is the conscious registration of normally unconscious body procedures (e.g., brain activity, electrocardiogram, electromyography, or skin conductance) that are represented by a visual, haptic, or audio signal (Gaume *et al.*, 2016). Biofeedback is a technology that uses instrumentation to detect and amplify internal physiological processes in order to make this ordinarily unavailable information available to the individual as "feedback" in a form that is meaningful, rapid, precise and consistent (Blumentstein *et al.*, 2002). Biofeedback strategies provide athletes with real-time information about physiological processes, enabling them to develop conscious control over typically involuntary functions. The main procedures used to manage stress and facilitate optimal performance include electromyography (EEG), electrodermal biofeedback, thermal biofeedback, respiratory training, heart rate variability (HRV), virtual reality (VR).

Neurofeedback, or EEG biofeedback is used to measure brain activity (frequency and amplitude), and as such, it helps to determine if appropriate parts of the brain (e.g., those regulating coordination or spatial awareness) are active during peak performance or inappropriate parts (e.g., language production, and negative self-talk) are active. Electromyography (EMG) biofeedback focuses on muscle tension and can be particularly valuable for athletes in sports requiring precise muscle control. This technique involves placing sensors on specific muscle groups to provide feedback about tension levels, helping athletes learn to optimize muscle activation patterns and reduce unnecessary tension (Peper *et al.*, 2020). HRV biofeedback is a psychophysiological marker for monitoring and managing stress. HRV reflects the dynamic interplay between the sympathetic and parasympathetic parts of the autonomic nervous system (ANS). High HRV generally indicates greater parasympathetic (vegal) activity and autonomic flexibility, while low HRV indicates sympathetic dominance and physiological stress (Shaffer & Ginsberg, 2017). HRV biofeedback training can help athletes to regulate autonomic function, enhance vegal tone, reduce anxiety etc. Studies have indicated that different biofeedback strategies can enhance attention, reduce anxiety, tension, and enhance self-control under stress, improve focus, attention and performance (Jaiyeoba, 2022; Gong *et al.*, 2021; Gruzelier, 2019; Blumentstein *et al.*, 2002).

Virtual reality (VR) technology has opened new possibilities for stress management training in athletics. VR-based interventions can provide athletes with realistic simulations of competitive environments while teaching stress management techniques in a controlled setting (Slater & Sanchez-Vives, 2021). Research suggests that VR-based stress inoculation training can help athletes develop coping skills that transfer effectively to real competitive situations.

Mobile applications and wearable devices have made stress management tools more accessible to athletes. These technologies can provide guided meditation sessions, breathing exercises, and real-time stress monitoring throughout training and competition periods (Firth *et al.*, 2020). While research on these consumer-grade technologies is still emerging, preliminary studies suggest they can be valuable supplements to traditional stress management interventions.

4.1.5. Social support and team-based strategies

Social support and team-based strategies play a significant role in the management of stress among athletes. Competitive sport often exposes athletes to high physical and psychological demands, which include performance pressure, injury risks and balancing training with personal life. The presence of a supportive social and team environment acts as a protective buffer against stress. Social support can be emotional, informational or instrumental. Emotional support from coaches, teammates, family and peers promote a sense of belonging and reduces feeling of isolation during stressful moments. Informational support, such as feedback and guidance, helps athletes reframe stressors as manageable rather than threats. Instrumental support, which include assistance with training routines or recovery strategies, further reduces the burden of stress by sharing responsibilities (Rees & Hardy, 2004). Research demonstrate that athletes with strong social support networks experience lower levels of stress and show better performance outcomes (Jaiyeoba *et al.*, 2023; Freeman & Rees, 2021).

Team-based strategies are particularly effective because they build a collective culture of coping and motivation. When teams engage in open communication, mutual encouragement and shared goal-setting, athletes are more likely to feel secure and less overwhelmed by individual pressures. Team cohesion, an athletes sense of unity and identification with the group has been linked with lower levels of stress and higher performance outcomes (Carron *et al.*, 2020).

4.2. AI driven stress management strategies in sports psychology

4.2.1. AI powered wearable monitoring

Smart watches, fitness bands, biometric shirts, biosensors can be used to track heart rate variability, cardiovascular strain, muscle fatigue, sleep, cortisol levels, fatigue, hydration and muscular extension for athletes. These devices track indicators such as skin conductance (a measure of stress), irregular heart rhythms, and sleep disturbances, enabling the detection of patterns that may signal burnout, anxiety, or mental fatigue. This will enable the athlete get alert and recommendations when stress levels rise and adjust training intensity and recovery time. Studies such as Giggins, Persson and Caulfield (2020) have highlighted the value of wearable technology in gathering real-time biometric data including heart rate variability sleep patterns and Cortisol levels. These wearables when combined with AI algorithms can recognise patterns and give feedback to prevent injury or burn out. It is used to prevent injury, monitor health and also for performance improvement injury. Advanced sensors, such as inertial measurement units (IMUs) and electromyography (EMG) sensors, have emerged as vital tools in sports science in which according to Zhao *et al.*, these sensors can detect complex signals that represent athletes' movements and conditions, thus enabling more precise performance analytics and monitoring. Zhao *et al.* (2024), additionally, advances in Triboelectric nanogenerator (TENG) technology are further refining the capabilities of wearable devices, allowing for improved energy efficiency and flexibility in monitoring sports activities (Luo *et al.*, 2021; Chen & Liang, 2024). This level of detailed analysis was previously unattainable, giving athletes and coaches a powerful tool to enhance performance (Beal *et al.*, 2019). Findings above implies that athletes can use AI to recognize stress symptoms, monitor and track their stress level with AI tools and get feedback for optimal performance.

4.2.2. Virtual therapy and chatbot counselling

Athletes can use AI driven mental health apps like Woebot, Wysa to provide real time counselling, mindfulness exercises, mood tracking which are available all day round for competition anxiety or self doubt or emotional distress. This AI tool serve as an accessible stress management tool which provides real-time psychological support, enhance coping with stressors while ensuring confidentiality. This shows that AI can be used to minimize stress arising out participation in sport activities by athletes. Vaidyam *et al.* (2019) highlighted that chatbots and virtual therapy platforms provide scalable care i.e a single AI-driven system can interact with thousands of athletes simultaneously, offering psycho-education, stress management strategies, and symptom monitoring outside clinical hours. This scalability is particularly beneficial during large sporting events or in team environments. According to Inkster *et al.* (2018), AI-powered chatbots such as Woebot can deliver cognitive-behavioral therapy (CBT)-based interventions, providing immediate support for stress, anxiety, and low mood. The implication for athletes is the real-time coping strategies during periods of competition stress when therapists may not be available.

4.2.3. Predictive analytics for stress forecasting

AI can be used to analyse training load, performance data, social media use and self report to predict risk of burnout, emotional instability, depression or anxiety which can aid timely intervention from coaches or psychologist through stress reduction programmes. It enhances resilience prediction and personalization. AI-driven analytics are revolutionizing athletic performance by offering personalized training programs that are tailored to an individual athlete's needs (Rahmani *et al.*, 2024). For example AI can analyze an athlete's movements in real-time, providing instant feedback and suggesting adjustments to improve technique and reduce the risk of injury (Mulgan, 2016). AI algorithm provides real time diagnostic and predictive tools that can adapt to athletes changing needs (Ajiye & Ukpabi, 2025).

Islam and Washington (2023) proposed a model using self-supervised learning on each user's multimodal wearable time-series data, the pre-training on unlabeled data allows the model to learn individual baseline signal dynamics and accurately predict recurrent stress events with minimal labeled data thereby boosting personalization and reducing annotation needs. According to Davis *et al.* (2019), AI-driven predictive analytics has become a critical tool for sports teams, providing insights that were previously impossible to obtain. This implies that AI can be used to gain insight into behavior of athletes or forecast behavior for stress management.

4.2.4. AI guided biofeedback training

AI tools can be used to provide feedback on breathing, muscle tension and stress level. Athletes can practice guided relaxation, focus training and cognitive control to build self regulation skills that enable calmness under pressure. Pagaduan *et al.* (2020) demonstrated in their study that HRV biofeedback improves stress regulation and athletic performance. AI systems enhance this process by adjusting session intensity, duration, and breathing techniques according to each athlete's physiological responses, promoting optimal adaptation.

Jerath *et al.* (2023) noted that integrating HRV biofeedback into smartwatch and AI platforms enables athletes to train autonomic regulation outside the clinic. This portability provides always-available stress support, allowing athletes to practice biofeedback during travel, competition, or recovery. These feedback provides timely intervention to all stress prone situations. Pagaduan *et al.* (2020) noted that AI-assisted HRV biofeedback training can help athletes regulate autonomic balance, lower anxiety, and improve emotional control under competitive pressure. This mental resilience complements physical recovery, thereby offering holistic stress management. Addleman *et al.* (2024) emphasized that AI-guided HRV biofeedback helps athletes maintain autonomic flexibility during high-pressure competition. This according to Addleman *et al.* (2024) is by training the body to return quickly to parasympathetic dominance after stress. Therefore, athletes are better able to recover between matches and maintain performance consistency which reduces anxiety, depressive symptoms and psychological unrest making the athlete resilient to stress and be able develop better coping mechanism to regulate stress.

4.2.5. AI supported cognitive behaviour training

AI can deliver customised coping strategies (reframing negative thoughts, build resilience and manage performance pressure) based on needs that is tailored to competition schedules, recovery phases or injury which strengthens mental resilience and emotional control. This produces a fast relief of symptoms of depression and anxiety in athletes.

High engagement is crucial for athletes who need on-demand coping strategies during acute stress as AI agents can prompt breathing exercises, cognitive reframes, and short CBT modules at moments of need (Inkster *et al.*, 2018). Recent bibliometric and review work of (Vanhée, 2025) highlights the rapid emergence of AI techniques including LLMs and model-based personalization that can adapt CBT content to individual users' language, symptom profile, and progress. This for athletes supports personalized cognitive restructuring, exposure tasks (mental rehearsal), and homework tailored to sport-specific stressors. In addition, Farzan's 2025 synthesis of AI-CBT trials reports consistent reductions in anxiety and depressive symptoms across several AI agents (Woebot, Wysa), with high scalability. This suggests AI-CBT can be deployed across teams or during major events (e.g., multisport competitions) to provide standardized, evidence-based psychological support to many athletes simultaneously. Hurley (2021) review of online supports used during COVID-19 shows that remote CBT and digital psychological interventions can maintain athlete well-being during major disruptions. AI-CBT is therefore a robust strategy for continuity of care in times when in-person sport psychology is limited and in which according to Li *et al.* (2020), these systems offer individualised insights into athletic performance by collecting and interpreting data in real time. This implies that AI can be used for mind training for athletes and to build their strength.

4.2.6. AI enhanced injury & recovery support

AI can be used to predict injury risk from biomechanical data (gait, joint angles, acceleration) and training patterns which prevents stress caused by unexpected downtime and creates personalised recovery plans to balance physical and psychological readiness. AR and VR can be applied to create immersive and personalized rehabilitation experiences, which motivate athletes during the processes of the recovery, for the improvement of results and accelerating their return to competitions (Ruiz-Vanoye *et al.*, 2025). These experience help manage mental agony associated with rehabilitation.

4.2.7. Integration of AI with human support systems

AI can be used to complement sports psychologist, by handling monitoring and early detention while psychologist handle complex therapy and emotional care thereby resulting in a balanced, athletic centered mental health approach. Te'eni *et al.* (2023) described the concept of Reciprocal Human-Machine Learning (RHML), in which AI and human experts continually learn from each other. In sports contexts, psychologist-in-the-loop systems could refine AI predictions based on real-time human feedback, while humans benefit from AI-generated insights with a virtuous cycle enhancing stress monitoring and intervention. AI can assist sport psychologist by automating stress monitoring, communication, mood tracking, injury tracking and other mental health issues. AI systems can also analyze biometric and emotional data to support mental resilience which allows the psychologist to effectively manage stress.

4.3. Benefits of AI integration in stress management among athletes

4.3.1. Improved performance

Stress management through AI can lead to improved focus, concentration and overall performance. AI has revolutionized how athletes train and perform. By leveraging machine learning algorithms and data analytics, AI systems can process vast amounts of data from sensors, cameras, and wearable devices to provide detailed insights into athletes' performance (Rahmani *et al.*, 2024). And the feedback obtained from this information is vital to athletes improved performance with minimal effort. According to Dadi (2020), AI systems have significantly enhanced the ability to track and analyze player performance, leading to more effective training regimens and improved game strategies (Dadı & Yıldız, 2022). Neurofeedback and biofeedback help athletes develop a greater awareness of their mental and physical state, allowing them to optimize their performance and achieve a state of "flow" during competition (Corrado *et al.*, 2024). Research indicates that heart rate variability (HRV) sensors, GPS trackers, and biomechanical motion sensors improve training precision and workload management (Dwyer *et al.*, 2022; Zhu, 2025). The workload management is essential to stress management. HRV biofeedback that is delivered or optimized through AI platforms has empirical support for improving autonomic balance, reducing anxiety, and enhancing recovery in athletes and review report positive effects on psychophysiological variables relevant to performance.

4.3.2. Enhanced well-being

Combining biomechanical wearables with physiological monitoring via AI helps detect fatigue-related technique breakdowns and injury risk reducing the long-term psychological stress of injuries. AI can analyze video streams and data logs from IoT sensors to detect abnormal movements or patterns that may indicate a risk of injury, enabling early intervention and prevention, ensuring athletes' participation in competitive actions (Ruiz-Vanoye *et al.*, 2025).

Furthermore, AI-powered computer vision technology has improved movement tracking and biomechanical assessments, enhancing precision in technique evaluation and rehabilitation planning (Dwyer *et al.*, 2022). This findings implies that when athletes are free of injury their well-being has been enhanced.

4.3.3. Continuous and objective stress monitoring

AI algorithms fuse multimodal wearable data to track physiological stress and readiness continuously, enabling early detection that single measurements miss. AI aids in recovery management by tracking rehabilitation progress and providing personalized recovery plans. Smart devices, such as wearables, collect continuous data on athletes' physical and mental conditions i.e Smart Tennis Shoes (equipped with sensors that record data on stride, speed and distance travelled), Smart

Wristbands (monitor heart rate, Heart Rate Variability or HRV, sleep patterns and activity levels), and Smart Caps (incorporate sensors to measure brain activity and stress, providing real-time feedback (Ruiz-Vanoye *et al.*, 2025). In addition, smart devices enable constant and detailed monitoring, facilitating immediate and effective interventions to improve the performance and health of athletes (Ruiz-Vanoye *et al.*, 2025).

4.3.4. All round support for athletes

AI tools provide continuous learning of stress management techniques and adaption across seasons, early detection and intervention for stress, social and environmental support for stressors, psychological support through HRV biofeedback, personalized training and recovery adjustment and holistic physiological and psychological monitoring. In addition AI provides all round support by reducing barriers to mental health intervention for stress management. According to Reis *et al.* (2024), AI-driven wearables and monitoring platforms integrate heart rate variability (HRV), sleep quality, and perceived exertion data, giving coaches and athletes continuous feedback on both physiological and psychological stressors and this comprehensive monitoring reduces reliance on subjective self-reports and allows for early intervention. Currie (2021) argued that athlete well-being is not only about physical load but also about social and environmental stressors (e.g., stigma, burnout, external pressure) in which AI now extends support beyond performance metrics i.e through online monitoring systems that detect abusive messages directed at athletes and flag them for removal, thereby preventing the occurrence of stressors in social contexts. AI tool offer all round support for athletes, particularly for populations with limited access to professional services these tools make mental health care more affordable and accessible by offering round-the-clock support (Inkster *et al.*, 2018). Zhou (2025) emphasized that AI does not only provide snapshots of athlete stress but evolves with the athlete with machine learning models that adapt to new data collected across training blocks and competition periods, ensuring that stress management strategies are dynamic and supportive over time. Virtual therapy platforms, supported by AI-driven monitoring, provide confidential, flexible sessions that align with the athlete's competition and training schedules, thereby reducing barriers to mental health care.

4.3.5. Injury prevention

AI tools can be used to prevent injury (Duking *et al.*, 2018; Rossi *et al.*, 2018). By continuously monitoring athletes through wearable devices, AI systems can detect early signs of fatigue or stress, predicting potential injuries before they occur (Rahmani *et al.*, 2024). AI systems can detect early signs of fatigue or stress, predicting potential injuries before they occur thereby allowing for timely interventions, such as adjusting training intensity or providing targeted physiotherapy, thereby reducing the incidence of injuries and ensuring athletes maintain peak performance levels (Wei, 2019). By implementing the optimization algorithm, actors in the sport industry can tailor training programs to individual athlete needs, fostering improved performance outcomes and long-term health (Zhou, 2024). This injury prevention benefit of AI is fundamental to saving the careers of many athletes.

4.3.6. Personalised training and recovery

AI models can individualize load adjustments and recovery recommendations (based on an athlete's baseline and response patterns), helping reduce physiological and psychological stress while optimizing performance. Addleman *et al.* (2024) highlighted that AI can support athletes by tailoring recovery and training prescriptions to their unique HRV and performance baselines and such personalized feedback loops act as stress buffers, preventing overtraining and ensuring recovery strategies match the athlete's physiological needs. AI can automatically adjust training and nutrition plans based on each athlete's data and results, taking into account factors such as fitness level, recovery needs and specific goals, contributing to improved training and competition results (Bodemer, 2023). AR and VR can be applied to create immersive and personalized rehabilitation experiences, which motivate athletes during the processes the recovery, for the improvement of results and accelerating their return to competitions (Ruiz-Vanoye *et al.*, 2025).

4.3.7. Early detention and Intervention

Early detection and diagnosis is one of the most significant applications of AI for athletes (Ajiye & Ukpabi, 2025). Real-time forecasting models like BERT-XGBoost allow coaches and athletes to proactively manage emergent stress before it undermines performance. Large-scale datasets such as social media activity, voice patterns, facial expressions, electronic health records, and physiological signals can be processed with machine learning algorithms to detect indicators of mental health conditions including bipolar disorder, schizophrenia, depression, and anxiety (Shatte *et al.*, 2019). For example, natural language processing (NLP) enables the analysis of written or spoken language to identify warning signs of suicidal thoughts or cognitive disturbances. Wearable sensors integrated with AI algorithms can monitor athletes' biometrics in real time, predicting fatigue or the risk of injury and providing opportunity for timely interventions (Chenyi *et al.*, 2024).

4.3.8. Confidentiality and stigma reduction

AI integration in stress management promotes confidentiality and stigma reduction for athletes which further helps alleviate their worries and reduce stress. Currie (2021) emphasized that athletes often face stigma and scheduling conflicts that limit access to traditional in-person therapy. Gaffney *et al.* (2019) reported that digital mental health interventions, including chatbot counseling, encourage athletes and young adults to seek help more readily by reducing fear of judgment. This makes AI-driven tools a valuable complement to traditional sports psychology, especially in cultures where mental health stigma is strong.

4.4. Future directions

Advances in AI should focus on refining AI-powered injury prevention models, improving biometric sensing capabilities, and advancing edge AI for real-time data processing, sweat sensors, improved data security measures which will ensure

that athlete stress management data is safe. This is with the view to ensuring that wearable technology and AI continue to aid stress management performance, injury mitigation, and athlete well-being at all levels of competition. One key area of research is the development of AI-driven injury prevention models that utilize real-time data streams from wearables to predict injury risks before they occur (Gascón *et al.*, 2025). Another promising innovation is wearables integrating sweat analysis to provide real-time hydration tracking that is AI-driven sweat sensors could help athletes optimize fluid intake and nutrition strategies to enhance endurance, recovery, and thermoregulation (Dudek *et al.*, 2025). Edge AI technology, which processes data locally on the device itself, could enable faster, more secure, and real-time decision-making for athletes without requiring constant cloud access (Zhu, 2025).

The future actions in AI will involve advancements in real-time AI processing, enhanced biometric sensing, and improved data security measures. The development of AI-driven injury prevention models, hydration monitoring via sweat analysis, and edge AI solutions for on-device data processing will enhance the efficiency and security of sports analytics (Gascón *et al.*, 2025; Stoican & Oeschger, 2025). Zhou (2025) argued that future AI-guided biofeedback systems will integrate multi-sensor data (HRV, EEG, respiration, sleep) to provide holistic stress management so that such adaptive systems can dynamically adjust training to optimize both mental health and athletic performance over a season.

5. CONCLUSION

Stress is an unavoidable occurrence in sport. But when managed effectively, it becomes a resource rather than a hindrance. This review demonstrates that effective stress management strategies are multifaceted. These include cognitive behavioural strategies, mindfulness-based strategies, relaxation strategies, biofeedback and technology-based strategies and social support and team-based strategies. AI powered intervention also includes wearable monitoring devices, virtual therapy platforms and chatbot based counselling, predictive analytics for stress forecasting, AI guided biofeedback training, AI enhanced injury and recovery support, AI supported cognitive behavior training, and integration of AI with traditional human support systems. Each strategy contributes uniquely to an athlete's capacity to cope with stress and perform under pressure. Even though artificial intelligence (AI) offers a lot of benefits, it use is raising ethical questions (Ajiye & Omokhabi, 2025). Even with this, Artificial intelligence in stress management is becoming the trend nowadays hence this study therefore suggested general strategies for stress management as well as AI strategies for stress management among peak athletes. It was recommended that recommended that multimodal, specific interventions should be integrated into regular athletic training, warm-up and recovery of athletes in order to enhance performance and overall well-being. When sport psychologist adopt a hybrid approach that integrates AI into stress management, athletes are more likely to experience quicker and more effective outcomes tailored to their needs. This hybrid approach helps solve the ethical issues raised by researchers in the use of AI for stress management among peak athletes.

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