**The Journal of Science and Medicine**
Vol 2 No 4 (2020): Journal of Science and Medicine, 1-14
Articles

# The Evolution of Psychological Response to Athlete Injury Models for Professional Sport

| | |
|---|---|
| *Billymo Rist* | College of Science, Health and Engineering, La Trobe University, Bundoora, Melbourne, Australia |
| *Tony Glynn* | Fit Mind Consulting, Spencer Street, West Melbourne, Melbourne, Australia |
| *Anthea Clarke* | College of Science, Health and Engineering, La Trobe University, Bundoora, Melbourne, Australia |
| *Alan Pearce* | College of Science, Health and Engineering, La Trobe University, Bundoora, Melbourne, Australia |

Elite competitive sport is linked with a unique collection of stressors distinct from the general population. While there have been advancements in understanding the role that stressors play within the elite sporting environment, uncertainty still exists around a clear process for measuring stressors, and their specific relationship to injury. A number of models have been proposed as useful frameworks for investigating and describing the role of stress and its interaction with the psychological response to athletic injury. While these models provide evolving points of view drawing on different theoretical backgrounds regarding their interpretation of athletic stress and injury, they offer little application to the applied elite sporting environment, and no detail of how they these models support athletes, and high performance staff in the applied setting. This narrative review will present two popular theoretical psychological models of sports injury rehabilitation. We argue that these models could be better applied in the current sporting environment if they utilized biological markers such as cortisol measures of personality. Extending from the Biopsychosocial model of injury, we present an updated model of injury quantifying the psychophysiological response for athletes [1]. This model is aligned with the current applied sporting landscape, incorporating the implementation of measurement practice guidelines, and offering high-performance staff an example that can be applied to their unique setting by assessing individuals' distinct measures of cortisol and personality in response to stress and injury.

## Citation

Rist B, Glynn T, Clarke A, Pearce A. (2020). The Evolution of Psychological Response to Athlete Injury Models for Professional Sport. Journal of Sciene and Medicine; 2(4): 1-14. https://doi.org/10.37714/josam.v2i4.53.

## Introduction

Elite athletes over many years of training develop a number of sport specific skills. These include the ability to repeatedly perform intense physical exercise in training and competition, and perceived mental resilience. The development of these skills provides elite athletes the opportunity to lead successful careers within professional sport. At the elite level, high-performance staff strictly control the athlete-training environment. Therefore, high-performance staff play a critical role in determining the success of professional athletes. Fewer factors than injury play a more critical role in determining the playing-career outcomes of an elite athlete. While acute injuries cannot be anticipated, the expectation to continually perform both physically and psychologically increases the likelihood of incurring physical and mental stress, and consequently an increased risk of injury [2]. Quantifying athletes' response to psychological stress would assist not only the

athlete, but also support staff who are intimately involved in the athlete's performance outcomes. Correcting the balance between the examination of physical and psychological factors is an important step to ensure a holistic approach exists within high performing sporting environments. Currently, the primary focus of athletic injury research has focused on the physical aspects that influence injury risk, onset and recovery (e.g. etiology, epidemiology, outcomes measures, prevention, diagnosis, and treatment). Conversely, relatively less exploration has been on the general psychological factors predisposing athletes to injury (e.g., personality traits). Limited research has been directed toward certain personality factors that may contribute to how an individual athlete copes within high-performance sporting environments, or respond to suffering an injury [3]. By acknowledging the nexus of personality traits and the psychophysiological response to stress and injury, professional sporting organizations can assist athletes to cope more effectively, preventing adverse responses to stress and injury by optimizing athlete recovery. Therefore, this is an area of strategic interest to high performance staff in professional sport.

The purpose of this scoping review is to assess the current literature from a wider perspective than a systematic review examining research that addresses sociocultural and personality factors that contribute to stressors and chronic injuries experienced by athletes in the elite environment. Firstly, this review will examine the distinct characteristics that exist within elite sporting environments. Highlighting the cultural barriers that currently exist within the majority of sporting environments and the important role of stress in injury occurrence and subsequent rehabilitation. Secondly, two popular theoretical psychological models of sports injury rehabilitation are presented and critically reviewed; The Integrated Model of Psychological Response to Sports Injury and Rehabilitation Process (Figure 1) [4] and The Biopsychosocial Model of Sports Injury (Figure 2) [5]. Finally, a new model The Athlete Prevention and Injury Response Model (Figure 3) adapted from the Biopsychosocial model of injury will be presented addressing the limitations of the current models which examines cortisol and personality as predictive markers of stress and sports injury rehabilitation.

# Part I: The Elite Sport Environment

For professional and elite (e.g., Olympics) athletes competitive sport and the training is, arguably, their primary form of employment. However, unlike employment for the general population, elite sport is linked with a unique collection of stressors. These include constant performance expectations from team administration, coaching and high performance staff and their peers (for example to win against weaker opposition or to perform well against strong opposition), as well as constant scrutiny from the media, and the wider community, particularly now from social media. Currently professional sporting teams are mostly invested in quantifying how athletes are responding to physical stress from training and competition, utilizing training and competition load variables, perceptions of exertion or soreness, and measures of fatigue and physical wellness [6]. As a result of the focus in quantifying physical load monitoring, elite sport is well advanced in the techniques utilized to manage an athlete's physical stress. However, less is known about the successful monitoring of psychological stress, as increasing numbers of elite athletes appear to be taking leave from their sport to deal with mental health concerns. Elite sport is yet to identify a specific approach to consistently mange an athlete's psychological stress [7].

## Sociocultural barriers associated with elite sport

Within the majority of elite competitive sports, an attitude exists that athletes must be "tough" and push through mental or physical discomforts [8]. Research into high performance sports culture has examined whether cultural pressure mechanisms which exist in these environments are directly related to injury and other negative health outcomes [9]. The willingness to sacrifice mental health in the pursuit of high achievement is visible within numerous sports, and evident through the many actions of the athletes, such as their willingness to use prescription drugs to mask physical and mental pain [10]. Embodying such an extreme cultural attitude, whilst in some circumstances can

lead to positive outcomes regarding performance in the short-term, can also serve to be detrimental to an athlete's overall health. Such expectations heighten the consequences for athletes and add additional stressors to an environment where an increased likelihood of physiological and psychological strain is anticipated. For example, Noblet and Gifford [11] examined 32 professional Australian Football League (AFL) players from two clubs highlighting several stressors which are associated with performing in the AFL. Researchers conducted eight in-depth interviews and four focus groups to gain insights into the sources of stress, which stemmed from AFL team environments. Results demonstrated eight key themes related to negative cultural norms which included: 1) a lack of feedback given to athletes, 2) athletes being ignored if they played poorly, 3) feedback that was provided was negative in language and tone, 4) athletes finding out through the media about non-selection in the team, 5) coaches and staff not listening to athlete concerns or issues, 6) athletes being ignored by staff if they were injured, 7) athletes being pressured to conform to the club image, and 8) athletes expressing a fear of being seen as "weak". Whilst elite sport has started to address the importance of athlete wellbeing by improving player support standards and resourcing [12], there is still room to improve the competitive sporting environment so that athletes can better prevent the onset of stress and injury to make sure they can maintain an optimal level of performance. The implementation of more precision-based measures, such as identifying unique personality traits that may predispose athletes to increased levels of stress, and assessing stress at a psychophysiological level, if implemented, it is plausible that the assessment of stress for athletes, high performance staff is improved.

## Stress load in elite sport

It is inevitable that athletes will experience varying levels of stress and injury occurrence throughout their professional sporting career. If not managed appropriately issues can arise, specifically when experiencing a number of sources of stress simultaneously, which can consequently mitigate the adherence of an athlete to their rigorous training protocols, influencing an athlete's ability to recover from training and competition. Stress for athletes can also have consequences that can increase risk of musculoskeletal on and off the field as well as hindering rehabilitation. Ruddock-Hudson, et al [13] demonstrated the impact of stressors associated with an athlete's long-term injury. By investigating the psychological responses to injury, researchers examined eight AFL athletes throughout the entirety of their rehabilitation (which ranged from nine weeks to 10 months with a mean of 24.5 weeks) conducting qualitative interviews at three time-points during their recovery process. Results identified 14 key themes that were present within three injury phases of their proposed framework of athlete injury rehabilitation. Phase one: *the reaction to injury phase,* key themes experienced by athletes included injury appraisal resulting in negative emotions, adopting a positive mindset in an attempt to regain control, disengaging from the club while seeking social support and support received from others. Phase two: *the reaction to the rehabilitation phase* included experiencing a roller coaster of emotions, being challenged by the rehabilitation program, being challenged by the isolation experienced and feeling a need to reconnect, utilizing the support received from others and finding a renewed optimism. Phase three: *reaction to returning to sport phase* identified themes including feeling mixed emotions, the pressure to perform to a high level, support received from others, feeling a positive outcome from the injury experience and experiencing a physical and psychological readiness to play. This research emphasizes how injury can significantly impair all areas of an athlete's life if they fail to maintain awareness, acknowledge their injury and the stressors associated with being an elite athlete. The sociocultural barriers (e.g., masking deficiencies or perceived 'weakness') that exists within elite sports setting, make it difficult for athletes to acknowledge the psychological impact of training, competition and injury on their levels of stress. Additionally, the lack of rigor associated with quantifying athletes stress limits athlete's ability to address any negative associations that they may experience. Therefore, emphasizing the need to implement more precision-based measures (e.g., personality measures and psychophysiological markers) allowing athletes to more openly acknowledge any stress they may be experiencing, to coaches and high performance staff. Conversely, if athletes fail to acknowledge stress for a prolonged period it may result in severe psychological consequences including influencing physical health and performance. This may in

turn perpetuate the stress cycle.

## Measuring elite athlete psychophysiological stress

The impact that stress can have on athletes has been previously described [14]. While the understanding that stress is an important part of human functioning, the monitoring of stress in the elite environment is essential to mitigate the negative consequences associated with an athlete's career outcomes. Chronic stress is a pathophysiological state of on-going arousal. This occurs when the body experiences many stressors or a single stressor continuously, and therefore, mitigating the ability to activate the relaxation response [7]. Determining an athletes' psychological state as it relates to stress should be an area of strategic interest to support staff within the elite sporting landscape, especially considering the varying degrees of stress experienced by athletes. Currently, data collection methods for monitoring player stress and injury in elite sports are self-report in nature, which leaves the results largely open to subjective interpretation, as well as athlete manipulation due to current sociocultural barriers being tolerated in elite sport (e.g., players not reporting a stressor for fear of non-selection, and to live up to the expectations related to extreme dedication and masking weaknesses) [15,16].

When quantifying athlete stress, measuring neuroendocrine factors of athletes is as an effective approach. Specifically examining the biomarkers of stress provides key insights into the neuroendocrine system (the interaction between the nervous system and the endocrine system, which allows the brain to regulate the hormonal activity in the body) which is the first to respond to a given stressor [17]. Measuring the biomarker cortisol (which causes an increase in heart rate and blood pressure when released in the body) can help quantify the stress an athlete may be experiencing [18]. Measured non-invasively by either urine, saliva, or serum (blood), cortisol measurements directly capture the status of the hypothalamic-pituitary-adrenal axis (HPA) functioning. While cortisol has been demonstrated to be a reliable biomarker of stress in the general population [19], we have recently demonstrated reliability (ICC=0.93) in an elite athlete cohort [20].

Research has shown that during acute stress, there is a spike in cortisol levels following exposure to a stressor, with levels returning to normal once the stress has been resolved [17]. However, cortisol measures are also sensitive to subtle changes. A mild change can trigger a response and small fluctuations from normal levels of neuroendocrine factors can be effectively detected [21]. Therefore, the ability to identify physiological changes in the neuroendocrine system of athletes, coupled with self-report measures can provide accurate quantifiable data, which is used to understand athletes stress reaction. Capturing this data may allow athletes to cope more effectively in response to stress.

Several studies have investigated and demonstrated proof of concept regarding the effectiveness of measuring salivary biomarkers for psychophysiological stress. Halson [22] conducted a review of physical training and competition load monitoring related to fatigue in athletes, determining the most appropriate measures to analyze physical and mental stress which included biomarkers of salivary cortisol, testosterone and immunoglobulin A. Researchers demonstrated that there is a relationship between cortisol and performance outcomes related to physical and mental fatigue in athletes. Additionally, Geva, et al [23] examined the pain inhibition of triathletes under acute psychological stress using biomarker technology. By analyzing athlete's salivary cortisol measures combined with self-report measures of stress and anxiety (Montreal Imaging Stress Task, Visual Analogue Scale, State Trait Anxiety Inventory), researchers demonstrated that under acute psychological stress triathletes reported an increased sensitivity to pain. By understanding the differences in individual's psychophysiological responses to stress and injury, athletes can better supported to develop optimal strategies to overcome stressors and injuries.

# Part II: A Critical Review of Current Models of Athletic

# Injury Rehabilitation

Recognizing the current limitations of the elite sport environment in regard to both the acknowledgment and assessment of psychological stress, it is important to understand the historical perspective with which psychological stress has been interpreted. Research has examined psychological stress through injury, which is the most well acknowledged form of stress experienced by athletes [13]. The impact of athletic injury has been examined predominately to assist rehabilitation personnel when treating injured athletes. Additionally, high performance staff should be aware of the psychological factors that impact the injury experience during an athlete's rehabilitation. A number of models have been proposed as useful frameworks for investigating and describing the psychological response to athletic injury and stress. Two popular theoretical psychological models of sports injury rehabilitation, The Integrated Model of Psychological Response to Sports Injury and Rehabilitation Process [4] and The Biopsychosocial Model of Sports Injury [5] will be critically reviewed, highlighting the key limitations as they relate to the elite sporting environment.

## The integrated model of response to sports injury and rehabilitation process

The Integrated Model (Figure 1)[4] holds that responses to injury are influenced by both pre-injury variables (e.g., personality, history of stressors, coping resources, interventions) and post-injury variables (e.g., personal factors such as age, behavioral or emotional response, and situational factors in sport). The way the injury and rehabilitation process is interpreted by athletes is thought to affect three interrelated parameters, emotional responses, behavioral responses and recovery outcomes. High performance staff need to be aware of these athlete interpretations as they will determine the emotional response of an individual [24] for example fear of re-injury, anger, and depression. Finally, these emotions affect the athlete's behavior, directly impacting the athlete's adherence to strict rehabilitation protocols required to achieve optimal recovery.

Characteristics of the individual (e.g., injury attributes, unique individual variables) and the situation (e.g., sport related variables and aspects of the social and physical environment in which rehabilitation is occurring) are determined to have a direct effect on the athlete. There is empirical support for core components of the Integrated Model, indicating that sports injury is a significant source of stress (more than high performance staff may admit) and that personal and situational factors are associated with psychological responses to sports injury, which impacts are related to sports injury rehabilitation outcomes [9].

Conversely, research into this model has also demonstrated that situational factors sometimes overlap with individual's interpretation and perceptionsof the situation [25]. Such overlap can cause difficulties when making inferences about whether the situational variable (for example where the team is placed on the table) alone or an athlete's interpretation of the situation, taking in personal factors and emotional responses, is directly affecting rehabilitation [26]. Although injury attributes reveal certain characteristics of the individual, they remain highly variable over time and therefore, reflective only of the situation and environment at the time of injury and rehabilitation process. Consequently, it has been posited [27] that parts of the Integrated Model lack clarity and require support from further research which includes the lack of application to the applied sporting environment and therefore, making it difficult for high performance staff to implement.

## The biopsychosocial model of sports injury

The Biopsychosocial Model of Athletic Injury [5] (Figure 2) is the most recent of models that has emerged to describe the role of psychological variables in sports injury rehabilitation [5]. This model differs from that of other psychological based models, as it merges medical and psychological viewpoints building out an integrative framework incorporating components of

previous models. Developed by Brewer, et al. [5], with the aim of widening the focus of rehabilitation research, the Biopsychosocial Model has seven different dimensions which make up the model in its entirety; injury characteristics, socio-demographic factors, biological factors, psychological factors, social and contextual factors, intermediate biopsychosocial outcomes and sports injury rehabilitation outcomes. The model explains sports injury rehabilitation occurring in the following manner: the process starts with the occurrence of the injury (e.g., physical damage) and initiates the sports injury rehabilitation process. The location in the body where the physical harm has occurred, the type, cause, and severity of the injury, and the history of the athlete and their previous injuries are factors that affect the biological, psychological, and the sociocultural factors [27]. Additionally, socio-demographic factors, including the age of the athlete, their sex, ethnicity, or socioeconomic situation, exert a parallel influence on the biological, psychological and socio-contextual factors. Subsequently, these three factors affect the intermediate outcomes of their injury including the range of motion, strength and endurance of the muscle and joints, the perception of pain, and the duration of the athlete's recovery. Finally, their intermediate outcomes influence the outcomes of the rehabilitation process, including functional performance, quality of life after injury, satisfaction of treatment, and readiness and desire to return to sport. A key role in the biopsychosocial model is played by psychological factors, specifically, at the intermediate and final outcomes [24]. The paths between psychological factors and sports injury rehabilitation outcomes are proposed as being bidirectional. While the biopsychosocial model addresses some limitations of the integrated model by highlighting the role of biological factors as contributing the role of athletic injury it is not clear how a high performance staff member would assess the respective key elements of the model in real time in an applied sporting setting [28].

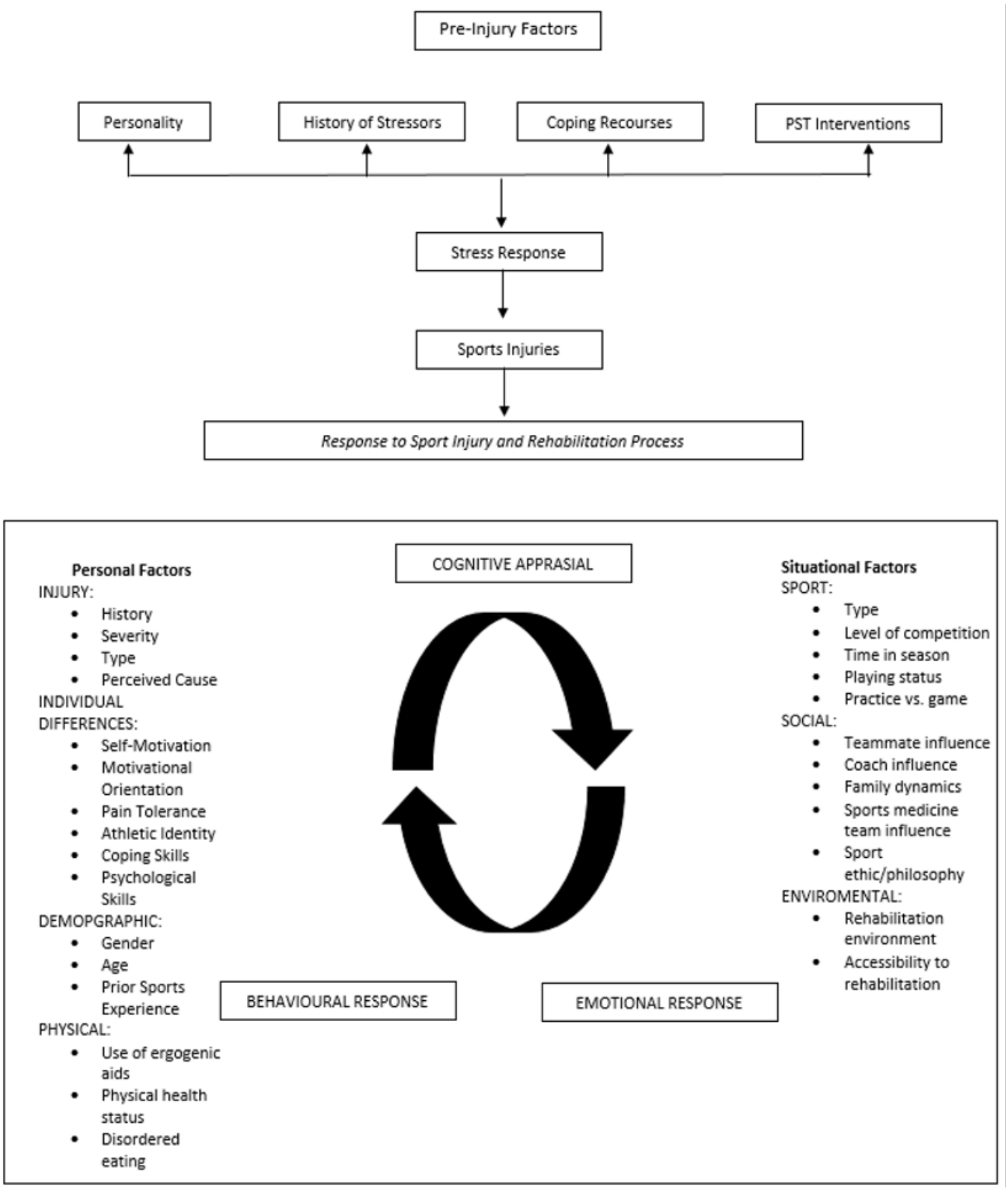



**Figure 1.** *The integrated model of psychological response to sports injury and rehabilitation process [4]*

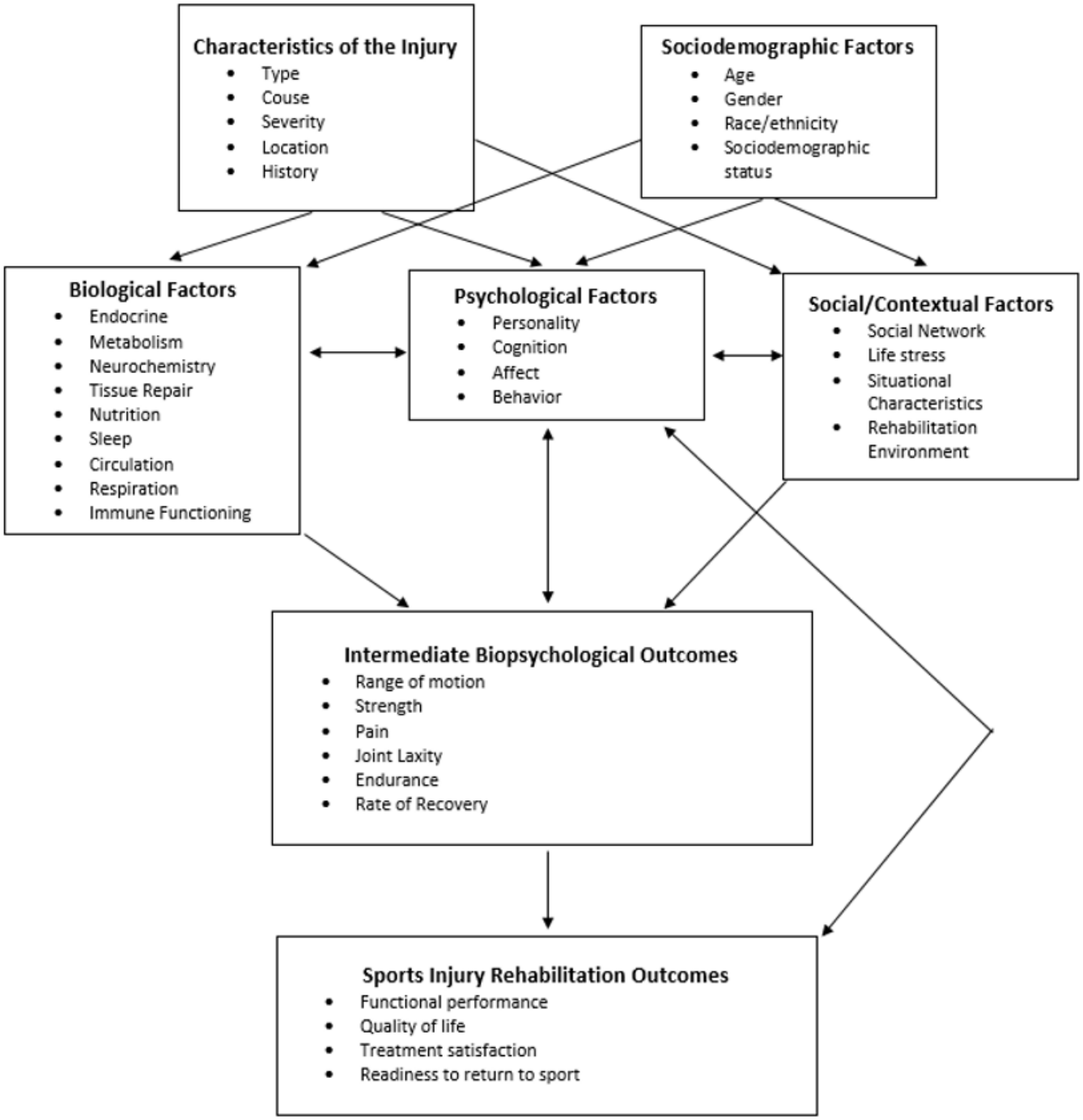



**Figure 2.** *The Biopsychosocial Model of Sports Injury [5]*

Despite the differences between these models, there is one common theme that is present throughout both the Integrated Model and the Biopsychosocial Model. Both psychological and physical rehabilitation and return to sport processes are influenced by an individual's interpretation of personal and situational factors, and emotional and behavioral responses to those factors that affect recovery outcomes. The process in which this takes place is cyclical in nature [3]. Therefore, individuals who exhibit personality traits that include a strong negative disposition prior to the occurrence of an injury are more likely to display that same negative disposition and appraisal of their circumstances during injury rehabilitation, and during the return to sport process. At the center of the injury occurrence, rehabilitation, and return to sport process appears to be the stress response (e.g., cortisol secretion), which if not addressed appropriately, can continue to amplify an

athlete's subsequent injury risk, and or negative mental health issues. The expansion of research on the psychological aspects of sports injury rehabilitation, and the trend towards increased methodological rigor has continued to enhance the return to sport process for injured athletes. However, continued attention to improving the methodological approach to this process is required to further develop knowledge regarding the psychological factors involved in the rehabilitation of sports injuries. The continued growth in the understanding of the variables that contribute to sports injury occurrence and rehabilitation outcomes, will allow for further integration of the optimal support throughout an athletes recovery process within applied environments. By more accurately and frequently measuring multiple factors of the injury rehabilitation process, will allow for a more optimal application of theoretical models quantifying the return to sport process. Rosenberger, et al. [29] have demonstrated the value in quantifying this process by measuring multiple variables within the return to sport process including pain, coping, physical functioning, and cortisol in athletes recovering from arthroscopic knee surgery. By adopting a greater degree of methodological rigor and improving the development and adaptation of theoretical models utilized within the sporting setting will allow for more accurate depiction of the dynamic rehabilitation process [30]. Both the integrated model and the biopsychosocial model have limitations in the high-performance environment. Firstly, both models identify key factors that contribute to stress and injury, yet neither attempt to incorporate the physiological measurement of stress, to determine the level of correlation with the athlete's interpretation of the situation. Similarly, while these models emphasize the clear role that personality plays in the likely occurrence of the stress response, these models fail to incorporate any form of assessment that high performance staff could utilize in an applied setting to determine an athlete's personality type [31]. Allowing, for assessment of an individual athlete’s susceptibility to stress and injury. Additionally, both of these models only begin once the athlete has sustained an injury, failing to understand the pre-injury variables which if addressed may contribute to the mitigation the occurrence of an injury entirely [28].

# Part III: A New Practical Model for Athlete Injury and Recovery

The aim of the following conceptualization (Athlete Prevention and Injury Response Model, Figure 3) is to offer a timeline framework to help apply psychophysiological processes for injury prevention and rehabilitation. Underpinned by the hypothesis that stress plays a central role in athlete injury risk, response to and the rehabilitation process, this model incorporates individual’s socio-demographic factors (e.g., age, sex, ethnicity, financial position), personality traits, and environmental factors (e.g., the sport an athlete participates in, their social circumstances) as mediating elements for the stress response. These factors, when combined with the physical and mental stress that the athlete is susceptible to, over time leads to physiological activation (stress hormone perturbation) within the body. This increase in stress (physiological adaptions) leads to changes in athlete behavior, specifically around maintaining optimal self-care and adhering to recovery protocols. If the athlete’s changes in behavior are managed appropriately and in a proactive manner (e.g., coping strategies) then they will likely have positive health outcomes (indicated by a plus symbol within the model), [32] which leads to a reduction in stress levels and a return to optimal functioning. If the athlete fails to utilize any coping strategies, or the coping strategies are ineffective an athlete will increase the likelihood of experiencing negative health outcomes (e.g., increased maladaptation to training, prolonged recovery period and a greater chance of sustaining a significant injury; indicated by a minus symbol in the model) [32]. Given the occurrence of an injury is an incident that an athlete is typically trying to avoid [33], it is proposed that more regular and quantifiable measurement of psychophysiological stress will facilitate successful injury prevention efforts and ensure more injury free training days. Allowing athletes to have lower levels of stress and consequently more optimal performances. Throughout this model, there are seven time points that athletes’ stress levels are measured both quantitatively (biomarker cortisol) and qualitatively (perceived stress state & personality traits).Therefore, assessing psychological trait, psychological state and psychophysiological markers.

## Applied Application of the Model

Time point one measures are conducted at baseline (e.g., athlete functioning optimally, generally during preseason), and are used as predictive markers to gauge the likelihood of stress and the occurrence of a potential injury, as well as acting as a baseline for future measures. Measurements taken at this time point include salivary cortisol, personality traits, and perceived stress levels. Time point two measurements (salivary cortisol, and perceived stress levels) are conducted on a regular basis (e.g., fortnightly) or at the sign of a psychophysiological stressor separate to an injury (e.g., negative life event). Time point three measurements (salivary cortisol, and perceived stress levels) are conducted post the implementation of any formal intervention (e.g., coping strategies) to assess whether this has had a positive impact on an athlete's levels of stress. If or when a player sustains an injury time point four measures (salivary cortisol, and perceived stress levels) are conducted. Time point five measurements (salivary cortisol, and perceived stress levels) are conducted mid-way through the rehabilitation program to monitor key psychophysiological markers that are indicators of rehabilitation progress (e.g., stress). Time point six measurements (salivary cortisol, and perceived stress levels) are conducted at predicted rehabilitation completion to examine key rehabilitation outcomes (e.g., stress, neuroendocrine function) and determine if the athlete is recovering as planned or behind their planned rehabilitation schedule. Finally, time point seven measurements (salivary cortisol, and perceived stress levels) are conducted when the athlete has completed their rehabilitation program and is cleared to return to sport ensuring their stress levels have returned to baseline. While this model appears horizontally confined and time based, players can move in both directions, depending on their progress of stress and injury from input from medical, coaching, and high performance staff.

## Chronic v Acute injuries

It is important to acknowledge the difference between the two main injury classifications of chronic (developing slowly or worsens over an extended period of time) and acute (sudden and severe) [34], With a chronic injury, the model would be applied in its entirety, with all seven-time point measures being utilized. Incorporating both pre-injury time point measures (T1, T2, T3) for prevention (e.g., monitoring stress to prevent a chronic injury becoming more severe) and post injury time point measures (T4, T5, T6, T7) assessing rehabilitation outcomes of injury. For acute injuries, five time points would be utilized (T1, T4, T5, T6, T7), with time points *two* and *three* being redundant due to the nature of acute injuries occurring suddenly. Therefore, time point one measures would still be captured forming the baseline measure. At the occurrence of an acute injury time point four measure would be taken followed by subsequent time points (T5, T6, T7), as demonstrated in the model.

Building on the knowledge provided by the integrated model and more specifically adapting elements of the Biopsychosocial model, our new model proposes that once an athlete sustains an injury their psychophysiological factors (biological and psychological factors), mediated by their personality, situational and environmental factors, interact in a cyclical nature (either positively or negatively), which facilitates the degree of success achieved within the rehabilitation process[10]. This cyclical interaction between the psychophysiological factors directly influences the intermediate rehabilitation outcomes. If the athlete's measurements are positive at this stage, then the athlete progresses to the overall rehabilitation outcomes stage (T6), before finally returning to sport. This stage of the model is also bidirectional. If an athlete's psychophysiological measures are negative at the intermediate outcomes stage (T5), the recovery process continues until the athlete observes positive intermediate outcomes and can progress to having positive overall rehabilitation outcomes (T6), and then ultimately returning to sport (T7).

Critical in the development of this model is its ability for the process to be utilized in an applied setting, and not just for theoretical purposes, with the objective being to expand on current techniques used by high performance staff. For this reason, it is important to provide a template for

how this model can be translated to a real-world elite sporting environment.

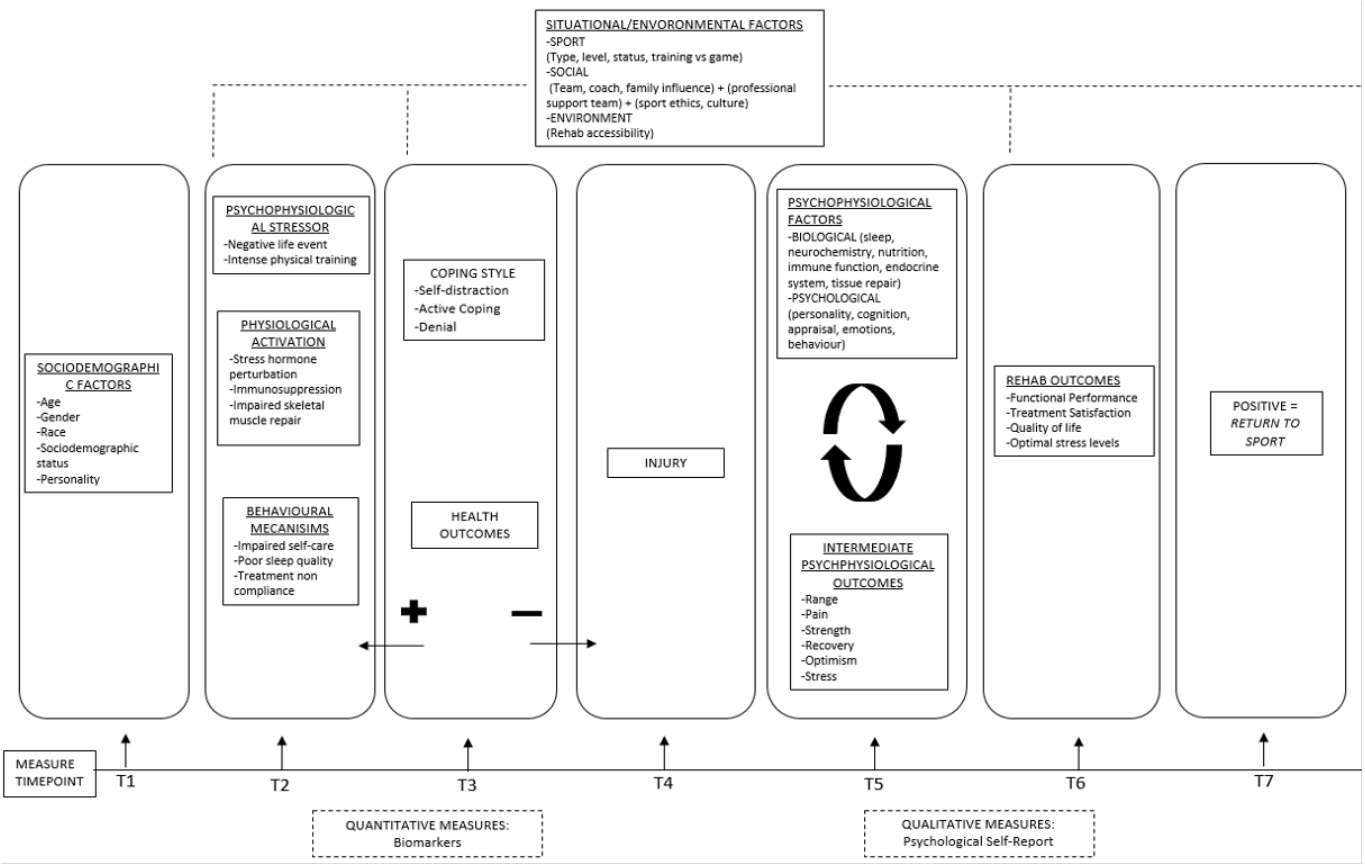



**Figure 3.** *The Athlete Prevention and Injury Response Model. T1 represents the assessment of salivary cortisol, personality traits, and perceived stress levels. T2, T3, T4, T5, T6, T7 represent the assessment of salivary cortisol, and perceived stress levels. The plus symbol indicates positive health outcomes, the minus symbol indicates negative health outcomes, and the cyclic symbol indicates interaction between psychophysiological factors and intermediate psychophysiological outcomes.*

## A working example to test the hypothesis

The following example pertains to the application of the Athlete Prevention and Injury Response Model (figure 3) for a professional team sport athlete. Upon commencement of the athlete's mandated pre-season training screening examination takes place. If the athlete is determined to be healthy and has no current physical injuries, the designated and qualified support staff member would conduct time point one (T1) measures (salivary cortisol, personality, and perceived stress). This includes assessing and recording the status of socio-demographic, situational, and environmental factors.. If a psychophysiological stressor (e.g., negative life event) is suspected, or becomes made aware to high-performance staff, time point two measures (T2) are taken. Taking into account any changes in measures and accounting for any situational and environmental factors the appropriate member of the support staff (e.g., sport psychologist) would work with the player to implement the appropriate professional intervention (e.g., coping strategies). Following the implementation of professional intervention by the athlete, the designated member of the support staff would then conduct time point three measures (T3) to determine the effectiveness of the professional intervention implemented, and to discern the athlete's health outcome status. At this point in time, the athlete's health outcome will be either positive (a reduction in stress levels) or negative (increased levels of stress). If the athlete's health outcomes are positive, the athlete will return to normal functioning and re-commence their training program and team activities, which will mean a reduction in the likelihood of athlete re-injury or the injury becoming chronic [35]. Alternatively, if the health outcome is negative, the athlete will continue working with the team appropriate professional member of the support staff either continuing or changing the current

professional intervention technique. If the athlete has negative health outcomes, they will have an increased likelihood of sustaining an injury or a current injury becoming chronic. If a chronic injury is diagnosed (e.g., tendonitis), the designated member of the support staff would conduct time point four measures (T4), to understand if any changes have occurred in stress levels from the previous time point (T2/T3) measures taken prior to the injury occurrence. Collaboratively, team high performance support staff would then develop the athlete's rehabilitation plan. Once the athlete commences their rehabilitation and reaches the scheduled mid-point, the designated member of the support staff would then conduct time point five measures (T5) to assess the athlete's intermediate psychophysiological outcomes, again comparing data to previous measures making sure the athlete is meeting their planned milestones, with no significant change in pre-determined key indicators of stress. If the athlete is making positive progress and meeting their planned rehabilitation milestones then the athlete continues on their rehabilitation schedule as planned. Time point six measures (T6) are conducted post the conclusion of the athletes planned rehabilitation program to assess the athlete's rehabilitation outcomes. If the athlete has met the required outcomes the athlete can cease rehabilitation and return to normal functioning, preparing for return to sport activities. Prior to returning to full sport activities the designated member of the support staff would conduct the final time point seven measures to ensure the athlete has maintained optimal functioning post the cessation of their rehabilitation plan. With this model being cyclical, if the athlete fails to meet the planned rehabilitation scheduled milestones, their rehabilitation plan is re-assessed or adjusted, and time point five and six measures are activated until such time that the athlete successfully completes full rehabilitation and reaches optimal functioning and is ready to return to sport.

The working example of the Athlete Prevention and Injury Response Model demonstrates the foundation of the model is grounded in strong methodological rigor, incorporating psychophysiological measures of stress. Specifically, the model expands on quantitative and qualitative measurement techniques not extensively utilized within elite and professional sport demonstrating their valid implementation. Measuring the biomarker cortisol and combining this measure with reliable and validated quantitative personality and stress self-report measures, allows this model to be utilized in an applied setting, and therefore not just for theoretical purposes which leaves the application of principles largely open to subjective interpretation. Consistently measuring an athlete’s levels of stress holistically will provide more accurate and reliable data, allowing for better monitoring of an individual athlete’s ongoing susceptibility to chronic injury, rehabilitation progress, and accurately determining when they are ready to return to a sporting activity.

# Conclusion

This review contends that the current models explaining the psychological process of injury rehabilitation, while theoretically sound, are limited in quantitative measures to support the psychological response to injury and focus heavily on stress management. Therefore, these models are reactionary in nature, only being implemented once the athlete is injured, rather than proactively predicting the internal and external determinants that may predispose athletes to psychological stress increasing risk of injury [35]. The Athlete Prevention and Injury Response Model has been developed to provide a detailed protocol, that can be applied, to the individual athlete by quantifying their unique personality traits that may account for any predisposition that the athlete has towards stress.. Additionally, utilizing a model that combines psychological trait measures of personality, psychological state measures of stress and psychophysiological measures of stress, allows high performance staff to better understand and manage athletes stress within the applied sporting environment.

# Acknowledgements

The author(s) declared no potential conflicts of interest with respect to the research, authorship,

and/or publication of this article. All authors have substantially contributed in writing and critically reviewing the manuscript.

## Author Disclosure Statement

No funding was provided for the completion of this study. AJP currently receives partial research salary funding from Sports Health Check charity. AJP has previously received partial research funding from the Australian Football League, Impact Technologies Inc., and Samsung Corporation. Other authors declare that they have no competing interests.

## References

1. Navalta JW, Stone WJ, Lyons S. Ethical Issues Relating to Scientific Discovery in Exercise Science. *International Journal of Exercise Science.* 2020; 12(1):1-8.
2. Forsdyke Dale, Smith Andy, Jones Michelle, Gledhill Adam. Psychosocial factors associated with outcomes of sports injury rehabilitation in competitive athletes: a mixed studies systematic review. *British Journal of Sports Medicine.* 2016; 50(9)DOI
3. Arvinen-Barrow Monna, Clement Damien. A Preliminary Investigation Into Athletic Trainers' Views and Experiences of a Multidisciplinary Team Approach to Sports Injury Rehabilitation. *Athletic Training & Sports Health Care.* 2015; 7(3)DOI
4. Wiese-bjornstal Diane M., Smith Aynsley M., Shaffer Shelly M., Morrey Michael A.. An integrated model of response to sport injury: Psychological and sociological dynamics. *Journal of Applied Sport Psychology.* 1998; 10(1)DOI
5. RUDDY JOSHUA D., CORMACK STUART, TIMMINS RYAN G., SAKADJIAN ALEX, PIETSCH SAMUEL, CAREY DAVID L., WILLIAMS MORGAN D., OPAR DAVID A.. Factors that Impact Self-reported Wellness Scores in Elite Australian Footballers. *Medicine & Science in Sports & Exercise.* 2020; 52(6)DOI
6. Ardern Clare L, Taylor Nicholas F, Feller Julian A, Webster Kate E. A systematic review of the psychological factors associated with returning to sport following injury. *British Journal of Sports Medicine.* 2012; 47(17)DOI
7. Williams Jean M., Andersen Mark B.. Psychosocial antecedents of sport injury: Review and critique of the stress and injury model'. *Journal of Applied Sport Psychology.* 1998; 10(1)DOI
8. Wiese-Bjornstal D. M.. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scandinavian Journal of Medicine & Science in Sports.* 2010; 20DOI
9. Ivarsson A, Johnson U. Psychological factors as predictors of injuries among senior soccer players. A prospective study. *Journal of Sports Science & Medicine.* 2010; 9(2):347-352.
10. J. Noblet, Sandra M. Gifford Andrew. The Sources of Stress Experienced by Professional Australian Footballers. *Journal of Applied Sport Psychology.* 2002; 14(1)DOI
11. Stansen Caroline, Chambers Timothy P.. An interpretative phenomenological analysis of the player development manager role in Australian professional sports. *Qualitative Research in Sport, Exercise and Health.* 2017; 11(2)DOI
12. Ruddock-Hudson Mandy, O'Halloran Paul, Murphy Greg. The Psychological Impact of Long-Term Injury on Australian Football League Players. *Journal of Applied Sport Psychology.* 2014; 26(4)DOI
13. Podlog Leslie, Lochbaum Marc, Stevens Tara. Need Satisfaction, Well-Being, and Perceived Return-to-Sport Outcomes Among Injured Athletes. *Journal of Applied Sport Psychology.* 2010; 22(2)DOI
14. Bellido Alberto, Ruisoto Pablo, Beltran-Velasco Ana, Clemente-Suárez Vicente Javier. State of the Art on the Use of Portable Digital Devices to Assess Stress in Humans. *Journal of Medical Systems.* 2018; 42(6)DOI
15. Vachon-Presseau Etienne, Roy Mathieu, Martel Marc-Olivier, Caron Etienne, Marin Marie-France, Chen Jeni, Albouy Geneviève, Plante Isabelle, Sullivan Michael J., Lupien Sonia J., Rainville Pierre. The stress model of chronic pain: evidence from basal cortisol and

hippocampal structure and function in humans. *Brain.* 2013; 136(3)DOI
16. Ghaderi H, Azarbayjani M, Atashak M, Shamsi S, Sharafi H. The effect of maximal progressive exercise on serum cortisol & immunoglobulin a responses in young elite athletes.. *Annals of Biological Research.* 2011; 2(6):456-453.
17. Fisher TN, McLellan C. The Validity and Reliability for a Salivary Cortisol Point of Care Test. *Journal of Athletic Enhancement.* 2015; 04(04)DOI
18. Rist Billymo, Pearce Alan. Tiered Levels of Resting Cortisol in an Athletic Population. A Potential Role for Interpretation in Biopsychosocial Assessment?. *Journal of Functional Morphology and Kinesiology.* 2019; 4(1)DOI
19. Baumann Nicole, Turpin Jean-Claude. Neurochemistry of Stress. An Overview. *Neurochemical Research.* 2010; 35(12)DOI
20. Halson Shona L.. Monitoring Training Load to Understand Fatigue in Athletes. *Sports Medicine.* 2014; 44(S2)DOI
21. Geva NIRIT, Prussner JENS, Defrin RUTH. Triathletes Lose Their Advantageous Pain Modulation under Acute Psychosocial Stress. *Medicine & Science in Sports & Exercise.* 2017; 49(2)DOI
22. Walker Natalie, Thatcher Joanne, Lavallee David. Review: Psychological responses to injury in competitive sport: a critical review. *Journal of the Royal Society for the Promotion of Health.* 2007; 127(4)DOI
23. Brewer Britton W.. The role of psychological factors in sport injury rehabilitation outcomes. *International Review of Sport and Exercise Psychology.* 2010; 3(1)DOI
24. Hess Courtney W., Gnacinski Stacy L., Meyer Barbara B.. A Review of the Sport-Injury and -Rehabilitation Literature: From Abstraction to Application. *The Sport Psychologist.* 2019; 33(3)DOI
25. Rosenberger Patricia H., Ickovics Jeannette R., Epel Elissa S., D'Entremont Danielle, Jokl Peter. Physical recovery in Arthroscopic knee surgery: unique contributions of coping behaviors to clinical outcomes and stress reactivity. *Psychology & Health.* 2004; 19(3)DOI
26. Evans L, Hardy L. EPsychological and emotional response to athletic injury: Measurement issues. *Psychological bases of sport injuries.* 1999;49-66.
27. Collins Dave, Collins Loel. Developing coaches' professional judgement and decision making: Using the 'Big 5'. *Journal of Sports Sciences.* 2020. DOI
28. Fares Jawad, Al Tabosh Hayat, Saadeddin Zein, El Mouhayyar Christopher, Aridi Hussam. Stress, burnout and coping strategies in preclinical medical students. *North American Journal of Medical Sciences.* 2016; 8(2)DOI
29. Habif SE. Examination of injury and the association between sport injury anxiety and injury severity and frequency among Olympic distance triathletes.. *Teachers College, Columbia University.* 2008.
30. Lavallee Mark E., Balam Tucker. An Overview of Strength Training Injuries. *Current Sports Medicine Reports.* 2010; 9(5)DOI
31. Ivarsson Andreas, Johnson Urban, Andersen Mark B., Tranaeus Ulrika, Stenling Andreas, Lindwall Magnus. Psychosocial Factors and Sport Injuries: Meta-analyses for Prediction and Prevention. *Sports Medicine.* 2016; 47(2)DOI
32. Wadey R, Day M, Cavallerio F, Martinelli L. Wadey R, Day M, Cavallerio F, Martinelli L. Multilevel Model of Sport Injury (MMSI): Can Coaches Impact and be Impacted by Injury?. 2018. DOI
33. Brewer BW. Psychology of sport injury rehabilitation. *Handbook of sport psychology.* 2007:404-424. DOI
34. Brewer BW, Andersen M, Van Raalte J. Psychological aspects of sport injury rehabilitation: Toward a biopsychosocial approach. *Medical and psychological aspects of sport and exercise.* 2002;41-54.
35. Saw AE, Main LC, Gastin PB. Monitoring athletes through self-report: factors influencing implementation. *Journal of sports science & medicine.* 2015; 14(1):137.