How Mental Factors Affect Psychomotor Skill Learning and Training and How to Measure Them: Running Case

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Abstract

Mental aspect is important for the overall learning and training of psychomotor skills such as running. To enhance the performance of a runner, it is crucial to identify and measure the relevant mental factors that influence their learning and training processes. This paper explores and describes mental factors that running experts consider essential and suggests common approaches to assess them. We also review some psychological theories and frameworks that can guide research in this field.

Keywords

Mental Aspect, Measurement, Running

1. Introduction

As long- and middle-distance running are endurance sports, runners experience diverse sensations during training and competition; for example, muscle pain, injury-related pain, heavy breathing and cramping discomfort. Moreover, during a race they must make quick challenging pacing decisions based not only on their current performance but also that of others [1]. In the same extension, it is unquestionable that mental or psychological factors exert an influence on the actions of sportspeople both the training and competition phases, then, it is crucial to gradually reach the optimal mental or psychological state for athletes so they can exhibit and maintain a top performance.

In this workshop paper, we present factors altering runner's performance that must be considered for the mental training of athletes in this sport discipline based on running experts' opinions. We also mention common methods to measure them.

2. Methods

Psychological factors have a significant impact on runners' performance. Therefore, we collected the most important ones that runners should focus on, according to running experts. To achieve this, we conducted interviews with running coaches.

2.1. Running coach interviews

We interviewed eleven running coaches from seven different countries. They had an average of 14 years of coaching experience. The interviews lasted about an hour each and were recorded with the interviewees' permission for further analysis.

The interviews sought to capture the coaches' opinions on the complexity of the running learning/training process and its associated factors.

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Two researchers analyzed the interviews following these steps. First, we identified and coded concepts and ideas from the coaches' statements. Next, we ranked the coded concepts and ideas by their frequency and importance to the coaches. This analysis enabled us to derive key insights into the mental aspects and their factors in running training.

3. Results

From the analysis of the running coach interviews, we identified the following factors of the mental aspect: *mental stress*, and *depression*, which are usually negative; and *motivation*, *concentration*, *self-efficacy*, *self-regulation*, *mental load-mental fatigue-mental recovery*, and *mental toughness*, which are neutral and can be turned into positive factors that enhance the runner's mental improvement. Preventing these negative factors is not only important for the athletes' performance, but also for their mental wellbeing. In the next subsections, we define the identified mental factors and how they are usually measured in research on this topic.

3.1. Mental Stress

It can be defined as a psychological state normally initiating an increased perceived anxiety related to the performance of a task [2, 3]. Besides, it is important to emphasize that due to the intrinsic duality between stress-anxiety, many theories and studies on stress mostly focus on the anxiety element [4, 5, 6]. Fear of failure, inadequate preparation and physical state, social evaluation, and unforeseen events are the most common sources of mental stress [5]. Curiously, and although anxiety associated with stress is seen as a negative attribute, it can also lead to better athletic performance depending on the athlete's personal capabilities to cope with stressful conditions [2] since it triggers the adaptation to these demands [7]. Anxiety consists mainly of two elements: a cognitive component referring to the mental response, and a somatic component enclosing the physical response [2].

Stress can be measured by physiological and psychological methods. Physiological methods involve markers such as blood pressure, heart rate, respiration rate, body temperature, galvanic skin response, and muscular and brain-wave activity. Psychological methods include questionnaires, scales, interviews and tests such as the perceived stress scale, the psychological stress measure, and the emotional stress reaction questionnaire [7].

3.2. Depression

The depression is a mental health problem where biological, psychological and social reasons play a decisive role in its triggering, it is characterized by fatigue, apathy, sleep and appetite disturbance; factors such as overtraining, perfectionism, loss of competition, conflicts with trainers, recent injuries, career termination and costs of the exercise are common depression sources in elite athletes [10, 11]. Injuries as a cause of depression [12], differentiation of gender [13] and differentiation of disciplines [14] are some useful qualities to evaluate depression in sports. Besides, the diathesis-stress model offers an alternative to explain the development of depression [15].

Depression is traditionally measured through scales that have psychological validation, however, only 5 are the most used, among which the Beck depression inventory and the Hamilton rating scale for depression stand out [16].

To the best of our knowledge, there are no completely reliable physiological markers that assess or predict depression, however, some researchers proposed the use of wearable devices to find correlation between physiological and behavioral response, for instance, the LiveNet [17], and the PSYCHE platforms [18].

3.3. Mental Load - Mental Fatigue - Mental Recovery

Mental load or cognitive load (CL) is the amount of available mental/cognitive resources that are invested in solving the demands imposed by a task; if these resources are depleted, mental fatigue can occur [19]. This definition is influenced by the cognitive load theory which proposes the existence of limited cognitive-processing capacities and cognitive resources and its implications in the performance of single or multiple tasks [20, 21]. On the other hand, in ergonomics and human factors, the term *mental workload (MWL)* has a similar meaning given it refers to the limitations of the human mental architecture and its cognitive capacities [22]. Under the MWL perspective, it is feasible to identify its relationship with the person/user/operator performance because they have a cause and effect relationship; two main causes of mental underperformance and their connected errors and incidents correspond to too low (underload) and too much (overload) stimulation [23]. In the sports domain, the CL load depends both on the properties of the task at hand and the interactions with its environment and also on individual factors such as mental effort or cognitive capacity to dynamically adjust to the demands of the task [24]. In team sports, the constant and dynamic interaction between members of the same team and those of their opponents requires making use of mental resources to adjust to circumstances of that moment, however, in individual sports athletes "indirectly" interact with other competitors; athletes regulated their pacing strategies as a consequence of the presence of competitors, since this pacing could be perceived as a learning capacity [25]. For runners, an increase in CL leads to a bad control of the pacing strategy and decrease in the voluntary running speed [26, 27]. Feedback and information recall also play central roles since athletes listen to, comprehend and respond to sources of feedback (i.e. coaches' instructions) and they also must recall tactics and experiences to apply them [24].

NASA Task Load Index, Subjective Workload Assessment Technique, Workload Profile are examples of assessment relying on rating or scoring MWL subjectively [28]. Common physiological methods to measure MWL physiologically use electrocardiac activity, respiration, blood pressure, and skin, ocular and brain measures [29].

Mental fatigue or cognitive fatigue is a type of fatigue which is induced by long periods of demanding mental activities generating a decrease in the athlete's performance [30]. Mental fatigue reduces the athletes' physical and cognitive performance through the alteration of all motivational factors pushing athletes to reach their goals; concretely, the mental fatigue can both *increase* the perception of *effort* to realize an activity, and *decrease* the perception of the *benefit/reward* that can be gained [31]. Additionally, it worsens athletes' performance via the *depletion/failure* of the limited cognitive *resources* due to the influence of *tactical tasks* and *training regimes* [32]. Some particular negative effects on working memory, judgment and attention [33], and technical skills of athletes [34] are also connected with this fatigue. It also reduces physical and decision-making performance [35].

The evaluation of mental fatigue can be done by subjective assessment and physiological methods. EEG [36], ocular [37], cardiac activity [38] are among the physiological methods commonly used for its measurement. As for the subjective methods, we can mention Mental Fatigue Scale [39], visual analog fatigue scale [40], and the fatigue severity scale [41].

Mental recovery or cognitive recovery is a restorative process which is used to return to the original mental baseline that existed prior to training or competition, and is achieved by the use of psychological strategies such as cognitive self-regulation, resource activation, and psychological relaxation techniques [42, 43]. Mental recovery strategies can be categorized into psychologically-oriented strategies and "other" strategies (e.g. restorative environment and music) [43].

To the best of our knowledge, there is no proper indicator that has been defined exclusively to measure the degree of cognitive recovery after cognitive fatigue, however, EEG sensors have also been used to measure indirectly the degree of recovery after cognitively fatiguing tasks, suggesting that alpha and theta brain waves may be used as indicators of mental recovery after cognitive fatigue [44].

3.4. Concentration-Attention

Concentration is an attentional process that involves the ability to optimally focus on a given task while ignoring distractions [45]. This attentional process accounts for selectivity of information processing, intensity of focus, consciousness and/or the allocation of a limited resource capacity to cope with ongoing cognitive demands. On the other hand, *attention* is defined as people's ability to focus on information originating either from the external world or from internal sources [46, 47]. In turn, attention encompasses (at least) three components or dimensions: *concentration* or *effortful awareness*, *selective perception* and *divided attention.* Hence, the concepts of concentration and attention are strongly correlated and mutually reinforcing.

The assessing of attention and its implicated concentration through subjective methods such as questionnaires is common. Some questionnaires used in physical activities and sports are the test of attentional and interpersonal style [48], and the thought occurrence questionnaire for sport [49]. Objective measurements to monitor the level of attention by means of devices, commonly use functional magnetic resonance imaging [50], EEG sensors [51], ECG sensors [52], or ocular activity [53, 54].

3.5. Motivation

Motivation is a process that influences the initiation, direction, magnitude, perseverance, continuation, and quality of goal-directed behavior. In sports psychology, the achievement goal theory and the self-determination theory are among those that acquire greater relevance [55].

To measure motivation, subjective assessments are typically used; six of the most cited motivation in sport are Sport Motivation Scale, Intrinsic Motivation Inventory, Situational Motivation Scale, Perceptions of Success Questionnaire, Behavioral Regulation in Sport Questionnaire, and Task and Ego Orientation in Sport Questionnaire [56].

3.6. Self-efficacy

Self-efficacy is a construct coined by Bandura [57, 58] which refers to a person's belief in his/her ability to execute behaviors necessary to produce specific performance achievements. By itself, self-efficacy is a theory, the self-efficacy theory. Specifically, the *construct self-efficacy* can also be interpreted as an *evaluation* or *judgment*, through beliefs of *perceived abilities*, of whether one *can* perform the necessary *actions* such as motor abilities and behaviors to successfully achieve a desired goal [59]. *Self-efficacy beliefs* are about "what one thinks one can do, not what one has" [60]; these beliefs are developed through the cognitive processing of sources of efficacy information, which are enactive mastery experiences or performance accomplishments, vicarious experiences, imaged experiences, social or verbal persuasion, and physiological and emotional states. In sport has been demonstrated, the improvement of self-efficacy through psychological performance enhancement techniques in motor tasks [61]. Alternatively, mental training techniques such as imagery and self-talk can also enhance confidence [62].

Since self-efficacy involves judgments and beliefs, the unique methods to measure it are subjective assessments; some examples are the sources of sport confidence questionnaire [63], and the self-efficacy for exercise scale [64].

3.7. Self-regulation

Self-regulation refers to the individual's ability with its associated processes to adjust the frequency and intensity of their own behaviors, thoughts, emotions and impulses by management of the stress-load and recovery in service of *longer-term goals* [65, 66]. The self-regulation construct comes from a theory with the same name, the self-regulation theory. The process of self-regulation has four main components: *commitment to a standard*, *monitoring*, *self-regulatory strength* or *willpower*, and *motivation* [67, 68].

To our knowledge, the only alternatives to wholly measure self-regulation are via subjective assessments, for instance, the self-regulation questionnaire [69], the self-regulation of learning self-report scale [70].

3.8. Mental toughness

Mental toughness can be defined as the mental ability to deal effectively with training and competition demands in an effort to maintain control of the situation [71]. Some studies, it has been found the relevance of mental toughness in educational and work settings, as well as mental health, sleep quality and stress coping [72].

The most preferred conceptual framework for its study finds its basics on the 4C's model which has four independent components: *Control, Commitment*, *Challenge*, and *Confidence* [73].

There are no objective indicators for mental toughness; its measurement is subjectively done using questionnaires, scales or indexes such as the sport mental toughness questionnaire, the mental toughness scale and the mental toughness index [71, 72].

4. Conclusions

Among mental factors that running experts target to improve people's performance can be evaluated objectively or subjectively. Objective methods use devices that capture the athlete's physiological signals, such as EEG and ECG. Subjective methods use tools like questionnaires and scales to generate a score. However, subjective methods are the only ones that are always available when evaluating mental factors for the running case. This is because mental factors are interrelated and influence each other, making it difficult to isolate them by exclusively physiological approaches.

The theories of self-efficacy, self-regulation, achievement goal and self-determination, as well as the 4C's model of mental toughness, are some potential approaches to further investigate the identified mental factors [Figure 1]. Although they can be used as references, it is not excluded the possibility to use others instead of them. As a future work, we would propose to create a framework that combines the most appropriate features of each theory to target the mental training of running.

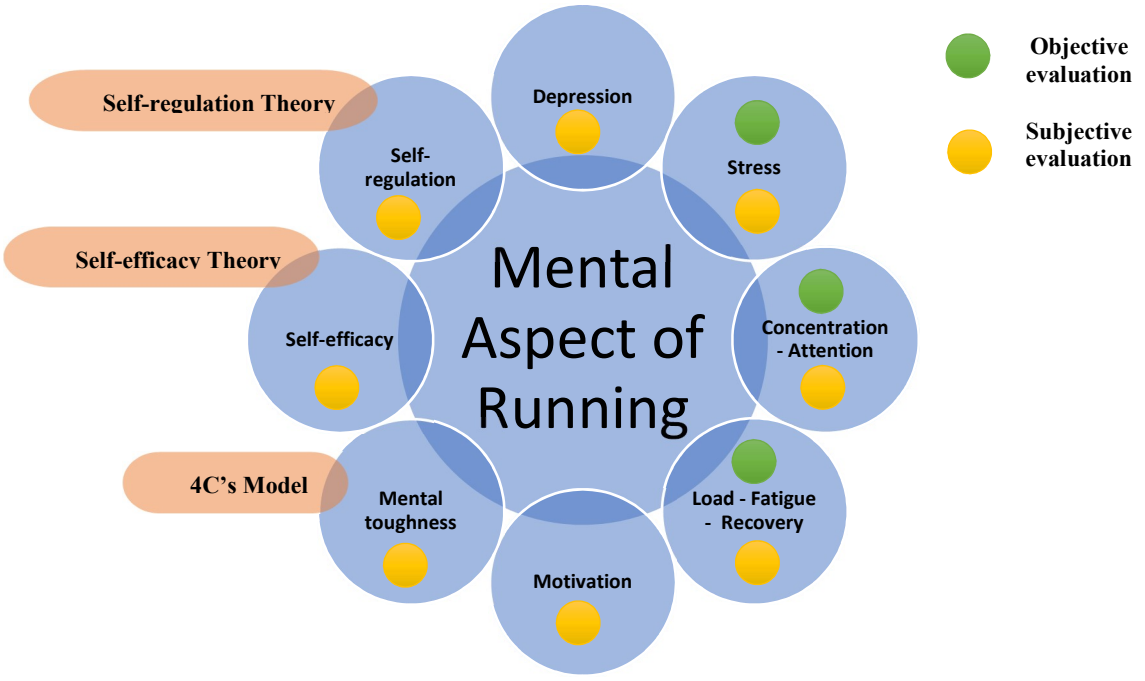

Figure 1: Mental factors of running

5. References

[1] McCormick, A., Meijen, C., Anstiss, P. A., & Jones, H. S. (2019). Self-regulation in endurance sports: theory, research, and practice. *International Review of Sport and Exercise Psychology*, *12*(1), 235–264. https://doi.org/10.1080/1750984X.2018.1469161

[2] Ford, J., Ildefonso, K., Jones, M., & Arvinen-Barrow, M. (2017). Sport-related anxiety: current insights. *Open Access Journal of Sports Medicine*, *Volume 8*, 205–212. https://doi.org/10.2147/OAJSM.S125845

[3] Hardy, L. (1992). Psychological stress, performance, and injury in sport. *British Medical Bulletin*, *48*(3), 615–629. https://doi.org/10.1093/oxfordjournals.bmb.a072567

[4] Graydon, J. (2002). Stress and anxiety in sport. *The Psychologist*, *15*(8), 408–410.

[5] Hardy, L. (1999). Stress, anxiety and performance. *Journal of Science and Medicine in Sport*, *2*(3), 227–233. https://doi.org/10.1016/S1440-2440(99)80175-3

[6] Tanguy, G., Sagui, E., Fabien, Z., Martin-Krumm, C., Canini, F., & Trousselard, M. (2018). Anxiety and Psycho-Physiological Stress Response to Competitive Sport Exercise. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01469

[7] Figueroa-Fankhanel, F. (2014). Measurement of Stress. *Psychiatric Clinics of North America*, *37*(4), 455–487. https://doi.org/10.1016/j.psc.2014.08.001

[8] Parnabas, V., Parnabas, J., & Parnabas, A. M. (2015). The Effect of Cognitive Anxiety on Sport Performances among Football Players. *The International Journal of Indian Psychology*, *2*.

[9] Steptoe, A., Moses, J., & Edwards, S. (1990). Age-related differences in cardiovascular reactions to mental stress tests in women. *Health Psychology*, *9*(1), 18–34. https://doi.org/10.1037/0278-6133.9.1.18

[10] Nixdorf, I., Frank, R., & Beckmann, J. (2015). An Explorative Study on Major Stressors and Its Connection to Depression and Chronic Stress among German Elite Athletes. *Advances in Physical Education*, *05*(04), 255–262. https://doi.org/10.4236/ape.2015.54030

[11] Wolanin, A., Gross, M., & Hong, E. (2015). Depression in Athletes. *Current Sports Medicine Reports*, *14*(1), 56–60. https://doi.org/10.1249/JSR.0000000000000123

[12] Gouttebarge, V., Frings-Dresen, M. H. W., & Sluiter, J. K. (2015). Mental and psychosocial health among current and former professional footballers. *Occupational Medicine*, *65*(3), 190–196. https://doi.org/10.1093/occmed/kqu202

[13] Junge, A., & Feddermann-Demont, N. (2016). Prevalence of depression and anxiety in top-level male and female football players. *BMJ Open Sport & Exercise Medicine*, *2*(1), e000087. https://doi.org/10.1136/bmjsem-2015-000087

[14] Nixdorf, I., Frank, R., Hautzinger, M., & Beckmann, J. (2013). Prevalence of Depressive Symptoms and Correlating Variables Among German Elite Athletes. *Journal of Clinical Sport Psychology*, *7*(4), 313–326. https://doi.org/10.1123/jcsp.7.4.313

[15] Nixdorf, I., Beckmann, J., & Nixdorf, R. (2020). Psychological Predictors for Depression and Burnout Among German Junior Elite Athletes. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.00601

[16] Santor, D. A., Gregus, M., & Welch, A. (2006). Focus Article: Eight Decades of Measurement in Depression. *Measurement: Interdisciplinary Research & Perspective*, *4*(3), 135–155. https://doi.org/10.1207/s15366359mea0403_1

[17] Sung, M., Marci, C., & Pentland, A. (2005). Wearable feedback systems for rehabilitation. *Journal of NeuroEngineering and Rehabilitation*, *2*(1), 17. https://doi.org/10.1186/1743-0003-2-17

[18] Valenza, G., Gentili, C., Lanatà, A., & Scilingo, E. P. (2013). Mood recognition in bipolar patients through the PSYCHE platform: Preliminary evaluations and perspectives. *Artificial Intelligence in Medicine*, *57*(1), 49–58. https://doi.org/10.1016/j.artmed.2012.12.001

[19] Fuster, J., Caparrós, T., & Capdevila, L. (2021). Evaluation of cognitive load in team sports: literature review. *PeerJ*, *9*, e12045. https://doi.org/10.7717/peerj.12045

[20] Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

[21] Sweller, J., & Chandler, P. (1991). Evidence for Cognitive Load Theory. *Cognition and Instruction*, *8*(4), 351–362. https://doi.org/10.1207/s1532690xci0804_5

[22] Orru, G., & Longo, L. (2019). The Evolution of Cognitive Load Theory and the Measurement of Its Intrinsic, Extraneous and Germane Loads: A Review (pp. 23–48). https://doi.org/10.1007/978-3-030-14273-5_3
[23] Young, M. S., Brookhuis, K. A., Wickens, C. D., & Hancock, P. A. (2015). State of science: mental workload in ergonomics. *Ergonomics*, *58*(1), 1–17. https://doi.org/10.1080/00140139.2014.956151
[24] Russell, S., Kelly, V. G., Halson, S. L., & Jenkins, D. G. (2020). Cognitive Load in Sport. In *Human Factors and Ergonomics in Sport* (1st ed., pp. 181–200). CRC Press.
[25] Konings, M. J., & Hettinga, F. J. (2018). Pacing Decision Making in Sport and the Effects of Interpersonal Competition: A Critical Review. *Sports Medicine*, *48*(8), 1829–1843. https://doi.org/10.1007/s40279-018-0937-x
[26] Blakely, M. J., Wilson, K., Russell, P. N., & Helton, W. S. (2016). The Impact of Cognitive Load on Volitional Running. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *60*(1), 1179–1183. https://doi.org/10.1177/1541931213601276
[27] McCarron, J., Hodgson, T., & Smith, M. (2013). Brain drain: evaluating the impact of increased cognitive load during self-paced running performance. *British Journal of Sports Medicine*, *47*(17), e4.38-e4. https://doi.org/10.1136/bjsports-2013-093073.43
[28] Rubio, S., Diaz, E., Martin, J., & Puente, J. M. (2004). Evaluation of Subjective Mental Workload: A Comparison of SWAT, NASA-TLX, and Workload Profile Methods. *Applied Psychology*, *53*(1), 61–86. https://doi.org/10.1111/j.1464-0597.2004.00161.x
[29] Charles, R. L., & Nixon, J. (2019). Measuring mental workload using physiological measures: A systematic review. *Applied Ergonomics*, *74*, 221–232. https://doi.org/10.1016/j.apergo.2018.08.028
[30] Pageaux, B., & Lepers, R. (2018). *The effects of mental fatigue on sport-related performance* (pp. 291–315). https://doi.org/10.1016/bs.pbr.2018.10.004
[31] Schiphof-Godart, L., Roelands, B., & Hettinga, F. J. (2018). Drive in Sports: How Mental Fatigue Affects Endurance Performance. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01383
[32] Sansone, P., Tessitore, A., Lukonaitiene, I., Paulauskas, H., Tschan, H., & Conte, D. (2020). Technical-tactical profile, perceived exertion, mental demands and enjoyment of different tactical tasks and training regimes in basketball small-sided games. *Biology of Sport*, *37*(1), 15–23. https://doi.org/10.5114/biolsport.2020.89937
[33] Lee, K. F. A., Gan, W.-S., & Christopoulos, G. (2021). Biomarker-Informed Machine Learning Model of Cognitive Fatigue from a Heart Rate Response Perspective. *Sensors*, *21*(11), 3843. https://doi.org/10.3390/s21113843
[34] Sun, H., Soh, K. G., Roslan, S., Wazir, M. R. W. N., & Soh, K. L. (2021). Does mental fatigue affect skilled performance in athletes? A systematic review. *PLOS ONE*, *16*(10), e0258307. https://doi.org/10.1371/journal.pone.0258307
[35] Schapschröer, M., Lemez, S., Baker, J., & Schorer, J. (2016). Physical Load Affects Perceptual-Cognitive Performance of Skilled Athletes: a Systematic Review. *Sports Medicine - Open*, *2*(1), 37. https://doi.org/10.1186/s40798-016-0061-0
[36] Cheng, S.-Y., & Hsu, H.-T. (2011). Mental Fatigue Measurement Using EEG. In *Risk Management Trends*. InTech. https://doi.org/10.5772/16376
[37] Bafna, T., & Hansen, J. P. (2021). Mental fatigue measurement using eye metrics: A systematic literature review. *Psychophysiology*, *58*(6). https://doi.org/10.1111/psyp.13828
[38] Huang, S., Li, J., Zhang, P., & Zhang, W. (2018). Detection of mental fatigue state with wearable ECG devices. *International Journal of Medical Informatics*, *119*, 39–46. https://doi.org/10.1016/j.ijmedinf.2018.08.010
[39] Birgitta Johansson, L. R. (2013). Evaluation of the Mental Fatigue Scale and its relation to Cognitive and Emotional Functioning after Traumatic Brain Injury or Stroke. *International Journal of Physical Medicine & Rehabilitation*, *02*(01). https://doi.org/10.4172/2329-9096.1000182
[40] Lee, K. A., Hicks, G., & Nino-Murcia, G. (1991). Validity and reliability of a scale to assess fatigue. *Psychiatry Research*, *36*(3), 291–298. https://doi.org/10.1016/0165-1781(91)90027-M

[41] Krupp, L. B. (1989). The Fatigue Severity Scale. *Archives of Neurology*, *46*(10), 1121. https://doi.org/10.1001/archneur.1989.00520460115022
[42] Kellmann, M., Bertollo, M., Bosquet, L., Brink, M., Coutts, A. J., Duffield, R., Erlacher, D., Halson, S. L., Hecksteden, A., Heidari, J., Kallus, K. W., Meeusen, R., Mujika, I., Robazza, C., Skorski, S., Venter, R., & Beckmann, J. (2018). Recovery and Performance in Sport: Consensus Statement. *International Journal of Sports Physiology and Performance*, *13*(2), 240–245. https://doi.org/10.1123/ijspp.2017-0759
[43] Loch, F., Ferrauti, A., Meyer, T., Pfeiffer, M., & Kellmann, M. (2019). Resting the mind – A novel topic with scarce insights. Considering potential mental recovery strategies for short rest periods in sports. *Performance Enhancement & Health*, *6*(3–4), 148–155. https://doi.org/10.1016/j.peh.2019.04.002
[44] Jacquet, T., Poulin-Charronnat, B., Bard, P., & Lepers, R. (2021). Persistence of Mental Fatigue on Motor Control. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.588253
[45] Moran, A. (2012). *Concentration: Attention and Performance*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199731763.013.0006
[46] Moran, A. (2017). Attention and Concentration Training in Sport☆. In *Reference Module in Neuroscience and Biobehavioral Psychology*. Elsevier. https://doi.org/10.1016/B978-0-12-809324-5.05476-6
[47] Moran, A., & Toner, J. (2017). *A Critical Introduction to Sport Psychology*. Routledge. https://doi.org/10.4324/9781315657974
[48] Nideffer, R. M. (1976). Test of attentional and interpersonal style. *Journal of Personality and Social Psychology*, *34*(3), 394–404. https://doi.org/10.1037/0022-3514.34.3.394
[49] Hatzigeorgiadis, A., & Biddle, S. J. H. (2000). Assessing cognitive interference in sport: Development of the thought occurrence questionnaire for sport. *Anxiety, Stress & Coping*, *13*(1), 65–86. https://doi.org/10.1080/10615800008248334
[50] Mather, M., Cacioppo, J. T., & Kanwisher, N. (2013). How fMRI Can Inform Cognitive Theories. *Perspectives on Psychological Science*, *8*(1), 108–113. https://doi.org/10.1177/1745691612469037
[51] Cooke, A. (2013). Readying the head and steadying the heart: a review of cortical and cardiac studies of preparation for action in sport. *International Review of Sport and Exercise Psychology*, *6*(1), 122–138. https://doi.org/10.1080/1750984X.2012.724438
[52] Belle, A., Hargraves, R. H., & Najarian, K. (2012). An Automated Optimal Engagement and Attention Detection System Using Electrocardiogram. *Computational and Mathematical Methods in Medicine*, *2012*, 1–12. https://doi.org/10.1155/2012/528781
[53] Duchowski, A. (2007). *Eye Tracking Methodology*. Springer London. https://doi.org/10.1007/978-1-84628-609-4
[54] Moran, A., Quinn, A., Campbell, M., Rooney, B., Brady, N., & Burke, C. (2016). Using pupillometry to evaluate attentional effort in quiet eye: A preliminary investigation. *Sport, Exercise, and Performance Psychology*, *5*(4), 365–376. https://doi.org/10.1037/spy0000066
[55] Roberts, G. C., Nerstad, C. G. L., & Lemyre, P. N. (2018). Motivation in Sport and Performance. In *Oxford Research Encyclopedia of Psychology*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190236557.013.150
[56] Clancy, R. B., Herring, M. P., & Campbell, M. J. (2017). Motivation Measures in Sport: A Critical Review and Bibliometric Analysis. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00348
[57] Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191
[58] Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.
[59] Gallagher, M. W. (2012). Self-Efficacy. In *Encyclopedia of Human Behavior* (pp. 314–320). Elsevier. https://doi.org/10.1016/B978-0-12-375000-6.00312-8
[60] Feltz, D. L., & Lirgg, C. D. (2001). Self-efficacy Beliefs of Athletes, Teams, and Coaches. In R. N. Singer, H. A. Hausenblas, & C. Janelle (Eds.), *Handbook of Sport Psychology* (2nd ed., pp. 340–361). John Wiley & Sons.

[61] Wright, B. J., O'Halloran, P. D., & Stukas, A. A. (2016). Enhancing Self-Efficacy and Performance: An Experimental Comparison of Psychological Techniques. *Research Quarterly for Exercise and Sport*, *87*(1), 36–46. https://doi.org/10.1080/02701367.2015.1093072
[62] Vealey, R. S. (2009). Confidence in Sport. In B. W. Brewer (Ed.), *Sport Psychology* (pp. 43–52). Wiley-Blackwell. https://doi.org/10.1002/9781444303650.ch5
[63] Vealey, R. S., Garner-Holman, M., Hayashi, S. W., & Giacobbi, P. (1998). Sources of Sport-Confidence: Conceptualization and Instrument Development. *Journal of Sport and Exercise Psychology*, *20*(1), 54–80. https://doi.org/10.1123/jsep.20.1.54
[64] Resnick, B., & Jenkins, L. S. (2000). Testing the Reliability and Validity of the Self-Efficacy for Exercise Scale. *Nursing Research*, *49*(3), 154–159. https://doi.org/10.1097/00006199-200005000-00007
[65] Eisenberg, I. W., Bissett, P. G., Zeynep Enkavi, A., Li, J., MacKinnon, D. P., Marsch, L. A., & Poldrack, R. A. (2019). Uncovering the structure of self-regulation through data-driven ontology discovery. *Nature Communications*, *10*(1), 2319. https://doi.org/10.1038/s41467-019-10301-1
[66] Shanker, S. (2016, July 11). *Self-Regulation vs. Self-Control - The reason for the profound differences lies deep inside the brain*. Psychology Today. https://www.psychologytoday.com/us/blog/self-reg/201607/self-regulation-vs-self-control
[67] Baumeister, R. F., & Vohs, K. D. (2007). Self-Regulation, Ego Depletion, and Motivation. *Social and Personality Psychology Compass*, *1*(1), 115–128. https://doi.org/10.1111/j.1751-9004.2007.00001.x
[68] Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The Strength Model of Self-Control. *Current Directions in Psychological Science*, *16*(6), 351–355. https://doi.org/10.1111/j.1467-8721.2007.00534.x
[69] Brown, J. M., Miller, W. R., & Lawendowski, L. A. (1999). The self-regulation questionnaire. In VandeCreek L. & T. L. Jackson (Eds.), *Innovations in clinical practice: A source book* (Vol. 17, pp. 281–292). Professional Resource Press/Professional Resource Exchange.
[70] Toering, T., Elferink-Gemser, M. T., Jonker, L., van Heuvelen, M. J. G., & Visscher, C. (2012). Measuring self-regulation in a learning context: Reliability and validity of the Self-Regulation of Learning Self-Report Scale (SRL-SRS). *International Journal of Sport and Exercise Psychology*, *10*(1), 24–38. https://doi.org/10.1080/1612197X.2012.645132
[71] Liew, G. C., Kuan, G., Chin, N. S., & Hashim, H. A. (2019). Mental toughness in sport. *German Journal of Exercise and Sport Research*, *49*(4), 381–394. https://doi.org/10.1007/s12662-019-00603-3
[72] Lin, Y., Mutz, J., Clough, P. J., & Papageorgiou, K. A. (2017). Mental Toughness and Individual Differences in Learning, Educational and Work Performance, Psychological Well-being, and Personality: A Systematic Review. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.01345
[73] Gucciardi, D. F. (2020). Mental Toughness. In *Handbook of Sport Psychology* (pp. 101–120). Wiley. https://doi.org/10.1002/9781119568124.ch6