The Sport and Exercise Scientist

The official publication of the British Association of Sport and Exercise Sciences

Issue 57, **Autumn 2018**

The BASES Expert Statement on Exercise Training for People with Intermittent Claudication due to Peripheral Arterial Disease

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ISSN 1754-3452

Head in the game: mental fatigue and its potential influence on the perceptual-cognitive element in sport

Robert McCunn, Christopher Thompson, Adam Beavan and Neil Gibson discuss mental fatigue.

Introduction

There are few, if any, sporting events in which the outcome is decided by physical attributes alone, despite the Olympic motto of *Citius, Altius, Fortius: Faster, Higher, Stronger.* We are all familiar with the old adage that at the very top level, psychological attributes provide the edge as homogeneity in physical qualities somewhat levels the playing field. An emerging area of research is concerned with 'mental fatigue' and its influence on sporting performance. In this article we introduce the theory of mental fatigue, explore how it may impact upon perceptual-cognitive abilities, and postulate what coaches and athletes might be able to do to protect against it.

What is mental fatigue?

Mental fatigue is a psychobiological state experienced following exposure to cognitively demanding tasks. A lack of energy and feelings of tiredness are associated with mental fatigue, and it causes a reduction in attention, reaction times, task planning and slower adjustments in performance after errors. Whilst sports performance is clearly physically demanding, it is also likely to be mentally demanding as a result of the requirement for rapid information processing during competition and subsequent decision-making. Aside from this, the monetary pressure, personal pressure to perform, plus the influence of multiple media outlets that are quick to glorify the successful and criticise those who fail have been cited in the literature as contributors. Indeed, the importance of investigating the effects of mental fatigue on team sport performance was highlighted in a recent editorial (Coutts, 2016).

However, the research investigating mental fatigue on sport performance is relatively scarce. A systematic review reported that endurance performance is negatively influenced by induced mental fatigue. In team sports, seven studies exist in the literature, six of which relate to football and were recently summarised by Smith *et al*. (2018). Within these studies, isolated physical tests and several parameters of 'performance' in small-sided-games were used as markers by which the influence of mental fatigue was judged. Induced mental fatigue negatively influenced football-specific physical, technical and tactical performance. Furthermore, it had unclear effects on visual search behaviour and decision-making. The only non-football team sport study was conducted in cricket, where it was found that cricket-specific sprinting performance (run-two test) and Yo-Yo IR1 distance were negatively affected by induced mental fatigue.

The perceptual-cognitive element

In the context of sport, the term 'perceptual-cognitive skill' refers to athletes' ability to process the environment around them via informational pathways such as visual feedback, integrate this information with existing knowledge developed over years of playing experience, and then formulate an appropriate response (Marteniuk, 1976).

The ability to make fast and effective decisions is one of many facets contributing to successful performance in team sports. Athletes must rapidly process large amounts of information to carry out movements that take into account the constraints imposed by the environment, the individual and the intended task. For example, in football, an attacker running down the wing might only have one chance to scan the area they intend to deliver the ball into prior to carrying out the action of kicking. During this time, the athlete must gather vital information on the trajectory of their teammates to pass the ball effectively, anticipate which teammate will be the most suitable option based on both the teammates' and opposition's positions, all whilst negating unimportant information such as crowd noise. Therefore, it is crucial that athletes refine their ability to recognise and then extract important information.

As visual feedback is the dominant source of information for team sport athletes, a myriad of research has focused on examining the visual search patterns of expert athletes. A meta-analysis determined that expert athletes across a variety of team sports have a unique way of looking at specific scenarios related to their sport in comparison to sub-elite or general populations (Mann *et al*., 2007). Expert players are able to distinguish the more information-rich areas and suitably direct their attention to extract this information as efficiently as possible. Accordingly, experts fixated on fewer areas on a display screen showing realistic filmed situations of offensive play (i.e. a 3-on-3 in football) for longer periods of time, whereas non-experts fixated on more areas on the display but for less time. In team sport, experts generally rely on their peripheral vision more so than novices who tend to focus solely on their central fixation (resembling a spotlight). For example, when attempting to tackle a player who is running with the ball towards them, a novice may be completely focused on the ball whereas an expert may be able to do this while also being aware of surrounding information like other players' positions and the attacking player's body position. This type of 'perceptual-cognitive skill' is perhaps what makes certain athletes, particularly those not known for their athleticism, seemingly able to perform at high levels in an effortless manner.

The ability to make fast and effective decisions is one of many facets contributing to successful performance in team sports

Is there an effect of mental fatigue on perceptual-cognitive skill?

Although the effects of mental fatigue have not been extensively studied in sport, prior research in non-sporting domains such as behaviour science can provide insight into how it may affect the perceptual-cognitive abilities of athletes. Research in buying automobiles (Levav *et al*., 2010) and judicial rulings (Danziger *et al*., 2011) has suggested that decision-fatigue, caused by repetitive decision-making, can deplete individuals' cognitive abilities and mental resources, which in turn influences their subsequent decision. Collectively, these studies demonstrate that a mentally depleted individual may make a decision characterised by ease of mental effort rather than rationality. As team sport players make an immeasurable amount of high-risk and high-pressure decisions within a game, it may be plausible that the presence of decision simplification strategies to compensate for decision-fatigue occurs.

However, as these studies are not within an athletic population, we can only speculate whether there is an effect of decisional-fatigue in team sport athletes until further research is conducted.

How might one protect against mental fatigue?

One novel method of developing resistance to mental fatigue is to incorporate prolonged cognitive tasks simultaneously alongside physical training. Marcora *et al*. (2015) investigated brain endurance training (BET), where participants cycled at 60% of $\dot{V}O_2$max for 60 minutes, 3 times a week for 12 weeks. The participants were split into two groups during this period, consisting of a BET group who completed a cognitively demanding task on a computer (AX - Continuous performance task) whilst completing all of the cycling sessions, plus a control group who only participated in the cycling trials. Time to exhaustion was significantly longer in the BET group. Whilst this early work appears promising, it may prove difficult to conduct similar studies in sporting disciplines with more multifaceted physical demands (i.e. team sports).

A more practical alternative is the use of caffeine before competition; a hypothesis two studies have tested. Firstly, Azevedo *et al*. (2016) demonstrated that consumption of caffeine (5 mg kg^{-1}) following a mentally fatiguing task resulted in a longer time to exhaustion in a cycling trial in comparison to the other conditions (control, mental fatigue, and mental fatigue and placebo). Secondly, it was recently reported that a caffeine mouth rinse (0.3 g/25 ml caffeine: 1.6g/25 ml maltodextrin) resulted in a lower perception of subjective mental fatigue and greater normalised accuracy in the final block of a 90-minute Stroop task when compared to a placebo substance (van Cutsem *et al*., 2018). Whilst these two studies provide intriguing findings, it would be interesting to investigate this with sport-specific protocols, plus evaluate the effectiveness of caffeine over repeated trials, as it has been previously found that chronic caffeine use reduces improvements in cognitive performance.

Unresolved issues

At present, the literature that has investigated the effects of mental fatigue on sport and exercise performance includes several limitations. First, it could be argued that the protocols typically used to induce mental fatigue (AX - Continuous performance task/ Stroop task) lack ecological validity from a sporting perspective. These studies also predominantly observed either sub-elite or recreational level athletes, whose perceptions of mental fatigue may well differ from elite demographics that perform under greater levels of pressure and performance standards. In addition, the majority of mental fatigue studies use a visual analogue scale to measure subjective mental fatigue. By solely using this measure, participants in studies may lack the understanding of the definition of mental fatigue and also confuse symptoms of mental fatigue with those of a physically fatiguing nature.

Future research must seek to elucidate some of the unique potential contributors to mental fatigue faced by elite athletes such as remembering numerous 'set plays' and positional requirements, commercial sponsorship commitments and daily public scrutiny. Such studies should use surveys/interviews, plus also consider the use of secondary measurements of mental fatigue (i.e. objective psychophysiological measurements such as electroencephalography) to further differentiate between physical and mental workload during task performance.

Furthermore, a concerning trend for researchers has been to organise participants into groups based on their level of expertise within their respective sport. This methodology may be flawed as players are subjectively assumed to have greater perceptual-cognitive skills at higher playing levels. However, the skills necessary to achieve excellence within a sport are multifaceted, and a deficiency in one domain such as decision-making can be compensated for in another (e.g. high physical conditioning), known as the compensation phenomenon. Lastly, although research can demonstrate what strategies experts employ to view a situation better, beginners cannot merely adopt more ecological visual search behaviour; as they do not yet possess the ability to interpret and integrate the available information with their underlying knowledge.

Conclusion

Unlike many physical qualities, which have well-established performance tests associated with them, perceptual-cognitive attributes and mental fatigue are less easily quantified. As technology advances and sport scientists increasingly turn their attention to the identification and development of perceptual-cognitive skills, assessments that are more representative of sporting demands will presumably follow suit. In this context, the next challenge for the applied practitioner will not be a new one: how best to use the resultant data from such tests? Mental fatigue appears to be a likely influence on perceptual-cognitive abilities in team sports particularly. Further research is needed before firm conclusions can be made regarding how (if indeed it is possible) to improve athletes' resilience to its effect. Watch this space. ■

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