Mental Fatigue and Physical Exercise: Exploring the Electrophysiological Labyrinth

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PUBLIC PHD DEFENCE FOR THE DEGREE OF
DOCTOR IN REHABILITATION SCIENCES AND PHYSIOTHERAPY

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ABSTRACT OF THE RESEARCH

Mental fatigue, caused by extended cognitive effort, affects both cognitive tasks and athletic performance, impacting endurance and sport-specific psychomotor abilities. Despite the well-documented effects and measurements of mental fatigue, comprehending its precise impact on physical performance and implementing effective countermeasures continues to be challenging. This doctoral research aimed to clarify the electrophysiological pathways connecting mental fatigue, perceived exertion, and physical activity by integrating various techniques for EEG analysis. The objectives of this study are centered on exploring the electrophysiological consequences of mental fatigue on physical exercise. Specifically, the research focuses on (i) identifying and comprehending the mechanisms underlying efficient mental fatigue countermeasures, (ii) analyzing variations in brain activity during sport-specific psychomotor tasks under mental fatigue, and (iii) investigating the effect of mental fatigue on brain activity during different endurance exercises in relation to perceived exertion ratings, to shed light on its electrophysiological pathway.

The systematic review in Chapter 2 highlighted that most countermeasures positively affect behavioral and subjective mental fatigue outcomes. Odor interventions and caffeine intake before tasks emerged as the most efficacious physiological countermeasures. Behavioral strategies, such as music listening, and psychological tactics, like enhancing extrinsic motivation, also showed promise. However, the lack of diverse and evaluated neurophysiological markers indicated a gap in understanding the mechanistic pathways of mental fatigue, prompting a shift towards more fundamental EEG-based studies to delve deeper into its electrophysiological mechanisms.

Therefore, Chapter 3 explored how mental fatigue influences sport-specific psychomotor task performance, with EEG findings providing insights into the brain's functioning under mental fatigue. Contrary to expectations, mental fatigue did not significantly alter ERPs during the visuomotor task. However, significant decreases in spectral power within certain brain wave frequencies, specifically, upper alpha, lower alpha, and theta bands during the task were observed, challenging prior assumptions, and shedding light on mental fatigue's effects during physical exercise.

In endurance-based physical exercises, Chapter 4's strength endurance task study aimed to analyze mental fatigue's expected impact on perceived exertion ratings, utilizing ERP analysis of movement-related cortical potentials (MRCPs). Despite inducing mental fatigue, the study found no significant changes in perceived exertion ratings or MRCPs. Surprisingly, an increase in alpha wave power was associated with reduced self-reported mental fatigue. These findings highlight a new role for spectral band activity in the relationship between mental fatigue and physical tasks, demonstrating that mental fatigue can impact endurance tasks in nuanced ways that challenge previous assumptions. A similar finding was present in Chapter 5, where applying continuous wavelet transformation in EEG analysis on brain activity during a cycling task revealed significant variations in the beta frequency band between conditions. These findings further emphasize the distinct impact of mental fatigue within physical exercise in comparison to cognitive tasks, also highlighting wavelet analysis as a promising neurophysiological measure for uncovering underlying mechanisms within physical exercises and suggesting novel approaches for future research and countermeasure evaluation.

The studies from Chapters 3, 4, and 5 reveal that the effect of mental fatigue on neurophysiological markers differs between cognitive tasks and physical exercise. The studies indicate that mental fatigue primarily affects the higher frequency bands (i.e., alpha and beta wave power), suggesting that other cognitive processes (e.g., internal focus of control) are used to counteract the negative effects of mental fatigue. This also demonstrates that neurophysiological markers are crucial in deciphering the mechanisms behind mental fatigue and countermeasures. These results, along with the findings of the systematic review in Chapter 2, contribute to the development of effective strategies and combinations of countermeasures for mental fatigue. Although the results have not led to an exit from the neurophysiological labyrinth, it is clear from these PhD findings what the labyrinth consists of.

CURRICULUM VITAE

Matthias Proost began his doctoral studies in 2020 as part of the Human Physiology and Sports Physiotherapy Research Group (MFYS). Following the completion of his Master's degree in Rehabilitation Sciences and Physiotherapy, with a specialization in Sports Physiotherapy, as well as his Honors College degree from VUB in 2019, he was given the opportunity to pursue his doctoral research in the area of mental fatigue. Leveraging the existing knowledge and expertise at MFYS, his research aims to uncover the impact of mental fatigue on physical exercise.