

BAB II

INTRODUCTION

Cardiorespiratory endurance is one of the most critical indicators of physical fitness, reflecting the body's ability to perform sustained aerobic exercise. A combination of physiological and psychological factors influences this endurance. Among these, body composition, hemoglobin concentration, and motivation are often identified as potential predictors of endurance capacity. While body composition and hemoglobin are physiological markers that directly influence oxygen transport and utilization, motivation affects individuals' intensity and persistence in physical activity. Understanding how these variables interact is essential to developing holistic approaches to improving aerobic performance. Numerous studies have evidenced that body composition, particularly the balance between fat and lean mass, significantly influences cardiorespiratory fitness. Higher body fat percentages are generally linked to reduced VO_2 max, a primary marker of aerobic capacity, with research showing a consistent negative correlation between fat mass and VO_2 max across various populations, including young adults, athletes, and university rugby players (Vargas et al., 2018; Dewi et al., 2015; Shalan et al., 2024). Conversely, lean body mass, especially skeletal muscle volume, demonstrates a positive relationship with peak oxygen consumption, underscoring its role in enhancing aerobic performance even when fat mass is controlled (Karlsson et al., 2024; Maciejczyk et al., 2014). Gender differences further complicate this relationship; for instance, waist circumference has been found to negatively correlate more strongly with respiratory exchange ratio in females than in males (Karlsson et al., 2024). In athletic youth populations, such as soccer players, reductions in fat percentage have been associated with improved aerobic endurance (Nalbant & Özer, 2018). However, individual differences, including age, activity levels, and genetics, also play a role, and the distribution and type of muscle fibers may influence how effectively lean mass contributes to VO_2 max. Thus, optimizing cardiorespiratory fitness requires a holistic consideration of body composition alongside other physiological and lifestyle factors.

The hemoglobin concentration is a critical physiological factor influencing aerobic performance due to its essential role in oxygen transport. Higher hemoglobin levels are positively associated with increased VO_2 max, a key indicator of aerobic capacity, as shown in multiple studies across diverse populations (Webb et al., 2023; Leoprayogo et al., 2020). For instance, research on endurance-trained cyclists has demonstrated that hemoglobin mass is linked to cardiac dimensions, further underscoring its impact on aerobic function. However, this relationship becomes less predictive when adjusted for lean body mass (Ahlgrim et al., 2009). Additionally, hemoglobin levels have been shown to correlate with muscular endurance in athletes, such as soccer players, and with overall functional capacity in young adults (Utami & Amani, 2023). These findings highlight the multifaceted influence of hemoglobin on physical performance, reinforcing its value as a biomarker in endurance sports. However, aerobic performance cannot be fully explained by physiological parameters alone. Psychological factors, particularly motivation, are pivotal in shaping athletic outcomes.

Motivation affects an individual's willingness to initiate and sustain physical effort and influences training consistency, which may amplify the physiological advantages conferred by high hemoglobin levels. Emerging research emphasizes integrating physiological and psychological metrics to develop a holistic understanding of endurance performance (Vyas & Khanvilkar, 2024).

Metabolomic-based models now support such integration, offering more profound insights into how internal and external factors interact to optimize performance. This comprehensive approach allows for personalized training strategies that address the body and mind, ultimately leading to more effective performance outcomes. Despite established links between physical characteristics and aerobic performance, limited research has explored the combined predictive power of body composition,

hemoglobin concentration, and motivation on cardiorespiratory endurance. Most existing studies analyze these variables in isolation, without a holistic understanding of their interrelationships. While the roles of body composition and hemoglobin in influencing VO_2 max are well-documented, the impact of psychological factors such as motivation on physiological performance remains underrepresented in the literature. This study aims to fill that gap by analyzing the individual and combined influence of body composition (including body fat and lean mass), hemoglobin concentration, and motivation on cardiorespiratory endurance in a single model path analysis. The research seeks to determine whether physiological and psychological variables can predict endurance performance more effectively when assessed together rather than separately. The findings are expected to offer valuable insights for sports scientists, coaches, and athletes by informing the design of more personalized and comprehensive training programs. Moreover, this research aligns with recent advancements in fitness science that promote the integration of biometrics, psychological factors, and metabolomic data to enhance performance prediction and optimization.