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Descriptive analysis of anthropometric and body composition characteristics in youth cycling performance

Burhaan Shodiq[1abcde)], Inosen Lingsir Maghribi [2bc)*], Muhamad Ihsan Hufadz[3bc)], Azry Ayu Nabillah[4bd], Erny Amalia Lestari[5bd]
[12345]Sports Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Indonesia

ABSTRACT
Cycling performance is influenced by anthropometric characteristics and body composition that play a role in power production and motion efficiency. This study aims to describe the relationship of anthropometric characteristics and body composition with bicycle racing performance in adolescent mountain bike (MTB) athletes. The study used a descriptive quantitative design with a sample of three top-ranked athletes in the 2025 MTB criteria race in the 12-15 year age category in Lampung, Indonesia. Variables measured include completion time, final rating, height, weight, body mass index (BMI), body fat percentage, and muscle mass percentage. Anthropometric Data were measured using a stadiometer, body composition using bioelectrical impedance analysis (BIA), and racing performance was obtained from official competition records. Data analysis is done descriptively. The results showed that athletes with better performance tended to have a lower percentage of body fat and a higher percentage of muscle mass. Athletes with the fastest times had the most favorable body composition profiles, while BMI and general anthropometric measures did not show a consistent pattern of relationship with performance. Inferences of body composition, particularly low body fat and high muscle mass, are more related to cycling performance than to general anthropometric measures or BMI. However, these findings need to be interpreted carefully due to the very small sample size. Further studies are suggested involving larger samples and additional physiological variables.
Keywords: cycling performance; body composition; body fat percentage; muscle mass; anthropometry

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Corresponding Author: Inosen Lingsir Maghribi, Sports Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, South Lampung, Indonesia
email: inosen.maghribi@ro.itera.ac.id
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INTRODUCTION

Cycling performance is influenced by a combination of physiological capacity, anthropometric characteristics, and body composition (van der Zwaard et al., 2019). As an endurance sport, cycling requires athletes to sustain power output efficiently over a prolonged period while minimizing energy loss. Performance outcomes such as finish time and rank are not determined solely by aerobic fitness, but also by physical characteristics that affect mechanical efficiency and the ability to produce power relative to body mass (Sarkar et al., 2020; Sellés-Pérez et al., 2019). Anthropometric variables, including height and body weight, describe the overall structure and size of the athlete, while body composition variables such as body fat percentage and muscle mass percentage provide more specific information about the functional and non-functional components of body mass (Lanferdini et al., 2024; Sánchez-Muñoz et al., 2023). Understanding the relationship between these variables and cycling performance is important for evaluating athlete profiles and identifying factors associated with performance differences.

Anthropometric characteristics provide basic structural information that may influence cycling performance. Height can affect biomechanics, leverage, and cycling posture, which may influence pedaling efficiency and aerodynamic positioning (Faulkner et al., 2020; Korff et al., 2009). Body weight is also a critical factor because it directly affects the amount of mass that must be moved during cycling. In endurance cycling, excess body weight can increase energy expenditure and reduce efficiency, particularly when maintaining speed over long distances (Fornasiero et al., 2018; van der Zwaard et al., 2019). However, body weight alone does not distinguish between fat mass and lean mass, which have different functional roles. Therefore, anthropometric measurements must be interpreted together with body composition variables to better understand their relationship with performance.

Body composition is considered a more relevant indicator of performance because it reflects the functional quality of body mass (Fornasiero et al., 2018; van der Zwaard et al., 2019). Body fat percentage represents non-functional mass that does not contribute directly to force production but increases the total load that must be moved (Dulloo et al., 2015; van der Zwaard et al., 2019). Higher body fat levels can reduce movement efficiency and negatively affect the power-to-weight ratio, which is a key determinant of cycling performance. A lower body fat percentage is generally associated with better efficiency because less non-functional mass must be carried, allowing more effective use of energy during cycling (Fornasiero et al., 2018; Sarkar et al., 2020).

In contrast, muscle mass plays a direct role in generating force and producing power. Skeletal muscle is responsible for pedal force production, and a higher proportion of muscle mass can support greater power output and endurance capacity (Kordi et al., 2020; Rønnestad et al., 2015). However, the relationship between muscle mass and performance is not based solely on quantity, but also on functional relevance. Optimal muscle mass contributes to efficient power production without excessively increasing total body weight (Belzunce et al., 2023; Mandal & Kadyan, 2021). Therefore, an appropriate balance between muscle mass and body fat is essential for achieving optimal cycling performance.

Body Mass Index (BMI) is commonly used as a general indicator of body status, calculated from body weight and height (Firmansyah et al., 2022). While BMI provides a simple overview, it has limitations because it does not differentiate between fat mass and muscle mass (Cichosz et al., 2023). Two athletes with similar BMI values may have very different body compositions and performance potential (Giovanelli et al., 2023; Cichosz et al., 2023). As a result, BMI alone may not accurately reflect the physical characteristics that influence cycling performance. More specific

indicators such as body fat percentage and muscle mass percentage provide more meaningful information for evaluating athlete readiness and performance capacity (Gilang et al., 2025; Summer et al., 2024).

Together, these factors relate to the concept of relative power, which refers to power output in relation to body mass. Athletes who can produce higher power relative to their body weight are generally able to achieve faster speeds and better performance outcomes, particularly in endurance cycling where the power-to-weight ratio is a key determinant of performance (Sitko et al., 2022). This highlights the importance of minimizing non-functional mass while maintaining sufficient muscle mass for effective power production and physiological efficiency. Anthropometric and body composition characteristics together provide a more complete understanding of the athlete's physical profile and its relationship with performance, as both body mass and its composition directly influence relative power and endurance capacity.

Descriptive analysis of anthropometric and body composition variables in relation to finishing time and rank can provide valuable insight into performance characteristics. Differences in rank may be associated with variations in body fat percentage, muscle mass percentage, and overall body structure. Athletes with lower body fat and adequate muscle mass may demonstrate better efficiency and performance compared to athletes with higher body fat levels. However, performance is also influenced by other factors such as training level, aerobic capacity, and technical ability. Therefore, anthropometric and body composition analysis should be considered as part of a broader performance evaluation.

Understanding the relationship between anthropometric characteristics, body composition, and cycling performance is important for athlete assessment and performance optimization. This information can serve as a baseline for monitoring athlete development and guiding training strategies aimed at improving body composition and performance. By identifying physical characteristics associated with better performance, coaches and practitioners can design more effective training and conditioning programs. Overall, evaluating anthropometric and body composition variables provides useful insight into the physical factors that contribute to cycling performance and supports evidence-based athlete development.

METHOD

This study employed a descriptive quantitative research design to examine anthropometric characteristics and body composition profiles in relation to cycling race performance. Participants are the top three finishers (ranked 1st, 2nd, and 3rd) of the 2025 MTB Criterium Race championship in the 12-15 Years old category in Lampung, Indonesia. All athletes were assessed on the same day under similar environmental conditions. Prior to data collection, participants provided informed consent. The variables measured included finish time, finish rank, body height, body weight, body mass index (BMI), body fat percentage, and muscle mass percentage. Body height was measured using a stadiometer, while body weight and body composition variables were assessed using a bioelectrical impedance analysis (BIA) device (Omron HBF-375, Omron Healthcare, Japan). BMI was calculated as body mass (kg) divided by height squared (m^2). Anthropometric and body composition measurements were conducted before the competition following standardized procedures. Race performance data, including finishing time and rank, were obtained from official competition records. All variables were analyzed descriptively. Results were presented in tabular form and interpreted based on observed patterns across finishing positions. No inferential statistical testing was performed due to the small sample size.

RESULTS

This study presents a descriptive overview of cycling race performance in relation to anthropometric characteristics and body composition among competitive athletes. The variables analyzed included finish time and rank, body height, body mass, body mass index (BMI), body fat percentage, and muscle mass percentage. The results provide an initial depiction of how individual physical characteristics vary across finishing positions. A summary of these findings is presented in Table 1.

Analysis of Table 1 indicates that athletes with better finishing ranks were observed to demonstrate lower body fat percentages and relatively higher muscle mass percentages, despite minimal differences in body height. BMI values across participants remained within the normal range, suggesting that BMI alone has limited discriminatory value for performance ranking in this context. The fastest finisher showed the lowest body fat percentage, whereas slower finishers exhibited progressively higher fat percentages and lower muscle mass.

Body mass and height did not show a consistent trend across rankings, indicating that body composition appears more closely aligned with performance outcomes than absolute anthropometric size. Overall, these results suggest that lean mass dominance may play a more relevant role in cycling performance than basic anthropometric measures within this sample.

Table 1. Individual Physical Characteristics (Race finish time in MM:SS.ss format)

Athlete	Time	Finish Rank	Height (m)	Body Weight (kg)	BMI	Body Fat (%)	Muscle Mass (%)
NA	36:25.09	1	1.68	62	21.9	9.70	40.60
FA	36:33.42	2	1.65	52	19.1	10.80	41.50
AZ	39:20.84	3	1.69	67	23.4	12.80	37.50

DISCUSSION

The results of this study indicate that athletes with better finishing ranks were observed to have lower body fat percentages and relatively higher muscle mass percentages, while anthropometric variables such as height and total body mass did not show a consistent pattern. This finding suggests that body composition plays a more important role than absolute body size in determining cycling performance. Recent research on elite mountain bike cyclists has demonstrated that performance differences between higher- and lower-ranked athletes are more strongly associated with relative power output and physiological efficiency than with absolute anthropometric dimensions (Sánchez-Jiménez et al., 2025).

The lower body fat percentage observed in higher-ranked athletes in this study supports the concept that reducing non-functional mass improves cycling efficiency. Excess fat mass increases the total load that must be moved, which can negatively affect relative power and increase metabolic cost during endurance exercise. A recent narrative review on ultra-cycling performance emphasized that body composition characteristics, particularly lower fat mass and higher lean mass, are associated with improved endurance performance due to their influence on metabolic efficiency and energy

utilization (Tiemeier et al., 2024). This reinforces the importance of maintaining an optimal body composition profile to enhance cycling performance.

In addition, the relatively higher muscle mass percentage observed in better-performing athletes suggests a functional advantage in power production capacity. Skeletal muscle is the primary contributor to force generation during pedaling, and greater lean mass relative to total body mass enhances the ability to produce and sustain mechanical power. Recent research examining cycling performance durability and physiological demands has highlighted that muscular capacity and physiological resilience are key factors influencing performance outcomes in endurance cycling (Peeters et al., 2025). This indicates that muscle mass contributes not only to peak power production but also to the ability to maintain performance over prolonged durations.

Interestingly, BMI did not appear to differentiate performance levels in this study, despite clear differences in body fat and muscle mass percentages. This observation is consistent with the known limitations of BMI; however, given that this conclusion is based on only three data points, any interpretation regarding the discriminatory value of BMI must be expressed with caution. Because BMI does not distinguish between fat mass and lean mass, it may fail to identify differences in performance potential between athletes with similar BMI values but different body composition profiles. Therefore, direct assessment of body composition may provide more meaningful insight into athlete performance capacity than BMI alone, though this warrants confirmation in larger samples.

Overall, these findings support the concept that cycling performance is closely related to the balance between fat mass and muscle mass. Athletes with lower body fat and adequate muscle mass demonstrate more favorable physiological characteristics for producing power efficiently relative to body weight. This highlights the importance of body composition monitoring as part of athlete evaluation and training programs. Optimizing body composition by reducing excess fat mass while maintaining or increasing functional muscle mass may contribute to improved cycling performance and competitive outcomes.

CONCLUSION

This study demonstrates that body composition characteristics are more closely associated with cycling performance than general anthropometric measures such as height, body weight, and BMI. Three athletes with better finishing ranks were observed to have lower body fat percentages and relatively higher muscle mass percentages, indicating a more favorable balance between functional and non-functional body mass. These findings suggest that body composition may be more closely associated with cycling performance than general anthropometric measures; however, it is critical to note that a sample of only three athletes is insufficient for drawing generalizable conclusions, and these observations should be treated as individual case descriptions rather than empirical evidence. In contrast, BMI did not clearly differentiate performance levels in this sample, suggesting that direct body composition measurements may offer more informative data for athlete profiling.

These results highlight the importance of monitoring body composition as part of athlete evaluation and performance development. Coaches and practitioners should focus on training and conditioning strategies aimed at optimizing muscle mass while minimizing excess fat mass in order to improve relative power and endurance performance. Body composition assessment can also serve as a useful tool for tracking athlete development and guiding individualized training programs. It should be explicitly acknowledged that this study's sample of three athletes is critically insufficient even for descriptive generalization, and all findings must be interpreted solely as preliminary individual observations. Future research with larger sample sizes and additional physiological

variables such as aerobic capacity and power output is recommended to further clarify the relationship between body composition and cycling performance.

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest in this study.

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