Original Article (short paper)

The relative peak power output of amateur mountain bikers is inversely correlated with body fat but not with fat-free mass

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Abstract - Aims: To evaluate whether body mass (BM) and body composition may influence mountain bike cycling performance. **Methods:** Forty male amateur mountain bikers attended the laboratory on two non-consecutive days. At the first visit, anthropometric measures (height, BM, body fat [BF], fat-free mass [FFM] and body mass index [BMI]) and familiarization to incremental cycling test were performed. On the second visit, cyclists performed again the incremental cycling test to measure peak power output (PPO), peak power output relative to BM (PPO-BM), and time to exhaustion (TE), which were posteriorly correlated with BM and anthropometric measures. **Results:** A moderate and strong significant correlation were observed between TE and BM ($p<0.01$; $r=0.40$) and FFM ($p<0.01$; $r=0.56$), respectively. Moderate significant correlation was found between PPO and BM ($p<0.01$; $r=0.45$), BMI ($p=0.03$; $r=0.35$) and strong with FFM ($p<0.01$; $r=0.59$). Also, PPO-BM significantly correlated with BM ($p=0.04$; $r=-0.31$), BMI ($p=0.02$; $r=-0.35$) and BF ($p<0.01$; $r=-0.55$). No other significant correlations were observed. **Conclusion:** Considering PPO-BM as mainly performance variable, BM and BF can be a determining factor in mountain biking performance but FFM did not.

Keywords: cyclists, performance, body composition, off-road cyclists, body mass, body mass index

Introduction

Mountain biking (MTB) is an off-road cycling modality including various types of terrain and repeated up- and downhills[1]. Since it was included in the Olympic Games programme, it became a more traditional and widespread sport around the world, comprising a large number of recreational, amateur and elite cyclists[1].

In this sense, the determinants of MTB performance are drawing the attention of sports scientists[1–3]. They included technical ability, nutritional strategies, physiological aspects, and body composition (BC)[1], being the last one also a determinant of performance in various other sports modalities[4–6]. In sprint runners, a greater fat-free mass (FFM) and lower body fat (BF) are directly correlated with better speed performance[4], and in ultra-marathon runners, body mass index (BMI) was positively correlated with the race time[7]. Lastly, in recreational male Ironman triathletes and ultra-cyclists, the percent BF was associated with total race time[8].

Although the BC, which includes BF, FFM and both alter body mass (BM), depends on the genetic compound, this parameter can be modified accordingly physical training[9] and/or nutritional behavior[10]. Considering that MTB performance indicators, such as power output and oxygen consumption, are more determinants when normalized by BM[11], it can be hypothesized that the BC components are relevant to success in this modality. Elite MTB athletes have a BC quite homogeneous[12], however, it does not occur for amateurs[6]. Therefore, a BC variation of amateur cyclists can lead to a direct influence on performance.

Although their effect on road[13] and elite MTB[12] cyclists performance were presented, there is still limited evidence on amateur mountain bikers[6,14]. Therefore, considering these parameters, this study aimed to evaluate whether BC and BM influence the performance of amateur mountain bikers.

Methods

Subjects

Forty male amateur mountain bikers were recruited to participate in the study. The power statistic was calculated by G*power software[15] based on the current sample size in this study (test power = 0.63). To inclusion, they needed to have a cycling training with a minimum of 2 hours per week and achieve at least 250 W or more in the incremental test[16]. The exclusion criteria were: i) any cardiovascular, metabolic, or respiratory disease; ii) any potential substance that could improve the exercise performance; iii) musculoskeletal, bone, or joint injury that could unsettle the exercise performance; iv) caffeine supplement intake; v) smoking history. This information, as well as the information about training and cycling experience, were identified via a questionnaire. Table 1 shows the volunteers' characteristics. This study was approved by the local Ethics Committee (number 2.250.458) for human experiments and was carried out in conformity with the Declaration of Helsinki. All the volunteers were informed about the testing procedures. Furthermore, all of them provided written informed consent about the research.

Table 1 - Demographic and anthropometric characteristics of the volunteers

Characteristics	**N = 40**
Age (years)	27.9 ± 4.19
Height (m)	1.75 ± 0.4
Body mass (kg)	77.8 ± 9.65
Body fat (%)	15.6 ± 4.21
Body mass index (kg/m^2)	25.3 ± 2.7
Fat-free mass (kg)	65.6 ± 7.3
Skinfolds	
Pectoral (mm)	10.6 ± 2.7
Abdominal (mm)	22.5 ± 7.4
Thigh (mm)	20.5 ± 7.4
Indices of Performance	
Time to exhaustion (s)	796.6 ± 141.8
Power output (W)	326.4 ± 53.9
Power output (W.kg^{-1})	4.2 ± 0.7
Training History	
Experience (years)	5.1 ± 4.26
Hours per week	2.5 ± 0.96

Data are mean ± SD.

Experimental design

The cyclists attended the laboratory on two non-consecutive days (48 h of the interval), at the same time of day to prevent circadian influences[17]. All tests were performed in a controlled environment (temperature: 22.3 ± 1.5°C; relative humidity: 72.7 ± 7.2%). At the first visit, anthropometric measures and familiarization with the incremental test were performed. At the second visit, which happened 48 hours later, they performed an incremental test for analysis. The cyclists were also asked to maintain their dietary intake throughout the experiment. They were instructed to did not perform any moderate or intense physical exercise, and not taking products with caffeine, tea and alcohol 48 h before the tests.

Body Composition

The anthropometric dimensions were taken by an experienced and trained professional. Height (m) and BM (kg) were measured to the nearest 0.1 kg using calibrated scales and 0.5 cm using calibrated stadiometer (Health-O-Meter, model 402EXP; Badger Scale, Inc., Milwaukee, WI, USA), respectively, with participant's unshod and wearing cycling apparel. Three skinfold thicknesses (Sanny®, Brazil, precision 0.5 mm) at three sites (pectoral, abdominal, and thigh) were taken on the right side of the body. All measurements of skinfold thicknesses were taken three times in a non-consecutive way, and then the mean value was used for calculation.

BF percentage (%BF) was estimated according to Jackson and Pollock[18]. Absolute BF was determined multiplying BM by %BF divided by 100; FFM was estimated through the difference between BM (kg) and BF (kg) (BM – BF); and finally, BMI using BM divided by squared height.

Incremental test

The cycle ergometer (Monark 839 E, Sweden) was used in all incremental tests. The bike setup was done by the cyclists before the familiarization test and maintained during the test for analysis. Participants completed a 4-minute warm-up at 40 W. The test then started at 40 W that was increased by 20 W per min until voluntary exhaustion and the participants were required to maintain a cadence of 80-90 rpm (measured electronically). The test was terminated on voluntary exhaustion or failure to maintain the required cadence for 10 seconds, where the time to exhaustion (TE) was recorded (total exercise time performed). The peak power output (PPO) was defined by multiplying the cadence by the total load (this load indicates the force applied on the pedals to spin the flywheel that was tensioned by a broken belt connected by a pendulum weight) of the final stage. The peak power output relative to BM (PPO-BM) was measured by PPO divided by the BM of the cyclists. The incremental test procedures were based on the Arriel et al.[19] and De Groot[20] studies.

Statistical analysis

The statistical analysis was performed through software GraphPad® (Prism 6.0, San Diego, CA, USA). The Shapiro-Wilk test was used to verify the normality of the data. For measurement of the correlations between anthropometric and performance variables, Pearson´s or Kendall´s bivariate correlations test were performed, using a scale to analyze the correlation coefficient (proposed by Hopkins - www.sportsci.org), where: < 0.1, trivial relationship; 0.1–0.3, low; 0.3-0.5 moderate; 0.5–0.7, strong; 0.7–0.9, very strong; > 0.9, nearly perfect. The level of significance adopted was ≤ 0.05.

Results

The TE was significantly correlated with BM (Figure 1A) and FFM (Figure 1C) ($p < 0.05$). Although the TE did not correlate significantly with BMI (Figure 1D) ($p > 0.05$), there was a low correlation coefficient ($r = 0.30$). No significant association between TE and BF (Figure 1B) was found ($p > 0.05$).

Regarding PPO, moderate correlations were found with BM (Figure 2A) and BMI (Figure 2D), but strong to FFM (Figure 2C) ($p < 0.05$). No significant correlation between PPO and BF (Figure 2B) was found ($p > 0.05$).

When peak power output was normalized to BM (PPO-BM), there was a moderate significant correlation with BM (Figure 3A) and BMI (Figure 3B), and a strong significant correlation to BF (Figure 3B) ($p < 0.05$). However, no significant correlation between PPO-BM and FFM (Figure 3C) was found.

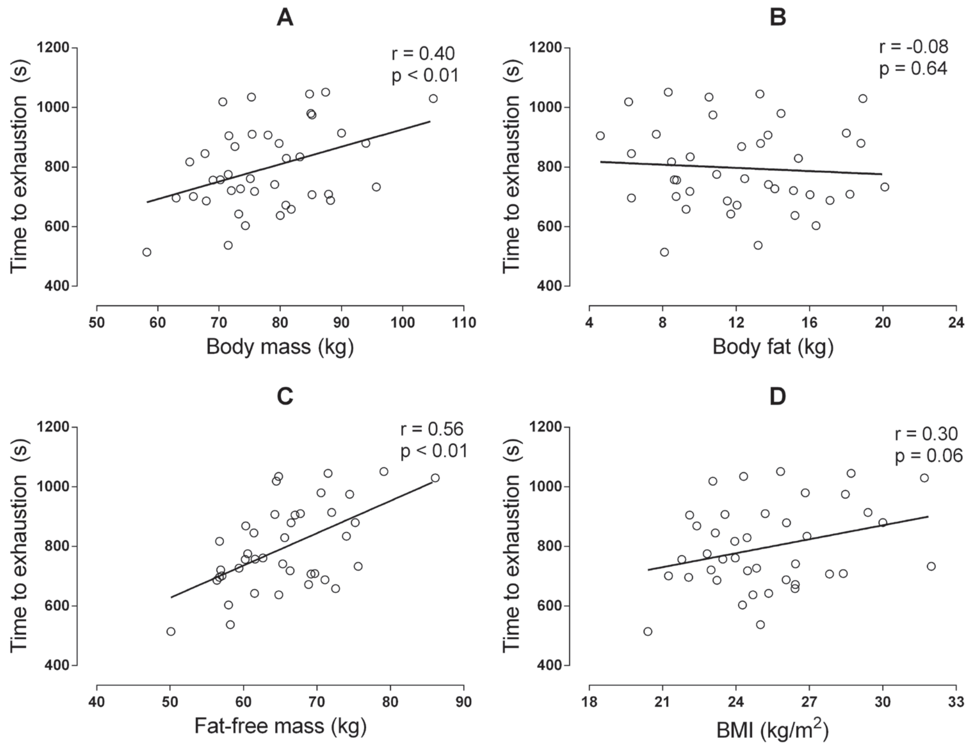

Figure 1 - Correlation between time to exhaustion and body mass (A), body fat (B), fat-free mass (C), and body mass index (BMI) (D). The values of r and p are shown in each figure.

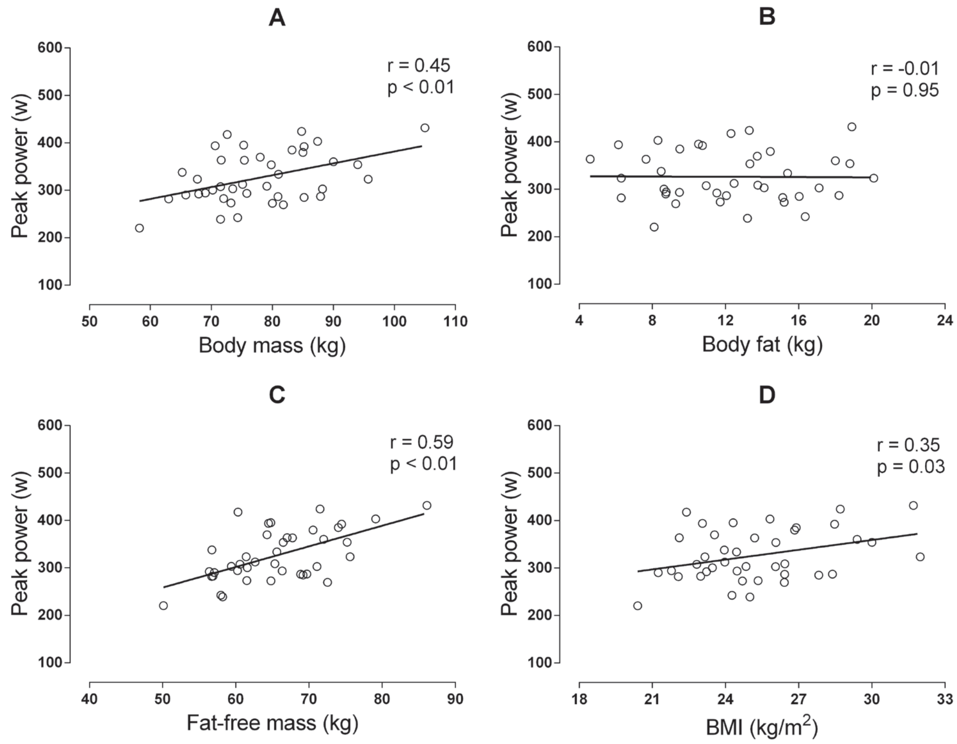

Figure 2 - Correlation between peak power output and body mass (A), body fat (B), fat-free mass (C), and body mass index (BMI) (D). The values of r and p are shown in each figure.

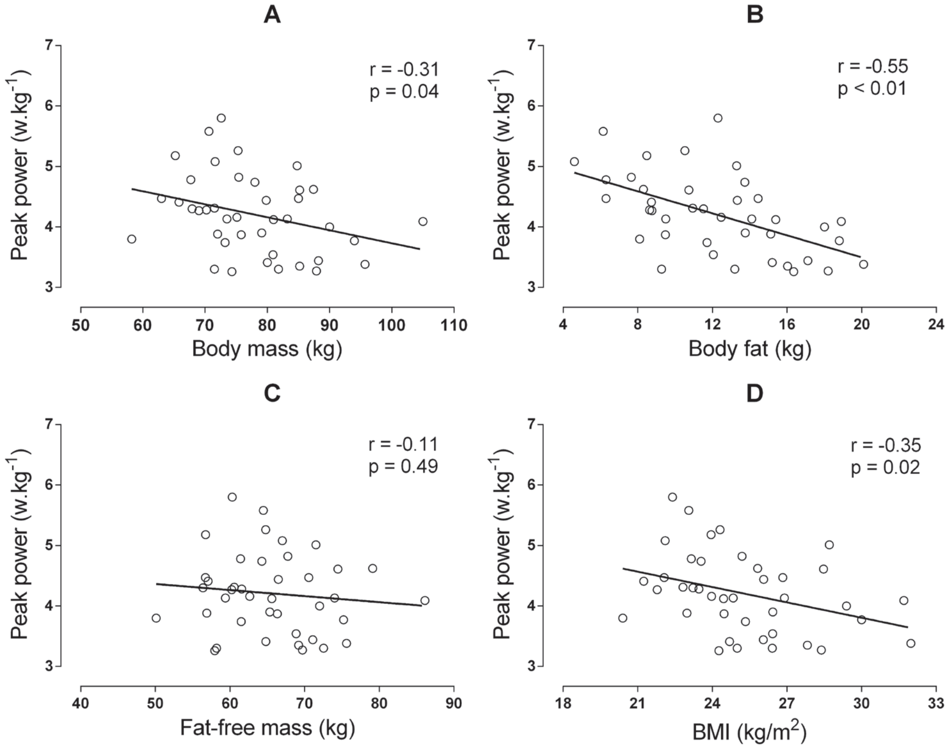

Figure 3 - Correlation between peak power output relative to BM and body mass (A), body fat (B), fat-free mass (C), and body mass index (BMI) (D). The values of r and p are shown in each figure.

Discussion

This study aimed to investigate whether BC and BM influenced the performance of amateur mountain bikers. Our findings were that some components of BC have a significant correlation with TE, PPO, and PPO-BM. In absolute values, the most significant findings were the possible influence of FFM and BM on TE and PPO. In relative values, a possible negative influence of the BM, BMI, and, mainly, BF on PPO-BM, but in FFM did not. However, it is important to highlight that indices of aerobic fitness, such as power output or oxygen uptake, when normalized to BM are more determinants of performance[11]. Moreover, the incremental test performed in this study was in cycle ergometer, which considers only absolute performance values. Thus, the PPO-BM value is closest to the actual values of a field test, which considers BM. Therefore, our finds identify possible effects of BF on cycling performance of amateurs MTB athletes.

The BF is an important energetic substrate for long time exercise. However, the excess of BF leads to an increase of BM which is associated with a negative effect on anaerobic[21] and aerobic[22] exercise performance of non-professional athletes, possibly caused by a decrease of the maximal power output and maximal oxygen uptake normalized to BM, respectively. However, in elite MTB athletes, no significant correlation was found between BF and race time performance in Olympic cross-country[12]. As observed in figure 3, the subjects with higher BF had a lower PPO-BM and the subjects with smaller BF had a higher PPO-BM. However, in figures 1 and 2, we did not find the influences of BF on TE and PPO. As the BF is a passive tissue during exercise, its excess may lead the subject to great effort on the same workload during weight-bearing activities, but without influence on stationary exercises. Thus, these results suggest that an increase in BF could negatively influence the aerobic performance of amateur MTB cyclists in field test or race time.

On the other hand, a greater in BM, resulting from an increase in muscle mass, as a consequence of anaerobic[21] but not aerobic[22] exercise performance. According to the study of Maciejczyk et al.[22], a higher BM may be a limiting factor, regardless of BC, because substantially reduced aerobic endurance performance of recreationally active subjects, where an excess of BF or high muscle mass levels exhibited similar responses. Unlike our findings, the BF adversely affects PPO-BM, but the FFM level, which contains a high muscle mass value, did not. However, the PPO and TE were significantly correlated with FFM. Therefore, in endurance performance, the change in FFM does not seem to be a determinant factor to modify the performance of amateur MTB athletes in exercises with weight-bearing, such as field tests and MTB races. The same has been related to elite MTB athletes[12].

The BMI and skinfold thicknesses are the most used anthropometric indicators of BC. According to Malina[23], BMI is reasonably well correlated with BF. However, BMI has limitations with professional and amateur athletes since this parameter did not consider the BC of the subjects, once physically active persons present a higher FFM[22]. In this study, we found significate adverse effects on PPO-BM when correlated with BMI, BM, and BF but no significate result to FFM. The BMI (BM/Body height[2]) is influenced by BM and body height. However, as the height of the participants was well homogeneous (1.75 ± 0.4 m), the BM of the cyclists (77.8 ± 9.65 kg) had a greater influence on BMI. Therefore, during weight-bearing activities, we can suggest that a high BMI can adversely affect the performance of amateur MTB cyclists due to a high BM, probably resulting from a high BF and not FFM.

The incremental cycling test is often used in research to evaluate psychophysiological responses[11,24] which are highly correlated with cycling performance[11]. However, for greater accuracy in correlation analysis, especially in laboratory studies, the indices of aerobic fitness should be normalized to BM. In our study, the BM influenced TE and PPO positively, but PPO-BM negatively. Probably this fact happened because the tests performed on cycle ergometers do not consider BM. In this way when the indices of aerobic fitness are normalized to BM, the results are different compared to non-normalized. To confirm this, Siegel-Tike et al.[6], investigating the relationship of the BC parameters on recreational trained cyclists performance, found a strong significant correlation between relative maximal oxygen uptake (i.e. ml/kg/min) and BF ($r = -0.81$; $p < 0.05$). However, no correlation was found between PPO and BF ($r = 0.19$; $p > 0.05$). The same happened for muscle mass. Although our study did not evaluate maximal oxygen uptake, considering the BF, the result is in line with our finding when considered the PPO but not when considered PPO-BM. Moreover, Lee et al.[25] found no differences between elite mountain bikers and professional road cyclists in maximal oxygen uptake, PPO, and the lactate threshold expressed in absolute values. However, the same variables, when normalized to BM, presented higher values to mountain bikers. These results confirm the importance of relative parameters to BM in elite[1] and amateur mountain bikers.

Limitations

The variability of the methods used for BC estimation could be highlighted as a limitation of this study since there are more precise methods. Skinfolds method presents a low cost and it is more feasible.[18] However, for not measuring the FFM components (such as water, mineral, protein, and additional minor constituents), this model may present some limitations when compared with a more current model of four-compartment[26]. In this way, the within-subject differences, particularly in the proportion of water and mineral, can interfere in FFM measurement. Thus, the correlation between indices of performance (such as TE, PPO, and PPO-BM) and FFM should be analyzed with caution.

Other tests, as Wingate[27] and time trial[28], can also measure performance. However, the characteristics of each test (i.e. time, intensity, and environment) may influence the relationship between BC and exercise performance. For example, anaerobic power performance is not affected by an increase in BM resulting only from an increased FFM[21], but maybe a limiting factor to aerobic performance[22]. In this study, we correlate BC with TE and PPO values that are above of lactate threshold and below the maximal power anaerobic achieved in short-time exercise, which is crucial for MTB performance[1,27]. Therefore, the results of this study should not be generalized.

Lastly, it is important to highlight that, as related by Impellizzeri et al.[11], significant positive or negative correlation does not imply causality. Therefore, futures experimental studies should investigate whether the changes in BM or BC components lead to changes in the performance of mountain bikers.

Practical Applications

Considering our results, changes in BM and BC (in order to reduce the fat mass that is a passive tissue during pedaling exercise) may be effective at improving MTB performance due to an increase in PPO-BM. However, the FFM should be maintained because, although this variable may increase BM, it is an important tissue to optimize power output in a short time duration such as sprints and technical climbs. In this hand, the nutrition strategy and the resistance training, as the main strategy to increase or maintain FFM and maximal force, should be included in the training routine of MTB amateur athletes.

Conclusion

The body mass and body composition could be determinant for mountain biking performance, where body fat influenced negatively the performance of amateur mountain bikers but the fat-free mass did not.

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