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Comparative Analysis of Body Composition and Nutritional Intake among Indonesian Adults with Low and High Physical Activity

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Abstract Physical activity offers numerous health benefits, including improved physiological function and a reduced risk of metabolic diseases. This study aimed to evaluate body composition and nutritional intake of individuals engaged in different levels of physical activity. Body composition metrics, including BMI, BMR, body fat mass, visceral fat, subcutaneous fat, and muscle mass were measured. In addition, macronutrient (energy, protein, carbohydrates, fat) and micronutrient (calcium, iron, vitamin B1) intake was assessed using a 24-hour dietary recall. A total of 283 participants (mean age 31.5 ± 11.21 years, 55.5% men, 44.5% women) were classified into two groups based on different physical activity levels of high (N=144) and low (N=139). The high physical activity group exhibited significantly higher BMR ($p< 0.001$) and muscle mass ($p< 0.001$), but lower subcutaneous fat ($p< 0.001$). No significant differences were observed for BMI ($p= 0.510$) and visceral fat ($p= 0.390$). In terms of dietary intake, the high physical activity group consumed significantly higher protein ($p< 0.001$) with lower carbohydrate ($p= 0.001$), but no significant differences were observed in energy ($p= 0.541$) and fat ($p= 0.913$) consumption. However, this group had lower intake of calcium ($p< 0.001$) and vitamin B1 ($p= 0.001$). This study highlights the influence of varying physical activity levels on body composition and provides a comparative analysis of nutritional intake across different physical activity groups.

Keywords Physical Activity, Nutritional Intake, Body Fat, Muscle Mass, Macronutrient Intake, Micronutrient Intake

1. Introduction

Physical activity plays a crucial role in maintaining overall health and well-being. According to the World Health Organization (WHO), adults should engage in 150–300 minutes of moderate-to-vigorous physical activity per week to promote good health and prevent various metabolic and musculoskeletal disorders [1,2]. Regular physical activity has been associated with a reduced risk of developing chronic conditions such as cardiovascular diseases, hypertension, type 2 diabetes, and certain types of cancer [1,3]. Moreover, the benefits of physical activity extend beyond physiological health. According to Bell et al. [4], regular physical exercise has been linked to improved mental health and lowered risk of mental health disorders. Furthermore, a recent systematic review reported by Mahindru et al. [5] highlights the positive effects of physical exercise, such as improved sleep quality, enhanced mood, reduced symptoms of depression and anxiety, and improved various psychiatric disorders.

The WHO defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure. Various types of exercise, including High-Intensity Aerobic Training (HIT), Low-Intensity Aerobic Training (LIT), Endurance Training (ET), High-Intensity Interval Training (HIIT), Moderate-Intensity Exercise (MIE), and Moderate-Intensity Continuous Training (MICT), have been shown to enhance health-related physical fitness [6]. Recent studies indicate that moderate-to-vigorous physical activity is associated with increased fat-free mass, bone density, and muscle mass while reducing adiposity levels [7]. Moreover, Soares Costa et al. [8] conclude that physical exercise in women led to improved anthropometric parameters, including reductions in body mass, waist and hip circumference, and skinfold thickness compared to inactive individuals. These findings indicate that physical exercises significantly impact physical performance and body composition. However, despite its well-documented benefits, physical inactivity remains a global concern. It is estimated that around 31% of adults and 81% of adolescents (aged 11-17 years) fail to meet WHO recommendations to be physically active [9,10]. Population-based data from 163 countries indicate an increasing trend in physical inactivity, rising from 23.4% in 2000 to 26.4% in 2010, and suggesting a further increase to 31% by 2024 [9].

In addition to physical activity, nutrition and diet also play a significant role in affecting body composition and preventing metabolic diseases [11,12]. Combinations of physical exercises and low-fat dietary intake have been shown to have the greatest impact on reducing body weight and body fat compared to exercise or dietary intervention alone, particularly in overweight and obese women subjects [13]. A similar finding based on systematic literature reported by Walker et al. [14] highlights the importance of lifestyle interventions, mainly through diet and exercise in preventing type 2 diabetes. According to Anderssen et al. [15], the combination of dietary modifications with physical activity was significantly more effective in mitigating metabolic syndrome risk factors such as waist circumference, triglyceride levels, blood pressure, fasting plasma glucose, and HDL cholesterol compared to dietary modification or physical exercise alone. In addition, different dietary patterns are associated with body composition; for example, individuals adhering to vegetarian diets exhibit lower body fat percentages than those following omnivorous or flexitarian diets, regardless of physical activity levels [16], suggesting that nutritional intake significantly impacts body composition.

This study aims to evaluate body composition in individuals classified into high and low physical activity levels. Body composition parameters, including BMI, BMR, fat mass, and muscle mass, were measured. In addition, this study also investigates dietary intake differences between the two groups of different physical activity. Studies examining the relationship between different physical activity levels and nutritional intake in the Indonesian population remain limited. A previous study by Iyakrus et al [17] reported the physical activity levels and BMI profiles of physical education teacher candidates in the city of Palembang, Indonesia. However, the study relied solely on survey data without assessing nutrient intake. Furthermore, it did not examine varying levels of physical activity and focused specifically on physical activity patterns during the COVID-19 pandemic. Therefore, this study aims to address this gap by providing current relevant data and insights into the different levels of physical activity and its nutrient intake among Indonesians.

2. Materials and Methods

2.1. Participants

This study included 300 participants, however, 17 were excluded due to incomplete data, resulting in a final sample of 283 participants (mean age: 31.5 ± 11.21 years; 55.5% men, 44.5% women) for final data analysis. The participants were classified into two groups consisting of low and high physical activity. Detailed participant characteristics, including sample size, age, gender distribution, recruitment criteria, and locations, are presented in **Table 1**. Participants were recruited using a non-probability sampling approach. The inclusion criteria comprised individuals who provided informed consent to voluntarily participate in the study and were healthy adults without any chronic diseases. The exclusion criteria included individuals who did not provide informed consent, pregnant or breastfeeding women, and those with reported chronic illnesses such as type 2 diabetes mellitus, hypertension, asthma, musculoskeletal disorders, or other metabolic diseases.

Table 1. Participants profiles of low and high physical activity groups

Groups	High Physical Activity	Low Physical Activity
Total participants (N)	144	139
Gender distribution	60% men, 40% women	51% men, 49% women
Mean age	30.8 ± 8.28 years	32.3 ± 13.59 years
Criteria	Engaged in regular physical exercises at least three times per week for a minimum of one hour per session	Engaged in sedentary occupations with no regular exercises
Place of recruitment	Gyms and sports clubs	Offices

Subjects categorized in the high physical activity group were recruited from gyms and sports clubs, and they were engaged in various types of physical exercises (e.g., tennis, running, weightlifting, aerobics, kickboxing, badminton, pilates, etc.) at least three times a week for a minimum duration of one hour per session. In contrast, the subjects categorized in the low physical activity group were primarily recruited from office settings and were characterized by sedentary occupations with no regular exercise. A questionnaire was administered to assess the participants' weekly hours of physical exercise in order to determine their physical activity levels. Participants who engaged in regular physical activity at least three times per week (with a minimum of one hour per session) were categorized into the high physical activity group, whereas those who reported no physical exercise or exercised only once per week for less than one hour were categorized into the low physical activity group.

The participants who agreed to participate were provided with a consent form and were explained regarding the study objective. Participation was voluntary, with the option to withdraw at any time without consequences. Data collection included self-reported age, exercise frequency, type, and duration of exercises, which were recorded. Ethical approval was obtained from the Research and Technology Transfer Committee of Bina Nusantara University, and the study adhered to the principles of the Declaration of Helsinki in involving human subjects.

2.2. Measurement of Body Composition

Body composition parameters, including body weight, BMI, total fat mass (%), visceral fat (%), subcutaneous fat (%), skeletal muscle mass (%), and basal metabolic rate (BMR), were measured. BMI was calculated using measured body weight (kg) and self-reported height (cm). The body weight and composition metrics were assessed using a Body Composition Scanner (Omron Karada Scan HBF-375, Omron Dalian Co., Ltd., China), and the results were recorded in a questionnaire. Prior to the measurement, the participants were instructed to remove heavy accessories (e.g., phones, wallets, jackets), and if they were wearing jeans, it was advised to change into lighter clothing.

2.3. Nutritional Intake Assessment

The nutritional intake was measured using a 24-hour dietary food recall. Food recall is a method to assess how much food is consumed and how it varies [18]. This is a structured interview method designed to capture detailed information on all foods and beverages consumed in the preceding day [18]. The participants were asked to recall their past 24-hour food and beverage consumption through a structured interview. During the interview, the participants reported the types and portion sizes of foods and drinks consumed, along with preparation methods (e.g., fried, boiled, baked, stir-fried, etc.). This practice was necessary to calculate the amount of fat and oil used, especially in fried foods. The fat intake of Indonesian diets was predominantly reported from fast food and deep-fried foods [19,20]. Therefore, this approach allowed for a better estimation of fat intake, considering the addition of oil absorption during the frying process [21]. The food recall interview along with the measurement of body compositions, required approximately 10-15 minutes per participant. This study employed a single 24-hour dietary recall, which is a widely used method for assessing dietary intake in population-based studies. While multiple-day recalls (2–3 days) may improve precision, they also require substantially more time and participant commitment, which can increase the risk of recall bias and inconsistent reporting.

2.4. Data Analysis

The body composition data, including BMI, BMR, total body fat (%), visceral fat (%), subcutaneous fat (%), and skeletal muscle (%), were compared between groups using an independent t-test with a 95% confidence interval ($\alpha = 0.05$). In addition, the nutritional intake data, including macronutrients (energy, protein, fat, carbohydrates) and micronutrients (calcium, iron, vitamin B1), were evaluated against the Recommended Dietary Allowance (RDA) of Indonesia and compared between groups using an independent t-test. The nutrient intake was calculated using the Indonesian Food Composition Database (DKBM), and for specific meals that were not listed in the DKBM, the nutrient intake was analyzed using the USDA Food Data Central. All statistical analyses were performed using IBM SPSS Statistics (version 25, USA).

3. Results and Discussion

3.1. Comparison of BMI and BMR between Different Physical Activity Groups

Figure 1 presents the BMI and BMR of individuals categorized into high and low physical activity groups. There was no significant difference observed for the BMI of both groups ($p = 0.510$). However, despite the similarity in BMI, BMR was found to be significantly higher in individuals who engaged in high levels of physical activity compared to those in the low physical activity group ($p < 0.001$).

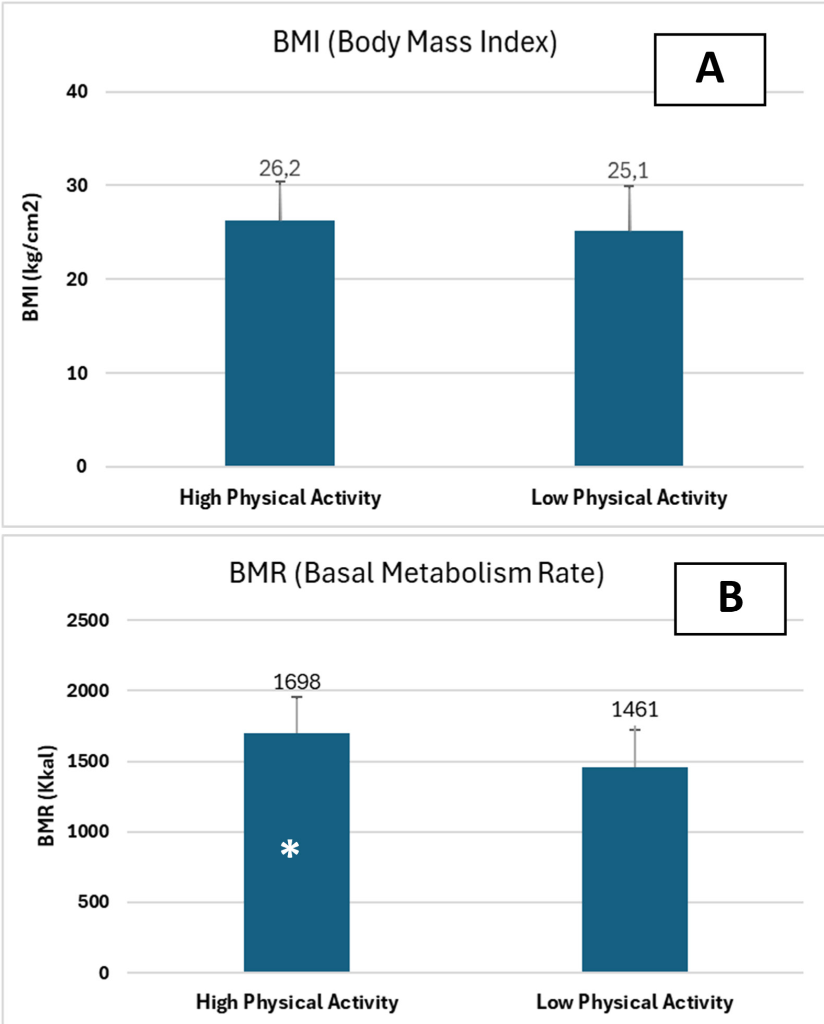

Figure 1. Comparing BMI (A) and BMR (B) between low and high physical activity groups (*significant difference at α=5% using student t-test)

The comparison of BMI and BMR between individuals engaged in high physical activity and those in low physical activity is consistent with the previous study reported by Drenowatz et al. [22], which outlined that physical activity levels did not significantly impact BMI, even after adjusting for gender, age, and ethnicity. Similarly, a study conducted using women aged 35–50 years found no significant differences in BMI between those who engaged in approximately nine hours of physical activity per week and those who were considered sedentary or had one hour or less of physical exercise per week [23]. In addition, the same study also reported a significantly higher resting metabolic rate in physically active women compared to their sedentary counterparts [23]. Further, a study by Sjodin et al. [24] also demonstrated a significantly elevated BMR in athletes who engaged in regular exercise compared to non-athletes who participated in physical activity on an irregular basis.

BMR is a fundamental parameter in calculating overall energy expenditure and caloric needs. It plays a critical role in formulating appropriate dietary and fitness strategies. BMR represents the minimum rate of energy expenditure required to sustain vital physiological functions, including respiration, circulation, and cellular maintenance [25]. Multiple factors can influence BMR, including body weight, height, age, body composition, and genetic predispositions [25]. Regular exercise has been shown to enhance BMR through increases in muscle mass. Individuals having regular exercise have more muscle mass and less fat, and the muscle mass tissue will burn more calories during resting time compared to fat tissue. Moreover, Lazzer et al. [26], identified that fat-free mass can act as the most significant predictor of BMR, in conjunction with age and gender, indicating that subjects with lean body fat and higher muscle mass will have higher BMR.

3.2. Body Compositions of Fat and Muscle Mass between Different Physical Activity Groups

The body composition results, including fat and muscle mass, are presented in **Table 2**. Significant differences were observed in total body fat and skeletal muscle composition between the groups. Participants in the physically active group exhibited a significantly lower total body fat percentage compared to those in the physically inactive group ($p< 0.001$). In addition, the subcutaneous fat levels were significantly lower in the high physical activity group ($p< 0.001$). However, no significant difference was observed in visceral fat between the groups, despite a trend toward lower visceral fat in the physically active group ($p= 0.390$). In contrast to fat composition, skeletal muscle mass was significantly higher in individuals with high physical activity levels compared to those with low physical activity ($p< 0.001$). These findings highlight the impact of regular physical activity on body composition, particularly in reducing subcutaneous fat and increasing skeletal muscle mass.

Table 2. Body composition between high and low physical activity groups

Body composition	High physical activity	Low physical activity	p-value
Total body fat (%)*	21.55 ± 5.33	27.47 ± 7.70	p< 0.001
Visceral fat (%)	7.93 ± 3.84	8.41 ± 5.52	p=0.390
Subcutaneous fat (%)*	16.41 ± 5.41	22.31 ± 6.15	p< 0.001
Skeletal muscle (%)*	34.61 ± 6.03	28.55 ± 4.66	p< 0.001

*significant difference at α=5% using student t-test

A large cross-sectional analysis utilizing data from the UK Biobank with more than 340,000 participants concluded that physical activity is inversely correlated with body fat percentage [27]. Individuals who engaged in more frequent and intense physical exercise exhibited lower adipose tissue levels compared to those with sedentary activity [22,27]. Moreover, a study using obese elders as participants demonstrated that various forms of physical exercise including resistance training, aerobic training, and combined training, led to significant improvements in skeletal muscle mass, reductions in body fat mass, and decreases in visceral fat following a 12-week training intervention, compared to a control group that did not participate in any physical training [28].

Regarding visceral fat, Winters-van Eekelen [29] reported that not all types of physical activity influence visceral adiposity. Specifically, only moderate-to-vigorous physical activity was associated with reductions in visceral fat, whereas light physical activity had no significant impact [29]. A population-based study conducted using Greenland population further supported this finding, demonstrating that replacing light physical exercise with moderate-to-vigorous exercise resulted in significant reductions in both subcutaneous and visceral fat as well as a decrease in waist circumference [30]. In addition, Slentz et al. [31] concluded that higher-intensity exercise was associated with significantly greater reductions in subcutaneous and visceral fat in individuals with overweight and dyslipidaemia. However, it should be noted that the higher subcutaneous fat observed in the low physical activity group may also be attributed to the greater proportion of female participants, as women generally have higher levels of subcutaneous fat compared to men. The variation in exercise intensity among participants may explain the absence of a significant difference in visceral fat observed in our study, since we did not ask for the intensity and vigor of physical activity within the high physical activity group, which may have resulted in heterogeneous exercise patterns among the participants engaged in this group. As previous studies have indicated, only moderate-to-vigorous physical activity effectively reduces visceral fat [29].

Physical exercise has been widely associated with increases in skeletal muscle mass. A study involving older adults with obesity demonstrated that various forms of exercise, including resistance training, aerobic exercise, and combined training, significantly improved skeletal muscle mass while simultaneously reducing body fat mass and visceral fat [28]. High-intensity exercise, particularly aerobic training, has been shown to enhance muscle mass through the induction of mitochondrial biogenesis and dynamics [32,33]. This process leads to increased muscle protein synthesis, promoting myofiber hypertrophy and overall muscle mass gain [33]. In humans, skeletal muscle constitutes approximately 40% of total body weight and contains 50–75% of the body's total protein content. In general, muscle mass depends on the balance between protein synthesis and degradation, and both processes are sensitive to factors such as nutritional status and intake, hormonal balance, physical activity/exercise, and injury or disease. Therefore, both nutritional intake and physical activity play a crucial role in maintaining and enhancing skeletal muscle mass [34].

However, evidence suggests that the combination of physical exercise and dietary modifications is the most effective strategy for reducing body fat mass while simultaneously increasing muscle mass gain [13,35,36]. A combination of calorie-restricted, low-fat diets and high-intensity aerobic exercise has been reported to induce the most significant changes in body composition among overweight and obese postmenopausal women [13]. Moreover, Longland et al. [35] also suggest that a high-protein diet combined with resistance exercise and HIIT activity was more effective in promoting lean body mass gain and reducing fat mass. Increased dietary protein intake has been shown to facilitate fat mass loss while supporting skeletal muscle maintenance and hypertrophy in individuals engaged in resistance and regular training [37]. Regular physical activity has been associated with improvements in muscle mass and the preservation of bone mineral density. These adaptations are critical for the prevention of osteoporosis and sarcopenia in aging populations [38,39].

3.3. Comparison Analysis of Nutritional Intake between Different Physical Activity Levels

The nutritional intake of participants in each group was measured using a 24-hour dietary recall. The comparison of nutritional intake, including total energy, protein, fat, and carbohydrates is presented in **Table 3**. Statistical analysis revealed no significant differences in total energy intake ($p= 0.541$) or fat intake ($p= 0.913$) between groups with varying physical activity levels. However, significant differences were observed in protein ($p< 0.001$) and carbohydrate ($p< 0.001$) intake. Participants classified in the high physical activity group exhibited significantly higher protein intake and lower carbohydrate intake compared to those in the low physical activity group.

Table 3. Macronutrient intake between high and low physical activity

Macronutrients	High activity group	Low activity group	p-value
Energy (Kcal)	2345 ± 576	2396 ± 424	0.541
Fat (g)	103.5 ± 27.9	104.2 ± 23.0	0.913
Protein (g)*	118 ± 32.6	83 ± 29.7	p< 0.001
Carbohydrates (g)*	214.5 ± 52.3	271.9 ± 65.1	p< 0.001

*significant differences at α=5% using student t-test

According to the Indonesian RDA, the recommended daily energy intake ranges from 2150 to 2650 kcal for men and 1800 to 2200 kcal for women, depending on age [40]. The energy intake recorded in this study, which ranged between 2,300 and 2,500 kcal, falls within these recommendations. Furthermore, these findings are consistent with previous studies conducted on urban Indonesian populations [19]. However, fat intake was found to exceed the recommended levels. The observed fat intake ranged from 103 to 104 g per person across all groups, whereas the Indonesian RDA recommends 60–85 g/day for men and 50–70 g/day for women for fat consumption [40]. These values are higher than what had been reported in the previous study [19]. Therefore, both groups exhibited excess fat consumption relative to the recommended intake for a healthy population. The Ministry of Health of the Republic of Indonesia has issued recommendations emphasizing the need to significantly reduce and limit the intake of sugar, salt, and fat [19,41], since Indonesia faces an increased prevalence of non-communicable diseases such as type 2 diabetes, hypertension, and obesity [42].

The high fat intake observed in both groups may be attributed to the methods of food preparation, particularly frying. In our dietary recall, most of the dishes were consumed as fried foods even though the food was sourced from protein (i.e. chicken, fish, eggs, tofu, and tempeh). Analysis of dietary recall data revealed that a significant proportion of protein-rich foods and starch-based foods were consumed in fried forms. Deep-fried foods are a prevalent component of the Indonesian diet [19]. This typical diet is largely influenced by Indonesia's substantial palm oil production since this country has become a key player of a global palm oil supply [43]. The consumption of deep-fried foods substantially increases dietary fat intake due to the high oil absorption during the frying process [20].

The protein and carbohydrate intake was observed to be significantly different between groups. Participants in the high physical activity groups showcased a higher consumption of protein and lower consumption of carbohydrates compared to participants in the low physical activity groups. Increased protein consumption among individuals with high exercise levels is essential for maintaining and enhancing muscle mass [33,37]. Based on our dietary recall, the participants involved in high physical activity groups consumed a higher proportion of protein-rich foods as part of their regular meals. In addition, most of their snack choices also included high-protein options such as protein bars, and some participants reported the use of protein supplements, including whey protein to further enhance muscle growth. Participants involved in the high physical activity group deliberately increased their protein intake through dietary modifications aimed at muscle mass gain. This behaviour aligns with previous findings indicating that individuals engaging in regular exercise are more likely to prioritize sports nutrition, particularly protein intake, to support muscle hypertrophy and lean body mass development [44]. The higher protein consumption observed in the high physical activity group was reflected in their significantly higher muscle mass and lower body fat composition compared to the low physical activity group (as shown in **Table 1**).

For micronutrient intake such as calcium (Ca), Iron (Fe), and vitamin B1 (thiamin), the results for different activity groups are outlined in **Table 4**. Significant differences were observed for calcium ($p< 0.001$) and vitamin B1 ($p= 0.001$) intake, indicating higher calcium intake for the group with high physical activity and lower vitamin B1 intake for this group. These findings suggest that physical activity levels may influence both macronutrient and micronutrient dietary intake.

Table 4. Micronutrient intake between high and low physical activity groups

Micronutrients	High activity group	Low activity group	p-value
Calcium (mg)*	383 ± 284	668 ± 348	p< 0.001
Iron (mg)	20.6 ± 10.9	24.1 ± 16.30	0.613
Vitamin B1 (mg)*	0.9 ± 1.12	1.4 ± 1.60	p= 0.001

*significant difference at α=5% using student t-test

For the micronutrient intake, the Indonesian RDA set by the Ministry of Health of the Republic of Indonesia recommended the daily calcium intake to be around 1000–1200 mg for both men and women [40]. However, the actual calcium intake recorded in this study ranged from approximately 300 to 600 mg/day, which is substantially very low compared to the recommended levels. However, this number was also subjected to high standard deviations, suggesting quite big variations for calcium intake among the participants, especially in the low-activity group. The type of food typically consumed in this group includes tofu, tempeh, and mungbean-based food in a significant amount, while some of them also consume tempeh chips and mungbean porridge to be consumed in between meals (as a snack). These types of meals were reported to have high amounts of calcium, and were often recommended to be consumed to substitute calcium from dairy products [45].

However, the Iron intake was found to be adequate and exceeded the RDA for Indonesian population. The RDA for iron is 9–11 mg/day for men and 12–18 mg/day for women, and the intake recorded in this study met these recommendations [40]. In contrast, vitamin B1 intake differed between groups: the low physical activity group met the RDA (1.2 mg/day for men and 1.1 mg/day for women), while the high physical activity group showed insufficient intake. The higher vitamin B1 intake observed in the low physical activity group can be attributed to their dietary patterns, which were predominantly composed of starch and cereal-based foods, including grains, whole grains, pulses, and vegetables. These food sources are well-established as primary dietary contributors of vitamin B1 or thiamine [46]. Conversely, participants in the high physical activity group consumed less of these types of foods; instead, they prioritized protein-rich diets and took additional meal supplements such as whey protein. This dietary shift was likely influenced by their engagement in structured exercise programs, since the high physical activity groups were recruited in the gym and sports club settings; therefore, they may focus on protein intake solely and may not pay attention to their micronutrient dietary balance. This may cause unbalanced micronutrient intake for those engaged in high physical activity.

3.4. Study Limitations

The findings of this study were derived from a cross-sectional design. The observed associations between physical activity levels and nutrient intake should be interpreted with caution, as this approach is not suitable for finding causal inference. Moreover, future studies are recommended to include a larger sample size and balanced gender distribution between groups to validate the current findings. In addition, the use of dietary records is suggested to better capture food consumption patterns, as the 24-hour dietary recall reflects intake at a single time point only.

4. Conclusions and Recommendation

Different physical activity levels were associated with differences in body composition and dietary intake. The participants in the high physical activity group exhibited a higher BMR with more lean body mass, as indicated by a significantly higher percentage of muscle mass. In addition, this group had lower total fat mass and reduced subcutaneous fat, but no significant differences were observed in visceral fat. In terms of macronutrient intake, the high physical activity group demonstrated significantly greater protein intake and lower carbohydrate intake compared to the low physical activity group. However, despite their higher energy and protein intake, individuals in this group had lower micronutrient intake, particularly for calcium and vitamin B1. This study presents a comparative analysis of body composition and dietary intake among Indonesian adults with varying levels of physical activity, offering insights into the nutritional implications of different activity patterns.

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Open Data Statement

All data generated in this study are included within the manuscript.

Author Contribution

The author EE was responsible for conceptualization, study design, data analysis and interpretation, original manuscript writing, and subsequent review and editing.

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