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Association of body mass index and body fat with agility and power: A cross-sectional study

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Abstract

Introduction: Body composition is a key determinant of athletic performance, particularly in soccer, where it influences strength, agility, and overall physical capacity. Body composition can be assessed through body mass index (BMI), body fat percentage, and muscle mass.

Objective: This study aimed to examine the association of BMI and body fat percentage with agility and lower-limb explosive power in university soccer players.

Methods: This cross-sectional analytical study employed purposive sampling and was conducted in March 2024 at the Hasanuddin University Soccer Student Activity Unit. BMI and body fat percentage were assessed using the Karada Scan, agility was measured with the Illinois Agility Test, and lower-limb explosive power was evaluated using the Vertical Jump Test.

Results: A total of 45 respondents participated in the study. The mean BMI was 20.65 kg/m² (within the normal range), mean body fat percentage was 12.70% (normal), mean agility score was 18.24 seconds (moderate), and mean vertical jump height was 50.20 cm (fair). Correlation analysis using Somers' D revealed no statistically significant associations between BMI and body fat percentage with either agility or lower-limb explosive power ($p = 0.412$).

Conclusion: No significant associations were found between BMI and body fat percentage with agility or lower-limb explosive power in university soccer players. These findings suggest that factors beyond body composition may play a greater role in determining agility and explosive performance in soccer athletes.

Keywords
Body Mass Index, Body Fat Percentage, Agility, Muscle Strength, Soccer

Introduction

Soccer players require various essential components, including technical skills, tactical awareness, appropriate strategies, athletic characteristics, physical fitness, and body composition.[1] Physical fitness is a fundamental aspect of soccer performance, as it directly influences performance on the field. Components of physical fitness include speed, explosive power, agility, balance, and coordination.[2] With optimal fitness, players can achieve maximum speed, meet the high physical demands of matches, prepare for competitive performance, reduce the risk of injury, and maintain an ideal body composition.[3]

In addition to technical factors, physical fitness aspects related to body composition play a crucial role in the complexity of soccer performance. Previous research has identified three key variables in assessing body composition: body mass index (BMI), body fat percentage, and muscle mass. [4,5] Body composition is described as the proportion of body components such as bone mass, water, muscle, and fat.[6] Optimal body composition has a significant impact on strength, agility, and athletic performance.[7]
Physiologically, BMI and body fat percentage are closely related to agility and lower-limb explosive power. An excessively high BMI, typically due to excess body fat, increases body load and reduces both speed and agility. Conversely, an ideal BMI supports mobility and enables more agile movements. [8,9]

Similarly, excessive body fat percentage reduces relative muscle strength and disrupts movement mechanics, whereas greater muscle mass enhances strength, neuromuscular coordination, and the ability to generate explosive power.[10] Thus, achieving a balance between muscle mass and body fat is a critical determinant in supporting agility and explosive power in soccer players.[11]

Previous studies have demonstrated that players with favorable body composition exhibit superior physical performance in terms of speed and strength, ultimately enhancing their explosive power.[10,12] Adequate lower-limb explosive power has been shown to significantly influence athletic performance, as optimal explosive ability improves the execution of sport-specific techniques during competition.[13]

However, data on body composition profiles and physical performance among university-level soccer players in Indonesia, particularly at Hasanuddin University, remain limited. Most existing studies have been conducted in general populations or professional athletes rather than collegiate athletes, indicating a research gap that warrants investigation.

Based on this rationale, the present study addresses the research question of whether BMI and body fat percentage are associated with agility and lower-limb explosive power in soccer players. Accordingly, the objective of this study was to analyze the association between BMI and body fat percentage with agility and lower-limb explosive power among members of the Hasanuddin University Soccer Student Activity Unit.

Methods

This study employed an analytical design with a cross-sectional approach using purposive sampling and was conducted in March 2024 at the Hasanuddin University Soccer Student Activity Unit. The study population consisted of 50 members, with inclusion

criteria of being male, aged 17–25 years, actively participating in training, and providing written informed consent. Exclusion criteria were fever, dialysis, osteoarthritis, edema, acute injury, or overuse injuries. Based on these criteria, 45 participants were eligible. The sample size was determined by including all eligible members of the population, applying a total sampling approach.

Data collection was carried out on two occasions. Body mass index (BMI) and body fat percentage were measured using the Karada Scan HBF-375, with participants assessed barefoot and the device calibrated according to manufacturer guidelines. Agility was measured using the Illinois Agility Test over a 10-meter course with standardized cones, which has a validity of 0.95 and reliability of 0.78. Participants performed zigzag running according to standardized procedures. Lower-limb explosive power was assessed using the Vertical Jump Test with the chalk mark method, which has a validity of 0.78 and reliability of 0.93, requiring participants to jump as high as possible against a wall-mounted board after marking a baseline reach with chalk. All measurements were performed by the same examiner to minimize inter-rater variability. Prior to testing, participants completed a standardized 10-minute warm-up session, and each measurement was repeated twice, with the best result recorded.

The exposure variables in this study were BMI and body fat percentage, while the outcome variables were agility and lower-limb explosive power. Potential confounding factors considered included body type, body weight, muscular strength, speed, and age. The operational definitions of each variable are presented in Table 1. Categories of BMI were based on World Health Organization standards, while body fat percentage, agility, and explosive power categories were adapted from established references.

Univariate analysis was performed to calculate means, standard deviations, and categorical distributions, while bivariate analysis employed Somers' D test, which is appropriate for assessing associations between ordinal independent and dependent variables. Statistical significance was set at $p < 0.05$, and data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 29.

All participants provided written informed consent prior to participation. To minimize information bias, instruments were calibrated regularly and measurements were conducted using standardized procedures. Ethical approval for this study was granted by the Research Ethics Committee of the Faculty of Nursing, Hasanuddin University (Protocol No. 673/UN4.18.3/TP.01.02/2024).

The characteristics of the respondents in this study include age, body mass index (BMI), body fat percentage, agility scores, and lower-limb explosive power. These data provide an overview of the participants' physical condition prior to further analysis of the relationships between variables. A summary of the respondents' characteristics is presented in Table 1.

Table 1. Operational Definitions of Study Variables

Variable	Operational Definition	Measurement Tool	Objective Criteria	Scale
Body fat percentage	Percentage of body fat relative to total body weight	Karada Scan HBF-375	Low <12% Normal 12–20% High >20%	Ordinal
Body mass index (BMI)	Classification of nutritional status based on weight and height	Karada Scan HBF-375	Severe underweight <17.0 Underweight 17.0–18.4 Normal 18.5–25.0 Overweight 25.1–27.0 Obese >27.0	Ordinal
Agility	Ability to rapidly and accurately change body direction and position without losing balance	Illinois Agility Test	Excellent <17.0s Good 17.0–17.9s Moderate 18.0–21.7s Poor 21.8–23.0s Very poor >23.0s	Ordinal
Lower-limb explosive power	Ability to generate explosive force during motor activities such as kicking, jumping, or sprinting	Vertical Jump Test	Excellent >65 cm Good 50–65 cm Moderate 40–49 cm Poor 30–39 cm Very poor <30 cm	Ordinal

Source: Primary Data, 2024

Results

This study was conducted in March 2024 at the Soccer Student Activity Unit (UKM Sepak Bola) of Hasanuddin University with a population of 50 respondents. A total of 45 participants met the inclusion criteria and were included in the final sample. Five individuals were excluded because they did not meet the inclusion criteria or declined to participate. Primary data were collected directly from the respondents through measurements of BMI and body fat percentage using the Karada Scan, agility using the 10 m Illinois Agility Test, and lower-limb explosive power using the Vertical Jump Test with the chalk mark method. No missing data were identified in this study. Potential confounding variables included body type, body weight, muscular strength, speed, and body mass index. Table 2 presents the general characteristics of the respondents in terms of frequency distribution and percentage, while numerical variables (age) are summarized as mean ± SD for clarity.

Table 2. General characteristics of respondents (n = 45)

Variable	Category	Frequency	Percentage (%)
Age (years)	Mean ± SD = 19.7 ± 1.8 (17–23)		
Faculty	FAPET	11	24.4
	FKEP	3	6.7
	FAHUTAN	4	8.9
	FAPERTA	9	17.8
	FIKP	4	8.9
	FISIP	1	2.2
	FT	4	8.9
	FEB	6	13.3
	FKG	1	2.2
	FIB	1	2.2
	FH	1	2.2
	FMIPA	1	2.2

Source: Primary Data, 2024

Table 2 (continued). General characteristics of respondents (n = 45)

Playing position	Midfielder	8	17.8
	Back	15	33.3
	Stopper	3	6.7
	Winger	12	26.7
	Striker	5	11.1
	Goalkeeper	2	4.4
Training frequency/week	0 times	6	13.3
	1 time	8	17.8
	2 times	9	20.0
	3 times	20	44.4
	5 times	2	4.4

Source: Primary Data, 2024

Based on Table 2, most respondents were aged 19 years (n = 14). The Faculty of Animal Husbandry (FAPET) accounted for the largest proportion (n = 11). The most common playing position was defender (back) (n = 15), and the most frequent training regimen was three sessions per week (n = 20). Table 3 summarizes the distribution of BMI, body fat percentage, agility, and lower-limb explosive power.

Table 3. Distribution of BMI, body fat percentage, agility, and lower-limb explosive power

Variable	Category / Interval	n	%	Mean ± SD	Min–Max
BMI	Severe underweight (<17.0)	3	6.7	20.65 ± 4.25	10.30–38.40
	Underweight (17.0–18.4)	9	20.0		
	Normal (18.5–25.0)	28	62.2		
	Overweight (25.1–27.0)	3	6.7		
	Obese (>27.0)	2	4.4		
Body fat %	Low (<12%)	24	53.3	12.70 ± 6.09	5.30–35.80
	Normal (12–20%)	16	35.6		
	High (>20%)	5	11.1		
Agility	Excellent (<17.0 s)	11	24.4	18.25 ± 2.01	16–28
	Good (17.0–17.9 s)	13	28.9		
	Moderate (18.0–21.7 s)	20	44.4		
	Poor (21.8–23.0 s)	0	0.0		
	Very poor (>23.0 s)	1	2.2		
Explosive power	Good (>65 cm)	2	4.4	50.20 ± 9.56	31–70
	Fairly good (50–65 cm)	22	48.9		
	Moderate (40–49 cm)	14	31.1		
	Poor (30–39 cm)	7	15.6		
	Very poor (<30 cm)	0	0.0		

Source: Primary Data, 2024

In addition to categorical distribution, the main quantitative results are presented as mean values and standard deviations (SD) to provide a more detailed overview. The results showed that the mean BMI of respondents was 20.65 kg/m², which is slightly higher than reported in other studies (20.46 kg/m²,[14] 19.8 kg/m²,[15] and 17.55 kg/m² [8]). This difference may be explained by variations in body composition, muscle mass, and fitness level. The mean body fat percentage was 12.70%, predominantly within the low category, although slightly higher than the ideal range for soccer athletes (9.6%–12.1%).[16] The mean agility score was 18.25 seconds, classified as moderate, and slightly better than a previous report (19.04 seconds).[8] The mean lower-limb explosive power was 50.20 cm (classified as fair), which was higher than another study that reported 44.4 cm.[17] To facilitate interpretation, the results of the bivariate analysis assessing the relationships between BMI, body fat percentage, agility, and lower-limb explosive power are summarized in Table 4.

Table 4. Bivariate associations between body composition indicators and physical performance outcomes (n = 45)

Independent variable	Dependent variable	Somers' d	p-value	95% CI	Remark
BMI	Agility	0.070	0.608	−0.18 to 0.32	Not significant
BMI	Lower-limb explosive power	0.148	0.322	−0.15 to 0.44	Not significant
Body fat percentage	Agility	0.125	0.382	−0.16 to 0.41	Not significant
Body fat percentage	Lower-limb explosive power	−0.039	0.787	−0.31 to 0.23	Not significant

Source: Primary Data, 2024

Bivariate analysis using Somers' d demonstrated no statistically significant associations between BMI or body fat percentage and agility or lower-limb explosive power (all p > 0.05). Although positive trends were observed for BMI and body fat percentage with agility and explosive power, the confidence intervals crossed zero, indicating weak and non-significant relationships.

Discussion

The findings of this study revealed no significant association between BMI or body fat percentage and agility or lower-limb explosive power among members of the Hasanuddin University Football Student Activity Unit. These results contradict the initial hypothesis, suggesting that these two variables are not the primary predictors of the measured physical performance outcomes.

Association between BMI and Agility

The absence of a significant association between BMI and agility may be attributed to several factors, including poor dietary regulation, insufficient nutritional intake, and inadequate rest.[18] This aligns with previous research that reported no significant relationship between BMI and agility due to the influence of other factors, such as physical readiness and motivation.[19]

Further examination of the distribution of respondents across BMI categories provides context for these findings. Individuals with lower BMI sometimes demonstrate better agility because lower body weight enables quicker and more agile movement.[20] Reduced fat mass may also enhance muscle responsiveness and efficiency of movement execution.[21] Conversely, higher BMI is not always associated with reduced agility, as some individuals may possess greater muscle mass.[22] This supports the theory that muscular strength is a key determinant of agility.[23]

Nevertheless, these findings differ from other studies suggesting that elevated BMI decreases agility due to the increased body load.[8,22] Maintaining BMI within the normal range remains important, as it can help optimize agility, consistent with evidence indicating that more ideal BMI values are associated with better control during physical activity. [9,24]

Association between BMI and Lower-Limb Explosive Power

This study also found no significant relationship between BMI and lower-limb explosive power, a result consistent with previous research.[25] Although the majority of respondents had normal BMI, their explosive power values were predominantly classified as fairly good. One possible explanation is insufficient energy intake, given the central role of energy availability in muscle contraction. Since muscular strength is a fundamental component of explosive power, inadequate nutrition may attenuate performance.[25]

Another factor worth noting is the age distribution of respondents, with most participants being 19 years old. Peak athletic performance typically occurs in the early to mid-20s.[26] This suggests that the results were not solely influenced by BMI, but also by age, competitive experience, training variations, and playing position. Insufficient training variation and position-specific specialization may also have contributed, as reported in prior research highlighting that training programs not tailored to playing position can affect football performance.[27]

Association between Body Fat Percentage and Agility

The results also demonstrated no significant relationship between body fat percentage and agility, supporting findings from previous studies. [28] Differences in training intensity and type among Hasanuddin University football players may explain this variation. This perspective is consistent with research emphasizing the importance of applying the FITT (Frequency, Intensity, Time, and Type) principle when designing training programs.[29]

Association between Body Fat Percentage and Lower-Limb Explosive Power

Similarly, no significant association was observed between body fat percentage and lower-limb explosive power, consistent with earlier studies.[30] Despite adequate training frequency (e.g., three sessions per week), low training intensity may have contributed to the absence of significant results. Previous research has also highlighted that weak training programs targeting lower-limb strength can limit explosive power performance.[31]

Muscle mass plays a central role in explosive power. Evidence indicates that greater muscle mass corresponds to greater force production.[32] This suggests that even with higher body fat percentages, individuals with strong muscle mass who consistently engage in strength training may still achieve fairly good explosive power outcomes.

Study Limitations

Several limitations must be acknowledged. First, measurements were conducted immediately following field training sessions, which may have influenced performance. Second, most respondents were fasting, potentially causing electrolyte imbalances (potassium, calcium, and magnesium) that can affect muscle contraction and physical performance.[33] Third, measurement bias may have occurred due to the use of the Karada Scan device, which is influenced by hydration status. Fourth, potential information bias exists because self-reported data on demographics and training frequency may be subject to recall bias. Finally, this study did not control for confounding factors such as dietary patterns, injury history, or physical activity outside the football club. The relatively small sample size (n = 45) also limited the statistical power of the analysis.

Generalizability and Implications

The findings indicate that BMI and body fat percentage are not primary predictors of agility or lower-limb explosive power in this population. However, the results cannot be generalized to professional football players, athletes of different age groups, or populations outside Hasanuddin University. They are most applicable to student-athletes with similar characteristics.

From a practical perspective, the implications of this study highlight the importance of structured training programs tailored to playing position, effective nutritional management, and the scheduling of physical tests under standardized conditions (e.g., not immediately after intense training or during fasting).

Conclusion

This study, conducted among 45 members of the Hasanuddin University Soccer Student Activity Unit, revealed that the majority of respondents fell within the normal categories for body mass index (BMI) and body fat percentage, with agility levels classified as moderate and lower-limb explosive power categorized as fair. Further analysis confirmed that no significant associations were observed between BMI or body fat percentage and agility or lower-limb explosive power.

The practical implication of these findings highlights the importance for coaches and athletes to consider factors beyond BMI and body fat percentage, including structured training programs, appropriate nutritional management, and adaptations based on playing position. Future research is recommended to involve larger sample sizes, broader age ranges, and additional fitness components to provide more comprehensive and practically relevant insights for coaching practice.

Author Contribution

Agusta Klaudia Wea: Conceptualization; Methodology; Data collection; Investigation; Data curation; Formal analysis; Writing – original draft; Visualization.
Kezia Febryanti Mustamu: Methodology; Formal analysis; Writing – review & editing; Supervision; Project administration.
All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest Statement

The author declares no conflict of interest.

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Ethics Statement

This study was approved by the Ethics Committee of Hasanuddin University (approval number: 673/UN4.18.3/TP.01.02/2024). Written informed consent was obtained from all participants prior to data collection.

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