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Postural Alignment and Body Fat Percentage as Associated Factors of Injury Risk in Students Athletes

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Abstract

This study aims to describe postural alignment and body fat percentage as factors associated with the risk of injury among student athletes. This study employed a quantitative descriptive design with a sample of 107 student athletes from the Faculty of Sports Science at Semarang State University, selected through purposive sampling. Postural alignment was measured using APECS for the ear, shoulder, ASIS, knee, foot, and overall alignment components, while body fat percentage was measured using calipers at three points for both men and women. The results showed that the greatest postural deviations were found in the foot segment, with a maximum value of 11°, and in the knee segment, with a maximum value of 9°, while the average body fat percentage among men was 14.91 ± 6.67%, with 48.8% of respondents falling into the "athlete" category. For women, the average body fat percentage was 26.98 ± 4.93%, and the majority fell into the average category (42.9%). These findings indicate that there is still variation in postural alignment and body composition among student athletes, which has the potential to affect biomechanical efficiency, movement stability, and susceptibility to injury.

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INTRODUCTION

Injuries can occur during or after exercise (Atmaja et al., 2024). A sports injury is damage to body tissue that occurs during exercise (Toriki et al., 2025). The body parts most frequently affected by injuries are the lower limbs (67.9%), the upper limbs (32.7%), and the head (11.9%) (Sari et al., 2023). Among the most common injuries experienced during exercise are sprains and muscle cramps. Sports injuries can result from accidents, technical errors, inadequate facilities, and overuse (Sanusi et al., 2020). For student-athletes who sustain sports injuries, the consequences extend far beyond pain and recovery time. Specifically, injuries often lead to delays in training routines and a loss of training hours needed to improve technical skills and physical conditioning (Al-qahtani et al., 2023).

High-risk injuries result in a loss of continuity in the motor learning process and hinder performance improvement, significantly impacting short-term achievement and, consequently, future participation in sports (Difiori et al., 2014). Sports injuries can be triggered by both internal and external factors. Internal factors include anthropometric characteristics, body composition, inappropriate training programs, lack of warm-up and cool-down routines, and incorrect exercise technique (Mandorino et al., 2023). Meanwhile, external factors include improper equipment setup, equipment in poor condition, unsuitable training gear, an unsafe training environment, and characteristics inherent to the sport itself (Hardyanto & Nirmalasari, 2020).

A history of injuries can lead athletes to engage in pain-masking behavior during competition (Liston et al., 2016). This behavior often emerges as a form of psychological adaptation to the demands of competition; however, from a biomechanical perspective, it actually encourages athletes to adopt inefficient compensatory movement patterns. Biomechanics is the science of understanding how the human body moves and adapts to various loads and mechanical demands (Irawan et al., 2025). Biomechanical analysis encompasses various aspects, including posture, movement patterns, load distribution, and injury mechanisms. The analysis and optimization of human movement rely on fundamental concepts such as kinematics, kinetics, and balance (Awaliyyah & Irawan, 2024; Qahtani & El-anwar, 2018).

Postural alignment is a key component of the body's biomechanical system that plays a role in maintaining stability, movement efficiency, and the distribution of mechanical loads during physical activity (Peterson et al., 2022). Optimal body alignment allows mechanical forces to be transferred evenly among body segments, whereas postural misalignment can lead to changes in kinematic and kinetic patterns that increase stress on muscles, tendons, ligaments, and joint structures (Morris et al., 2024). In addition to biomechanical factors related to postural alignment, body composition is also an intrinsic factor that can potentially influence injury risk. Body fat percentage is an important indicator of body composition because excessive fat accumulation may be associated with reduced motor function, impaired balance, and an increase in musculoskeletal complaints (Mahfuz et al., 2025).

This condition has the potential to reduce movement efficiency, disrupt balance, and increase biomechanical demands on joints and supporting tissues (Neri et al., 2021). Several studies have observed that greater limb asymmetry and lower physical fitness are associated with a higher predisposition to injury (Vanmeerhaeghe et al., 2020). A decline in athletic performance was observed with as little as a 5% difference in limb asymmetry (Bishop et al., 2021). The prevalence of limb asymmetry which reflects the complexity of sports movements and the physical qualities associated with athletic performance is supported by the muscles of the lower limbs (Fox et al., 2023). Research by (Delfa-de et al., 2021) indicates that a higher percentage of body fat is associated with reduced functional performance, impaired postural control, decreased balance ability, and increased musculoskeletal complaints, all of which may contribute to an increased risk of injury in physically active individuals. Previous research has focused more on the relationship between body posture and musculoskeletal disorders or the relationship between body composition and physical performance, whereas the integration of these two characteristics remains relatively limited.

The characteristics of student-athletes involved in various sports may result in different movement demands, postural adaptations, and body composition characteristics; therefore,

findings from a population of athletes in a single sport may not necessarily be generalizable to this population. This study aims to analyze the relationship between postural alignment and body fat percentage and injury risk among student-athletes. This approach is expected to expand upon previous research findings by integrating structural factors (postural alignment) and body composition factors (body fat percentage) into the study of injury risk among student-athletes.

METHODS

The study design employed a descriptive method with a quantitative approach. The study population consisted of 150 student-athletes from the Faculty of Sports Science, Semarang State University. This study used purposive sampling with predetermined inclusion criteria, resulting in a sample of 107 athletes. Inclusion criteria: Enrolled as active students at the Faculty of Sports Science, Semarang State University. Students must be in good physical and mental health. Willing to participate as respondents and sign the informed consent form. Willing to participate in a series of tests administered by the researcher. Students must still be active in a sport as athletes with at least a district-level qualification. Ethical approval was granted by the Ethics Committee of Semarang State University to ensure the study complied with research ethics regarding respect, beneficence, and justice, under number 346/KEPK/FK/KLE/2026. This study was conducted at the Sports Biomechanics Laboratory, Faculty of Sports Science, Semarang State University, from June 23, 2026, to June 30, 2026.

The instruments used in this study were the APECS (Assessment of Postural Evaluation and Correction System) and the Body Fat Caliper. The APECS measurements included the ears, shoulders, ASIS, knees, feet, and alignment, while the Body Fat Caliper measurements included the chest, abdomen, thighs, suprailiac region, and triceps. The research procedure began with a preparation phase, during which participants were provided with information and then given the opportunity to stretch. Measurements began with the APECS, where participants were photographed one by one. Afterward, the participants underwent body fat caliper measurements at three sites chest, abdomen, thigh, suprailiac, and triceps as referenced in the study (Jagim et al., 2023).. All measurement results were recorded by the researchers as research data for further analysis. Data analysis in this study was performed using IBM SPSS version 26. Descriptive statistics were used to present the mean, minimum, maximum, and standard deviation.

RESULTS AND DISCUSSION

Table 1. Descriptive statistics of APECS measurement results

Variabel	Mean ± SD	Min	Max
Ears (°)	1,36 ± 1,262	0	5
Shoulders (°)	8 ± 0,936	0	3
Asis (°)	1.57± 1.325	0	5
Knees (°)	1.78± 1.939	0	9
Feet (°)	2.27± 2.409	0	11

The results of postural alignment measurements using APECS in **Table 1** show that the most significant postural deviations were found in the lower extremities. The feet segment had the highest deviation (2.27 ± 2.409°) with the widest score range, namely 0–11°, followed by the knees at 1.78 ± 1.939° with a range of 0–9°. In the ASIS and ears segments, the deviations were at relatively lower levels, at 1.57 ± 1.325° and 1.36 ± 1.262°, respectively, with a score range of 0–5°. In contrast, the shoulders showed the most consistent alignment, as indicated by the lowest deviation of [value]° and a narrow range of 0–3°. Overall, the average deviation in overall alignment was 3.22 ± 1.574°, with a range of 0–6°, indicating that the sample's postural profile generally fell within the range of mild to moderate misalignment, with the greatest contribution to the deviation coming from the lower extremity segments.

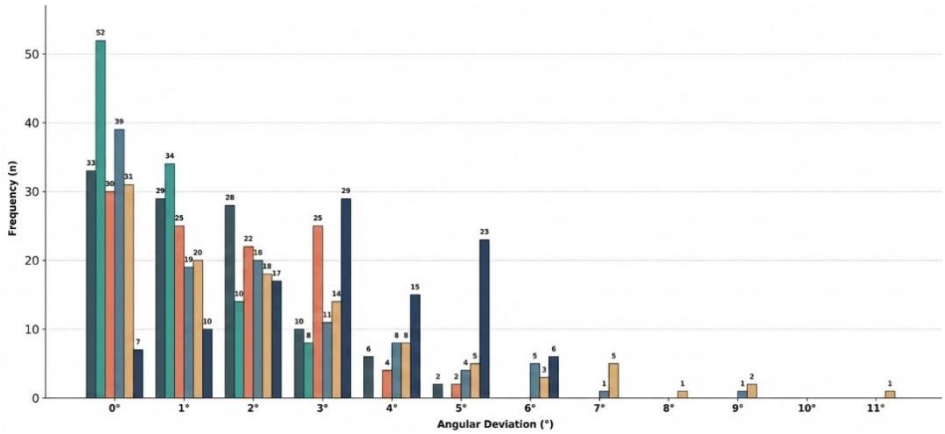


Figure 1. Distribution of APECS Measurements

The distribution pattern in **Figure 1** shows that most subjects had minimal deviations (0–1°) at nearly all anatomical landmarks. The 0° angle was the most common value, particularly in the shoulders (52 samples), followed by the knees (39), ears (33), feet (31), and ASIS (30). However, the distributions for the feet and knees show a right-skewed trend, reflecting the presence of some subjects with larger deviations of up to 7–9° at the knees and 8–9° at the feet. Unlike individual anatomical markers, the distribution of overall alignment shows a shift in the mode toward higher deviations. The frequency then decreased at 4° (15 samples), 5° (23 samples), and 6° (6 subjects), indicating overall that the accumulation of deviations across segments resulted in a global posture distribution that was more concentrated at the level of mild deviations.

Table 2. Descriptive statistics on the percentage of body fat in male samples

Variabel	Mean ± SD	Min	Max
Chest	14.63 ± 7.808	4	41
Abdomen	18.97 ± 10.250	6	53
Tigh	20.58 ± 9.409	9	57
Chest	14.63 ± 7.808	4	41

Based on **Table 2**, the thickness of the fat fold in the male group showed the highest mean value in the thigh area, namely 20.58 ± 9.409 mm with a range of 9-57 mm, while the abdomen area had a mean of 18.97 ± 10.250 mm and exhibited the widest range of measurements, namely 6-53 mm. In contrast, the chest area recorded the lowest average value of 14.63 ± 7.808 mm, with a range of 4-41 mm. Overall, the pattern indicates that subcutaneous fat distribution in male subjects tends to be greater in the thigh and abdominal regions than in the chest.

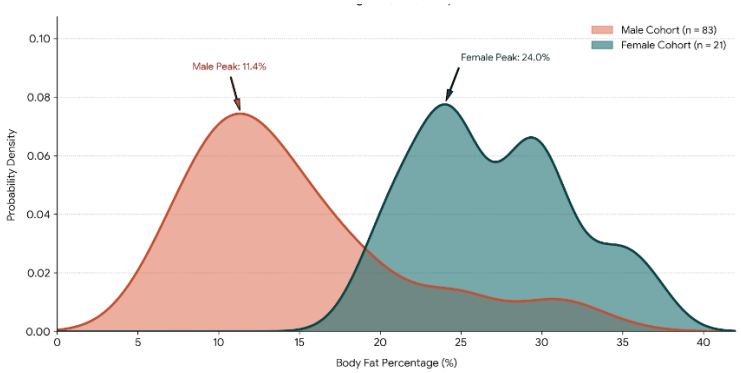


Figure 2. Distribution of Body Fat Percentage

The distribution pattern of body fat percentage shown in **Figure 2** reveals a clear difference between the male and female groups. The distribution among males tends to be concentrated at lower fat percentages, with a main male peak of 11.4%, and then gradually decreases at higher values. In contrast, the distribution for women shifted toward a higher percentage, with a primary female peak of 24.0% and a secondary peak in the range of 29-30%. These differences in distribution patterns indicate distinct characteristics of body fat composition based on gender, with women having a higher percentage of body fat and a relatively broader distribution compared to men.

Table 2. Descriptive statistics of body fat caliper measurements for the female sample

Variabel	Mean ± SD	Min	Max
Tigh	29.67 ± 6.537	20	42
Suprailiac	20.38 ± 7.166	10	37
Triceps	21.62 ± 7.749	10	39

Referring to **Table 3**, the results of subcutaneous fat thickness measurements show that the highest value was found in the thigh area, with an average of 29.67 ± 6.54 mm and a range of 20–42 mm. These findings indicate that subcutaneous fat accumulation in the sample tends to be greater in the lower extremities than at other measurement sites. Furthermore, the triceps area had a mean value of 21.62 ± 7.75 mm with a range of 10–39 mm, indicating considerable variation in fat distribution among participants in the upper extremities. Meanwhile, the suprailiac area showed a mean value of 20.38 ± 7.17 mm with a range of 10–37 mm, indicating that fat accumulation in the trunk area was relatively lower than in the thighs, though it still exhibited considerable variation among the sample. The magnitude of the standard deviation at the three measurement sites indicates heterogeneity in body fat distribution among the participants. Overall, these findings suggest that the distribution of subcutaneous fat in the sample tends to be concentrated in the thigh area, followed by the triceps and suprailiac regions. This distribution pattern indicates differences in body composition characteristics among individuals that may affect movement efficiency, postural balance, and the body's biomechanical response during physical activity and exercise.

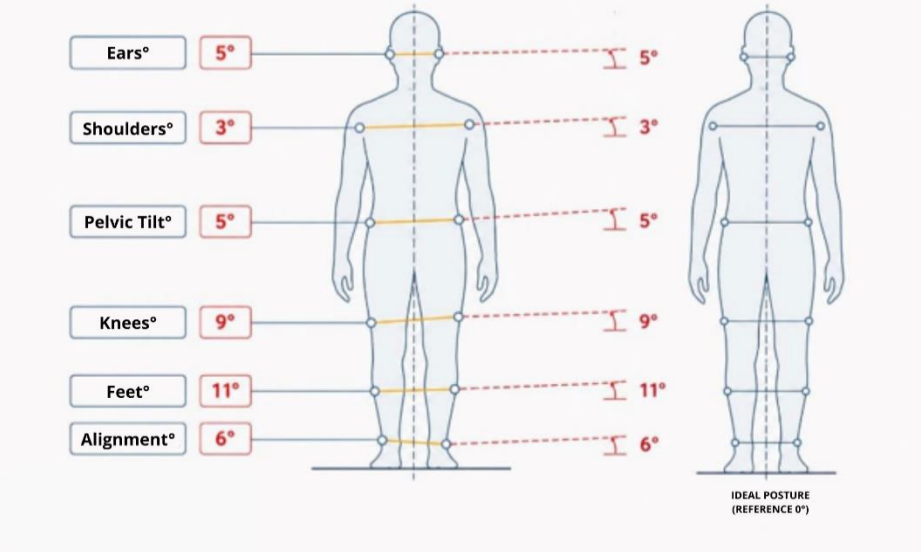


Figure 3. Illustration of ideal posture

Based on **Table 1**, the research results show that the greatest postural deviation was found in the feet, with a maximum value of 11°, followed by the knees at 9°, while lower deviations were found in the ears, ASIS, and shoulders. Consistent with this, as shown in **Figure 1**, these findings indicate that postural misalignment in the sample tends to be more prevalent in the lower extremity kinetic chain compared to other body segments. In line with a study

(Belkhelladi et al., 2025) that explains this from a biomechanical perspective, the feet serve as the primary foundation for supporting body weight and maintaining body stability during both static and dynamic activities. Therefore, changes in foot alignment can affect the distribution of ground reaction forces, alter loading patterns on the joints, and trigger compensatory movements in the body segments above them. If these conditions occur repeatedly during sports activities, the accumulation of mechanical stress on the musculoskeletal tissues has the potential to increase the risk of injury. These findings are consistent with (Kobayashi et al., 2021) who reported that foot posture abnormalities and ankle alignment issues are associated with impaired functional stability and an increased incidence of recurrent injuries in the lower extremities.

The high degree of deviation observed in the knee segment also indicates a potential disturbance in the biomechanics of the lower extremities. The knee serves as the primary link between the hip and the foot; therefore, changes in the position or alignment of this joint can affect the efficiency of force transfer during activities such as running, jumping, landing, and changing direction. Consistent with the findings (Butler et al., 2024) knee misalignment can increase the load on ligaments, tendons, and cartilage, which ultimately increases susceptibility to both repetitive-use and traumatic injuries. Furthermore, a combination of foot and knee deviations can lead to changes in neuromuscular control, which in turn reduces the body's ability to maintain dynamic stability during athletic activities.

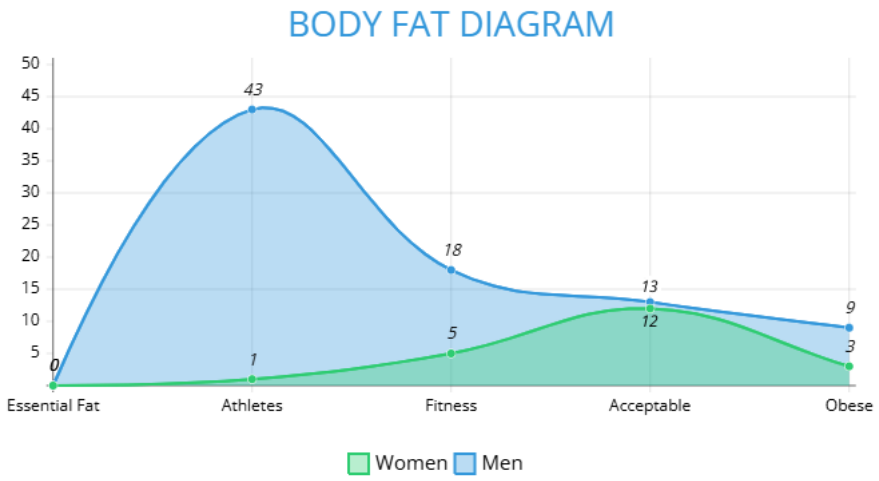


Figure 4. Percentage Fat Distribution Chart for Women and Men

Based on **Figure 2**, 51.81% of the male participants were classified within the "athlete" category for body fat percentage, followed by 21.69% in the "fitness" category and 15.66% in the "acceptable" category. However, 10.84% of the male participants were categorized as "obese," indicating heterogeneity in body composition despite their status as student athletes. Among female participants, 57.14% were classified within the "acceptable" category, followed by 23.81% in the "fitness" category, 14.29% in the "obese" category, and only 4.76% in the "athlete" category. This distribution indicates that the female participants generally had a higher proportion of body fat than their male counterparts. Such a pattern is consistent with established physiological differences between males and females. Gender-related differences in body composition are influenced by hormonal, anatomical, and metabolic factors, with males generally possessing greater lean mass and lower relative fat mass, whereas females physiologically maintain a higher proportion of adipose tissue. A recent consensus statement from the American College of Sports Medicine similarly emphasizes that sex differences in hormones, muscle mass, and body composition contribute substantially to differences in physical performance characteristics between male and female athletes (Hunter et al., 2023). Empirical evidence from elite soccer players also demonstrated that male athletes had greater muscle mass and lower fat mass than female athletes, supporting the presence of sex-related

differences in athletic body composition (Petri et al., 2024). Furthermore, a systematic review and meta-analysis of 80 studies involving 4,335 basketball players reported significantly higher pooled body fat percentages among female players (20.7%) than male players (13.1%), demonstrating that sex-related differences in body fat are also evident across athletic populations (Sansone et al., 2022).

The predominance of the "athlete" category among male participants may therefore reflect a body composition profile characterized by relatively lower fat mass and greater lean tissue, which is generally advantageous for activities requiring strength, power, speed, and movement efficiency. In contrast, the greater proportion of female participants in the "acceptable" category should not be interpreted directly as poor athletic status because sex-specific physiological characteristics must be considered when interpreting body fat percentage. The International Olympic Committee consensus on body composition in sport emphasizes that body composition is only one component of athletic performance and that the relationship between body fat and performance should not be interpreted using a single universal threshold. Nevertheless, higher body fat has been reported to be negatively associated with endurance performance, whereas increases in muscle mass are more consistently associated with performance benefits across sporting contexts (Mathisen et al., 2023). Thus, the presence of participants in the "obese" category, particularly among female participants, warrants attention because excessive fat accumulation may increase the mechanical demands associated with locomotion and physical activity, although the classification itself should not be interpreted as a direct indicator of injury.

From a biomechanical perspective, differences in body composition may influence the distribution of body mass, mechanical loading, and postural control during movement. An increase in fat mass contributes to total body mass without providing a proportional contribution to force production, potentially increasing the mechanical demand required to accelerate, decelerate, or stabilize the body during physical activity. This consideration is particularly relevant to student athletes because repeated loading during running, jumping, landing, and change-of-direction activities requires adequate control of the body's center of mass. Previous research examining body composition, posture, and postural stability in professional handball players demonstrated that body composition was associated with differences in postural characteristics and stability, supporting the relevance of considering body composition when interpreting neuromusculoskeletal function in athletes (Wilczynski et al., 2022). In addition, (Domaradzki & Kozlenia, 2022) reported that body composition indices showed sex-specific associations with musculoskeletal injury risk in physically active young adults. Their findings indicated that fat-related indices, particularly the fat mass index and muscle-to-fat ratio, were relevant to injury prediction among women, whereas muscle-related indices were more informative among men. These findings reinforce the importance of interpreting body composition according to sex rather than applying an identical physiological interpretation to male and female athletes.

The findings of the present study therefore suggest that body fat percentage represents an important component of the physical profile of student athletes, but its interpretation should be integrated with sex, lean mass, physical performance, postural alignment, and other biomechanical characteristics. The relatively high proportion of male participants in the "athlete" category may indicate a body composition profile that is more favorable for sport-related physical demands, whereas the predominance of female participants in the "acceptable" category indicates that their body fat percentage remains within an acceptable range but differs from the male athletic profile. Importantly, the 10.84% of male and 14.29% of female participants classified as "obese" indicate that athletic participation does not necessarily guarantee an optimal body composition. This finding supports the view that body composition among student athletes is influenced by multiple interacting factors, including training characteristics, nutritional intake, sport specialization, hormonal factors, and individual lifestyle. Consequently, body fat percentage should be considered as one component within a multidimensional assessment of athletic readiness and injury risk rather than as an independent determinant of injury.

CONCLUSION

Based on the results of a study on postural alignment and body fat percentage among student athletes, significant variations were found that indicate a potential increase in injury risk, particularly in the lower extremities. The greatest postural deviations were found in the feet (11°) and knees (9°), while the average body fat percentage was 14.91% for men and 26.98% for women, with the distribution categories dominated by "athletes" among men (48.8%) and "average" among women (42.9%). These findings confirm that body composition and postural alignment are intrinsic factors that require attention, as both can influence biomechanical efficiency, movement stability, and mechanical loads on the musculoskeletal system, thereby increasing the susceptibility to injury among student athletes. A limitation of this study is the absence of physical tests as indicators of other types of injuries. Future research is expected to include additional test components to obtain more accurate indicators of injury risk.

AUTHOR CONTRIBUTION STATEMENT

Author Safina Azzahra1: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. Author Fajar Awang Irawan2: Investigation, Visualization, Validation, Supervision, Project administration, Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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AI USAGE STATEMENT

During the preparation of this work, the author(s) used ChatGPT in order to language editing. After using this service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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