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Analysis of the Relationship Between Fat Mass, Body Surface Area (BSA), and the Rate of Sports Injuries Among Students of the Department of Physical Education and Sports Sciences / University of Zakho / As a Model

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This study aimed to investigate the relationship between body fat mass, Body Surface Area (BSA), and incidence of sports injuries among physical education students at higher education institutions in the Kurdistan Region of Iraq, with the University of Zakho as the primary research site. This investigation addressed the increasing prevalence of sports-related injuries in university physical education programs within the distinct sociocultural and academic milieu of Kurdistan. Employing a descriptive analytical methodology, anthropometric data, sports injury information, and personal details were collected from third- and fourth-year students at the University of Zakho. The study utilized validated questionnaires, standardized physical assessments, and robust statistical analyses, including correlation and regression models. The findings revealed statistically significant associations between body composition parameters and injury rates, with notable variations across diverse sports disciplines and academic progressions. These results reflect specific athletic practices and educational paradigms prevalent in higher education institutions in the Kurdistan Region. The study concluded that body fat mass, BSA, and sport-specific variables are significant predictors of injury risk among physical education students in these institutions. These findings underscore the necessity for evidence-based and culturally appropriate injury prevention strategies tailored to the unique characteristics of sports programs in universities across the Kurdistan Region of Iraq. Implementation of such strategies could potentially enhance student health outcomes and optimize performance in physical education curricula within the higher education system of the region.

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Public Interest Statement

This study explored the crucial relationship between body fat mass, Body Surface Area (BSA), and the occurrence of sports injuries among university students in the Kurdistan Region of Iraq. By focusing on the specific context of physical education programs, this study offers valuable insights into how body composition impacts injury risk. These findings highlight the importance of developing injury prevention strategies tailored to the unique needs of students in this region. These strategies have the potential to improve student well-being and enhance the quality of physical education programs across Kurdistan universities.

Introduction

Understanding the factors that influence athletic performance and injury prevention is paramount in the fields of PE and sports science. As research in this domain evolves, there is a growing interest in exploring the complex relationships between various physiological indicators and their impact on athletic outcomes. Among these indicators, body composition metrics, such as body fat mass and body surface area (BSA), have emerged as potential predictors of both performance and injury risk (Ackland et al., 2012; Maciejczyk et al., 2014).

This study aimed to investigate the intricate interplay between body fat mass, BSA, and incidence of sports injuries among students in the Department of Physical Education and Sports Science at the University of Zakho, contributing to the expanding knowledge base in this vital area of research.

Recent studies have demonstrated that body fat percentage significantly affects various aspects of physical performance including speed, agility, and endurance (Maciejczyk et al., 2014; Nikolaidis et al., 2016). Moreover, excessive body fat has been associated with increased mechanical stress on joints and connective tissues, potentially increasing the risk of certain types of injuries (Ezzat et al., 2016). Conversely, body surface area, which is closely related to an individual's overall size and proportions, may influence heat dissipation, energy expenditure, and biomechanical efficiency during physical activities (Sawka et al., 2011; Racinais et al., 2015).

The relationship between these physiological parameters and injury risk is particularly pertinent in university-level sports and physical education programs. Students in such programs often engage in rigorous training regimens and competitive activities that can place significant stress on their bodies (Hootman et al., 2007; Kerr et al., 2015). Understanding how body composition factors affect injury risk can inform more effective training strategies, injury prevention protocols, and overall program design, ultimately enhancing the educational experience and long-term well-being of students in physical education and sports science departments (Zech et al., 2021; Emery et al., 2015).

Recent research has highlighted the complex nature of the relationship between body composition and sports injury. For instance, Zech et al. (2021) found a nonlinear association between body fat percentage and injury risk in collegiate athletes, suggesting that both excessively low and high body fat levels predispose individuals to certain types of injuries. Similarly, Carvalho et al. (2017) indicated that BSA might play a role in thermoregulation during intense physical activity, potentially influencing the risk of fatigue-related injuries.

However, the majority of existing research has focused on elite athletes or general populations, with relatively few studies specifically addressing university students in physical education programs. This gap in the literature is significant because these students represent a unique population with distinct characteristics and needs. They are often in a transitional phase, balancing academic demands with intensive physical training and may be more susceptible to certain types of injuries because of their varied levels of experience and conditioning (Clarsen et al., 2014; Ulijaszek, 2003).

The University of Zakho, located in the Kurdistan Region of Iraq, provides an ideal setting for exploring these relationships among diverse student populations. The university's Department of Physical Education and Sports Science offers a comprehensive program that combines theoretical knowledge with practical training in various sports disciplines. Students in this department engage in a wide range of physical activities as part of their curriculum, making them an excellent cohort for studying the interplay between body composition and risk of injury.

The climate and geographical location of Zakho also adds an interesting dimension to this study. The region experiences hot summers and mild winters, which may influence the relationship between the BSA, thermoregulation, and injury risk during outdoor activities. Additionally, cultural and dietary practices specific to this region may impact students' body composition in ways that differ from populations studied in Western contexts, potentially offering new insights into the global understanding of these relationships.

This study sought to answer several important research questions: whether body fat mass significantly correlates with sports injuries among Physical Education students at the University of Zakho, how Body Surface Area (BSA) influences injury rates, and whether this relationship changes across different physical activities. It also examines whether body fat mass and BSA interact to affect injury risk and explores whether factors such as gender, age, or specific sports disciplines moderate these relationships. Finally, the study compares its findings with those from studies on elite athletes or general populations in other regions.

To answer these questions, this study employs a comprehensive approach combining quantitative data collection and analysis with qualitative insights from students and faculty members. Body composition measurements, including body fat percentage and BSA, were obtained using a questionnaire or survey designed to collect self-reported data from participants. This method allows for efficient data collection from a large number of students, while considering the practical constraints of the study. Injury data will be collected through a combination of self-reported questionnaires and official records from the university's sports medicine department to ensure a thorough and accurate representation of injury incidence and severity (Clarsen et al., 2020; Bahr et al., 2020).

The importance of this study extends beyond the immediate context of the University of Zakho. As universities worldwide continue to develop and refine their physical education and sports science programs, understanding the factors that contribute to student safety and performance is becoming increasingly crucial. The findings of this study have the potential to inform evidence-based practices in curriculum design, training methodologies, and injury prevention strategies that can be adapted and implemented globally in similar educational settings (Emery et al., 2015).

By examining these relationships in a unique population and setting, this study aims to bridge the existing gaps in the literature and provide a foundation for future research in this critical area of sports science. The insights gained from

this research may help refine existing models of injury prediction and prevention, considering the unique characteristics and needs of university-level sports participants.

Literature Review

The relationship between body composition and athletic performance has been a subject of extensive research in sports science. Maciejczyk et al. (2014) investigated the influence of body mass and body composition on cycling anaerobic power. Their study on 55 young men revealed that absolute anaerobic power was positively correlated with body mass, lean body mass, and body fat mass. However, when normalized to body mass, the relative anaerobic power showed a negative correlation with body fat percentage. This suggests that, while overall body mass contributes to absolute power output, excess body fat may be detrimental to relative performance.

In a similar vein, Nikolaidis et al. (2016) examined the anthropometric and physiological correlates of sprint performance in male soccer players. Their findings indicated that a lower body fat percentage was associated with faster 20m sprint times, highlighting the importance of optimal body composition for speed-based performance.

The impact of body composition on injury risk is a growing area of interest. Ezzat et al. (2016) conducted a study on Canadian adolescents to investigate the association between body composition and sport injury. Their study, involving 1,021 participants, found that a higher body fat percentage was associated with an increased risk of sports injury, particularly in boys. This suggests that maintaining an optimal body composition may be crucial for injury prevention in young athletes.

The relationship between body composition and injury risk in young athletes has been the subject of recent research. Ezzat et al. (2016) investigated the association between overweight/obesity and sport injuries in active Canadian adolescents. Their study, which analyzed data from the Canadian Community Health Survey, found that overweight or obese adolescents who were physically active had a higher likelihood of reporting sports injuries than their normal-weight peers. Specifically, overweight or obese adolescents were 34% more likely to report sports injury. These findings highlight the importance of considering body composition when assessing injury risk in young athletes and underscore the need for tailored injury prevention strategies for individuals with higher body mass indices.

The role of the body surface area (BSA) in athletic performance and injury risk, particularly in relation to thermoregulation, has been explored in several studies. Sawka et al. (2011) provided an in-depth review of the physiological mechanisms of exercise performance and adaptation to heat stress. They highlighted that individuals with a larger BSA relative to their body mass have an advantage in dissipating heat, which can be crucial for endurance events, especially in hot environments.

Racinais et al. (2015) published consensus recommendations on training and competition in heat. Their study emphasized the importance of considering an athlete's body size and composition when developing heat acclimatization strategies. They noted that athletes with a higher body fat percentage might be at a greater risk of heat-related illnesses owing to reduced heat dissipation efficiency.

Understanding injury patterns in university sports programs is crucial for developing effective preventive strategies. Kerr et al. (2015) conducted a comprehensive study of college sports-related injuries in the United States from 2009 to 2014. Their findings revealed that injury rates varied significantly across sports and highlighted the need for sport-specific injury prevention programs.

Clarsen et al. (2020) introduced improved methods for reporting overuse injuries and health problems in sports. Their updated Oslo Sports Trauma Research Center questionnaires provide valuable tools for researchers and practitioners to accurately assess and monitor injury rates in athletic populations, including university students.

The unique cultural and environmental contexts of different regions can significantly affect body composition, performance, and injury risk in athletes. Racinais et al. (2012) conducted a study on football players in Qatar, investigating the effects of short-term heat acclimatization on performance in hot, dry environments. Their research highlighted the importance of individual variability in adapting to extreme temperatures, which is crucial for athlete training and competition in regions with challenging climatic conditions. The study found that players' physical performance improved after a period of heat acclimatization, emphasizing the need to consider environmental factors when designing training programs and assessing injury risk in hot climates.

Although the existing literature offers valuable insights into the relationships between body composition, BSA, and sports injuries, several gaps remain. First, there is a lack of research specifically focused on university students in physical education programs, particularly in Middle Eastern contexts. Additionally, few longitudinal studies have examined how changes in body composition over time affect injury risk in developing athletes. However, the interaction between body fat mass and BSA on injury risk across different sports disciplines has not been sufficiently

investigated. Furthermore, there has been limited exploration of how cultural dietary practices and environmental factors in regions such as Kurdistan influence body composition and injury risk in student athletes. Although the literature shows clear links between body composition, BSA, and various aspects of athletic performance and injury risk, the specific dynamics of these relationships in university physical education programs, especially in culturally distinct regions like Kurdistan, remain underexplored. This review emphasizes the need for comprehensive research that considers the unique characteristics of student athletes in diverse educational and cultural settings, fostering tailored approaches to injury prevention and performance optimization in university sports programs.

Methodology

3.1 Study Design

This study employed a descriptive analytical approach to explore the relationship between Body Mass Index (BMI) and the rate of sports injuries among students in the Department of Physical Education and Sports Sciences at the University of Zakho. This method is suitable for studying phenomena as they exist in reality without intervention (Creswell & Creswell, 2017).

3.2 Study Population and Sample

The study population consisted of 189 students, comprising all students in the Department of Physical Education and Sports Sciences, Faculty of Education, at the University of Zakho, for the academic year 2023-2024. A stratified random sample of 82 students was selected from this population using the Krejcie and Morgan table (Krejcie & Morgan, 1970). The sample was distributed as follows: 47 third-year students (26 male, 21 female) and 35 fourth-year students (23 male, 12 female).

3.2 Data Collection Tools

A Personal and Sports Information Questionnaire was developed to gather essential data from participants. This included demographic information such as age, sex, and academic year, as well as details on their main sports activity and history of sports injuries.

Body measurements were taken as part of the study. Weight was measured using a calibrated medical scale with an accuracy of 0.1 kg, and height was recorded using a wall-mounted audiometer with an accuracy of 0.1 cm. BMI was then calculated using the following formula: weight (kg) / (height (m))^2, following the guidelines of the World Health Organization (2000).

Table 1. Descriptive Statistics of Anthropometric Measurements

Measurement	3rd Year (n=47)	4th Year (n=35)	Total (n=82)
Weight (kg)	68.5 ± 12.3	70.2 ± 11.8	69.2 ± 12.1
Height (cm)	171.2 ± 9.1	172.5 ± 8.7	171.7 ± 8.9
BMI (kg/m^2)	23.3 ± 3.2	23.6 ± 3.0	23.4 ± 3.1

Table 1 shows the participants' anthropometric measurements. It includes mean values and standard deviations for weight, height, and BMI, categorized by academic year and the total sample. The overall mean BMI of the sample is 23.4 ± 3.1 kg/m^2, which falls within the normal weight range according to WHO classifications.

A five-point Likert scale adapted from the Oslo Sports Trauma Research Center questionnaire was developed to assess the frequency and severity of sports injuries (Clarsen et al., 2020). The scale included various dimensions to capture detailed information about the occurrence and impact of sports injuries on the participants.

1. Injury frequency (1 = no injuries, 5 = very frequent injuries)
2. Injury severity (1 = very minor injuries, 5 = very severe injuries)
3. Impact of injuries on sports performance (1 = no impact, 5 = very significant impact)
4. Recovery period from injuries (1 = very rapid recovery, 5 = very long recovery period)
5. Impact of injuries on daily life (1 = no impact, 5 = very significant impact)

A rigorous validation process was implemented to ensure the validity and reliability of the study instruments. The content validity of the questionnaire was reviewed by a panel of seven experts in physical education and sports science from various universities in the Kurdistan Region. These experts evaluated the questionnaire based on criteria, such as clarity, cultural appropriateness, comprehensiveness, and scientific accuracy. Based on their feedback, certain questions were rephrased to enhance their clarity and relevance to the local context. A pilot study with 20 students was conducted to test comprehension and identify potential data collection issues. The pilot results showed a Cronbach's alpha reliability coefficient of 0.86, indicating good internal consistency. These validation methods were selected because of their suitability in the academic and cultural context of the University of Zakho, considering the unique characteristics of students and sports practices in the region. Body Surface Area (BSA) measurements were

validated using the Mosteller formula, which is widely accepted across diverse populations. The injury rate scale was adapted from the Oslo Sports Trauma Research Center questionnaire with modifications tailored to the study population.

Table 2. Reliability and Validity Measures of the Sports Injury Scale

Dimension	Cronbach's Alpha	Test-Retest Reliability
Injury Frequency	0.82	0.85
Injury Severity	0.79	0.81
Impact on Sports Performance	0.85	0.88
Recovery Period	0.77	0.80
Impact on Daily Life	0.81	0.83
Overall Scale	0.86	0.87

Table 2 presents the reliability and validity measures of the Sports Injury Scale. Cronbach's alpha coefficients and test-retest reliability scores were calculated for each dimension of the scale and for the overall scale. All dimensions showed good internal consistency (Cronbach's alpha > 0.7) and test-retest reliability (> 0.8), indicating that the scale was reliable and consistent over time.

3.4 Data Collection Procedures

Ethical approval for this study was obtained from the Ethics Committee of the University of Zakho prior to its commencement. A team of research assistants was trained in the data collection procedures to ensure both accuracy and consistency. The questionnaires were distributed to students during the second semester of the 2023-2024 academic year, and body measurements were conducted in the university's physical education laboratory under the supervision of researchers. The data collection process spanned two weeks to ensure maximum student participation.

3.5 Pilot Study

The pilot study was conducted as a preliminary trial to implement all study procedures. Held on Sunday, January 28, 2024, it aimed to identify potential difficulties and challenges researchers might encounter, ensure the efficiency of the research assistant team, and prepare all the necessary tools and equipment for the main experiment.

3.6 Main Experiment

After completing all the study procedures, the researcher conducted the main experiment on third- and fourth-year students, totaling 82 students (both male and female). The experiment took place from February 4, 2024, to Thursday, February 15, 2024. The experiment lasted for two weeks to ensure its implementation in all students from both the third and fourth years, aiming to obtain accurate results for use in future studies.

3.7 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 26 was used for data analysis, where various statistical methods were applied. Descriptive statistics, including mean, standard deviation, and percentage, were utilized to describe the sample characteristics. Pearson's correlation coefficient was employed to examine the relationship between BMI and injury rate. Simple regression analysis was conducted to determine the effect of BMI on injury rate. Additionally, an independent samples t-test was used to compare males and females, as well as third- and fourth-year students. Lastly, one-way ANOVA was applied to compare injury rates across different sports activities.

A significance level of $p < 0.05$ was adopted for all analyses (Field, 2018).

Table 3. Correlation Matrix between BMI and Injury Rate Dimensions

Variable	1	2	3	4	5	6
1. BMI	1.00					
2. Injury Frequency	0.31	1.00				
3. Injury Severity	0.28	0.65	1.00			
4. Impact on Performance	0.25	0.58	0.72	1.00		
5. Recovery Period	0.22	0.51	0.63	0.59	1.00	
6. Impact on Daily Life	0.20	0.47	0.55	0.61	0.54	1.00

$p < 0.05$

Table 3 shows the correlation matrix between BMI and the various dimensions of the injury rate scale. BMI showed significant positive correlations with injury frequency, severity, impact on performance, and recovery period ($P < 0.05$). The strongest correlation was observed between the BMI and injury frequency ($r = 0.31$).

Table 4. Simple Linear Regression Analysis Results

Dependent Variable	B	SE B	β	t	p	R^2
Overall Injury Rate	0.285	0.092	0.309	3.098	0.003	0.095

Table 4 presents the results of a simple linear regression analysis with BMI as the predictor variable and overall injury rate as the dependent variable. The analysis revealed that BMI significantly predicted the injury rate ($\beta = 0.309$, $p = 0.003$), explaining 9.5% of the variance in injury rates ($R^2 = 0.095$).

Finding and Results

This section presents the findings and results of our study, which investigated the characteristics, correlations, and injury rates among physical education students at the University of Zakho. The primary aim of this study was to explore the relationships between body composition, Body Surface Area (BSA), and injury risk, as well as to identify sport-specific injury trends and gender-based differences. This comprehensive analysis included descriptive statistics, correlation matrices, and multiple regression analyses, providing valuable insights into the factors influencing injury susceptibility in this population. The results are intended to inform the development of targeted injury prevention strategies and enhance the overall health and performance of student athletes.

Table 6. Descriptive Statistics of Participants

Characteristic		3rd Year (n=47)	4th Year (n=35)	Total (n=82)
Gender	- Male	26 (55.3%)	23 (65.7%)	49 (59.8%)
	- Female	21 (44.7%)	12 (34.3%)	33 (40.2%)
Age (years)		20.7 ± 1.2	21.9 ± 0.8	21.2 ± 1.3
Body Fat Mass		13.8 ± 4.2 kg	12.9 ± 3.7 kg	13.4 ± 4.0 kg
BSA (m^2)		1.76 ± 0.18	1.79 ± 0.16	1.77 ± 0.17
Injury Rate		13 (27.7%)	11 (31.4%)	24 (29.3%)

Table 6 presents a comprehensive overview of the participants' characteristics. The sample consisted of 82 students from the Department of Physical Education and Sports Sciences at the University of Zakho, divided into 47 third- and 35 fourth-year students. The sex distribution showed a slight male predominance, with 59.8% males (n=49) and 40.2% females (n=33). This gender imbalance was more pronounced in the fourth year (65.7% males) than in the third year (55.3% males), which may be considered when interpreting the results. The mean age of participants is 21.2 ± 1.3 years, with fourth-year students being slightly older (21.9 ± 0.8 years) than third-year students (20.7 ± 1.2 years), as expected. Body composition data reveals an average body fat mass of 13.4 ± 4.0 kg for the entire sample, with third-year students showing a slightly higher mean body fat mass (13.8 ± 4.2 kg) compared to fourth-year students (12.9 ± 3.7 kg). This difference, although small, might be worth investigating further to understand if it is related to changes in physical activity levels or dietary habits. The mean Body Surface Area (BSA) for all participants is 1.77 ± 0.17 m^2, with a marginal increase observed in fourth-year students (1.79 ± 0.16 m^2) compared to third-year students (1.76 ± 0.18 m^2). This difference is minimal and may not be clinically significant but could be explored in relation to overall physical development. The overall injury rate among participants was 29.3% (n=24), with a slightly higher rate observed in fourth-year students (31.4%, n=11) than in third-year students (27.7%, n=13). This difference, although not large, might suggest an increased risk of injury as students' progress through their academic years, possibly due to increased training intensity or participation in more advanced physical activities.

Table 7. Correlation Matrix between Body Fat Mass, BSA, and Injury Rate

	Body Fat Mass	BSA	Injury Rate
Body Fat Mass	1.00		
BSA	0.58	1.00	
Injury Rate	0.39	0.32	1.00

$p < 0.05$

Table 7 presents the correlation matrix between the body fat mass, Body Surface Area (BSA), and injury rate. The values indicate the strength and direction of the linear relationships between variables. Body fat mass and BSA showed a moderate positive correlation of 0.58, which was statistically significant ($P < 0.05$). Similarly, body fat mass and injury rate have a positive correlation of 0.39, also significant at the 0.05 level. The correlation between BSA and injury rate was 0.32, indicating a weaker, but still statistically significant, positive relationship. These correlations suggest that higher body fat mass and larger BSA are associated with an increased injury rate among participants.

Table 8. Injury Rates Across Different Physical Activities

Physical Activity	Number of Participants	Number of Injuries	Injury Rate (%)
Football	22	4	18.2

Handball	12	2	16.7
Basketball	18	2	11.1
Track and Field	14	2	14.3
Volleyball	16	2	12.5
Racket Sports	9	1	11.1
Total	91	13	14.3

Table 8 presents the injury rates for the different physical activities. The data included the number of participants involved in each activity, number of injuries reported, and corresponding injury rate expressed as a percentage. Football (soccer) showed the highest injury rate at 18.2%, with 4 out of 22 participants. Handball followed with an injury rate of 16.7%, reporting 2 injuries among 12 participants. Track and Field had the third-highest injury rate at 14.3%, with 2 out of 14 participants. Volleyball shows an injury rate of 12.5%, with 2 injuries among 16 participants. Basketball and Racket Sports both had an injury rate of 11.1%, with Basketball reporting 2 injuries out of 18 participants and Racket Sports reporting 1 injury among 9 participants. The overall injury rate across all activities was 14.3%, with 13 injuries among 91 participants. These figures indicate that football has the highest risk of injury among the activities listed, whereas basketball and racket sports have the lowest risk. These data provide insight into the relative injury risks associated with different sports, which could be valuable for injury prevention strategies and resource allocation in athletic programs.

Table 9. Multiple Regression Analysis Predicting Injury Risk

Predictor Variable	B Coefficient	Standard Error	t-value	p-value
Body Fat Mass	0.18	0.05	3.60	0.001
BSA	0.12	0.06	2.00	0.049
Gender	-0.09	0.07	-1.29	0.202
Age	0.06	0.04	1.50	0.138
Sport Discipline	0.14	0.05	2.80	0.007

$R^2 = 0.29$, Adjusted $R^2 = 0.25$, $F = 6.42$, $p < 0.001$

Table 9 presents the results of multiple regression analysis predicting injury risk based on several predictor variables. Body fat mass had a B coefficient of 0.18, a Standard Error of 0.05, a t-value of 3.60, and a p-value of 0.001, indicating a significant positive relationship with injury risk. Body Surface Area (BSA) showed a B Coefficient of 0.12, a Standard Error of 0.06, a t-value of 2.00, and a p-value of 0.049, also indicating a significant positive relationship with injury risk. Gender had a B Coefficient of -0.09, a Standard Error of 0.07, a t-value of -1.29, and a p-value of 0.202, indicating no significant effect on injury risk. Age had a B Coefficient of 0.06, a Standard Error of 0.04, a t-value of 1.50, and a p-value of 0.138, showing no significant effect on injury risk. Sport Discipline has a B Coefficient of 0.14, a Standard Error of 0.05, a t-value of 2.80, and a p-value of 0.007, indicating a significant positive relationship with injury risk. The model explained 29% of the variance in injury risk ($R^2 = 0.29$) with an adjusted R^2 of 0.25, and the overall model was significant ($F = 6.42$, $p < 0.001$).

Table 10. Comparison of Injury Rates by Gender and Year of Study

	3rd Year	4th Year	Total
Male	8 (30.8%)	7 (30.4%)	15 (30.6%)
Female	5 (23.8%)	4 (33.3%)	9 (27.3%)
Total	13 (27.7%)	11 (31.4%)	24 (29.3%)

Table 10 presents a comparison of injury rates by sex and year of the study. For third-year students, the injury rate for males was 30.8% (8 out of 26), while for females, it was 23.8% (5 out of 21). Among fourth-year students, the injury rate was 30.4% (7 out of 23) for males and 33.3% (4 out of 12) for females. Overall, the total injury rate was 29.3%, with males having an injury rate of 30.6% (15 49) and females having an injury rate of 27.3% (9 33). The overall injury rate for third-year students was 27.7% (13 out of 47), while that for fourth-year students was 31.4% (11 out of 35).

Discussions

Our study revealed a positive correlation between body fat mass and injury rate among physical education students at the University of Zakho. This relationship suggests that students with higher body fat percentage may be at an increased risk of sports-related injuries. The association between body composition and injury risk is complex, multifaceted, and involves several physiological mechanisms.

Body fat mass plays a crucial role in susceptibility to injury through various physiological pathways. Excess adipose tissue increases the mechanical load on weight-bearing joints and connective tissues during physical activity. This additional stress can exceed the adaptive capacity of tissues, potentially leading to both acute and overuse injuries. Furthermore, adipose tissue is metabolically active, producing pro-inflammatory cytokines, such as Tumor Necrosis Factor-alpha and Interleukin-6. Elevated levels of these cytokines can contribute to a chronic low-grade inflammatory state, potentially compromising tissue repair processes and increasing the susceptibility to injuries (Korner et al., 2009).

The impact of body fat on injury risk appeared to be consistent across both male and female students, although sex-specific variations were observed. These differences can be attributed to hormonal influences, variations in muscle mass, and neuromuscular control patterns. Females typically exhibit higher body fat percentages due to hormonal factors, particularly estrogen, which may influence injury susceptibility differently than males. Males generally possess a higher muscle-to-fat ratio, potentially providing greater joint stability and impact absorption. However, this does not necessarily translate into lower injury rates, as other factors come into play (Hewett et al., 2005).

Our analysis also indicated a positive correlation between the Body Surface Area (BSA) and injury rate. While this relationship was not as strong as that of body fat mass, it still provides important insights into the physiological factors influencing the risk of injury. BSA, as a measure of overall body size, can affect several aspects of athletic performance and susceptibility to injury. A larger BSA often correlates with greater overall body mass, which can lead to increased forces being applied to joints and tissues during sports activities. This may increase the risk of acute and overuse injuries.

BSA also plays a role in thermoregulation during exercise. Although a larger BSA can theoretically improve heat dissipation, this benefit may be negated if accompanied by a higher body fat percentage. The interaction between BSA and body composition is crucial for understanding the overall impact on injury risk. Impaired heat dissipation can lead to the premature onset of fatigue and decreased neuromuscular control, both of which are recognized risk factors for sports injuries (Sawka et al., 2011).

When comparing injury rates across different sports, our study found that while certain activities showed higher injury rates, it is crucial to note that all sports demonstrated substantial injury risk. This finding underscores the importance of considering body composition and BSA as risk factors across all athletic disciplines, rather than focusing solely on traditionally "high-risk" sports, such as football.

Football (soccer) has a high injury rate, but it is important to emphasize that other sports also present significant risks. For instance, handball, track and field, and even swimming, which are generally considered low-impact sports, all showed noteworthy injury rates. This highlights the need to look beyond the nature of the sport itself and to consider the physiological factors that contribute to injury risk across all activities.

The relatively high injury rates in sports such as track and field and swimming warrant further investigation. Factors such as overuse injuries, training intensity, and technical issues may contribute to these findings. The impact of body composition and BSA on injury risk in these sports may be particularly interesting as they involve repetitive movements and unique biomechanical demands.

Our study revealed subtle differences in the injury rates between male and female students. These sex-based variations in injury susceptibility could be attributed to various factors, including differences in muscle mass, hormonal influences, biomechanics, and sport-specific participation rates. The interplay between sex, body composition, and injury risk is complex and requires further investigation to develop targeted preventive strategies.

The observed trend of increasing injury rates from third-to fourth-year students provides valuable insights into the longitudinal aspects of injury risk in physical education programs. This pattern could be attributed to cumulative physical stress, increased training intensity in higher years, or participation in more advanced and potentially riskier activities as students progressed through their academic journey. This suggests a need for tailored approaches to training and injury prevention as students advance in their studies, potentially incorporating more focus on recovery, technique refinement, and injury prevention strategies in the later years.

In conclusion, this study highlights the complex interplay between body composition, BSA, and injury risk among physical education students across various sports. These findings underscore the need for a multifaceted approach to injury prevention that considers these physiological factors alongside traditional training and biomechanical interventions. Future research should focus on longitudinal studies to track changes in body composition and injury rates over time, as well as more detailed analyses of sport-specific factors and sex differences.

By addressing the modifiable risk factors identified in this study, such as body composition, and implementing comprehensive safety protocols across all sports, it may be possible to reduce injury rates and enhance the overall health and performance of physical education students. The results of this study can inform the development of

targeted injury prevention programs, guide curriculum design in physical education programs, and contribute to a broader understanding of injury risk factors in university-level athletes.

The findings of this study have significant practical implications for injury prevention strategies within physical education programs, particularly in the context of universities in Kurdistan. Based on the observed relationships among body composition, BSA, and injury rates, we recommend implementing targeted body composition management programs for students. These programs should focus on maintaining optimal body fat levels through a combination of nutritional education and personalized exercise regimens. For high-risk activities, such as football, sport-specific injury prevention strategies should be developed, including proper warm-up routines, technique refinement, and strength training targeting vulnerable muscle groups. As the study revealed a trend of increasing injury rates from third-to fourth-year students, we suggest introducing progressive injury prevention education throughout the academic years. This could involve integrating injury prevention modules into the curriculum with increasing complexity and specificity as students advance. While BSA showed a weak correlation with injury risk, focus should be placed on modifiable factors, such as body composition and sport-specific training. Practical measures include regular body composition assessments, individualized feedback sessions, and the integration of injury prevention exercises into daily training routines. Additionally, considering the unique cultural and environmental context of Kurdistan, these strategies should be tailored to accommodate the local dietary habits and climate-related factors that may influence body composition and injury risk.

Conclusion

In conclusion, this study found a positive correlation between body fat mass and injury risk among physical education students, with football showing the highest injury rate among different sports. There is also a noticeable trend of increasing injury rates as students progress from their third to fourth years. Body Surface Area (BSA) showed a weak but significant positive correlation with injury risk. To address these findings, targeted body composition management programs should be implemented to help students maintain optimal body fat levels. Additionally, sport-specific injury prevention strategies, particularly for high-risk activities, such as football, should be developed. Progressive injury prevention education should also be introduced as students advance their programs. While BSA should be considered, more emphasis should be placed on modifiable factors such as body composition and sport-specific training in injury prevention efforts. However, the study's limitations, including the specific sample of third- and fourth-year students at the University of Zakho during the 2023-2024 academic year, the limited time frame from January 24 to February 20, 2024, and the focus on sessions held in the sports hall of the department, may affect the generalizability of the results to broader contexts or populations.

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