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The Role of Q-Angle in the Risk of Iliotibial Band Syndrome Among Runners in Denpasar: A Cross-Sectional Study

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Abstract

Introduction: Iliotibial Band Syndrome (ITBS) is a common overuse knee injury among runners and the second leading cause of knee pain in this population. Genu varus and genu valgus are suspected to increase ITBS risk. The Q-angle is a key parameter in assessing knee alignment, influencing force distribution during running. This study examines the relationship between Q-angle and ITBS incidence among runners in Denpasar.
Methods: This cross-sectional study used purposive sampling, involving 99 runners aged 30–45. Knee alignment was measured using a goniometer, and ITBS was diagnosed via the Noble compression test. Data were analyzed using the Chi-Square test and Cramer's V.
Results: ITBS was found in 34 participants (34.3%), primarily those with genu varus and valgus. Runners with a Q-angle outside the normal range had higher ITBS. Statistical analysis showed a significant relationship between knee alignment and ITBS ($p = 0.001$, $p < 0.05$), with a moderate correlation ($r = 0.369$).
Conclusion: Knee alignment, as measured by the Q-angle, is significantly associated with ITBS among runners in Denpasar, with a moderate correlation.

Keywords: knee alignment, Q-angle, iliotibial band syndrome, runners

Introduction

The knee joint is the largest joint in the body, bearing a significant portion of human body weight. Physical activities, particularly movements involving the lower extremities, depend heavily on knee function. One such activity that places substantial stress on the knee joint is running. Running is a continuous exercise that uses the lungs and heart to generate energy. During running, there is a phase where the body is airborne with no contact with the ground.[1] Running is also considered one of the most efficient exercises for achieving physical fitness, associated with longevity. In recent years, running has gained popularity across various demographics in Indonesia, both as a recreational and competitive sport.[2] However, despite its numerous health benefits, runners risk developing musculoskeletal injuries due to long-term repetitive loading (overuse).[3]

One of the most common injuries among runners is Iliotibial Band Syndrome (ITBS). This condition is a leading cause of pain in runners and ranks as the second most frequently reported complaint.[4] ITBS is the most common cause of knee pain and discomfort at the Lateral Femoral Epicondyle (LFE), which can lead to movement restrictions, particularly in knee flexion, ultimately reducing running performance.[5] ITBS can result in lateral knee pain, especially during running, walking, or jumping. This pain typically subsides with rest, but without proper treatment, it can interfere with exercise and daily activities.[6]

A McKay et al. (2020) study reported that ITBS affects approximately 62% of female runners and 38% of male runners.[7] In line with this prevalence, various factors contribute to ITBS development in runners. These include anatomical factors such as knee deformities (genu varus and genu valgus), leg length discrepancies, increased hip and knee adduction, hip abductor weakness, prominent lateral femoral epicondyle, and activity-related factors such as running distance, overtraining, downhill running, and improper footwear.[8] One of the primary risk factors associated with ITBS is knee deformity, including genu varus and genu valgus. These conditions result from bone growth disturbances caused by rotational misalignment at the joint between the femur and the knee, leading to an abnormal femur-knee angle.[9]

Knee alignment variations can be influenced by the Quadriceps angle (Q-angle), which is the angle formed between two reference lines on the frontal plane: one extending from the tibial tuberosity to the center of the patella and the other from the center of the patella to the Anterior Superior Iliac Spine (ASIS). An abnormal Q-angle is associated with knee deformities: a large Q-angle is linked to genu valgus, while a small Q-angle is associated with genu varus.[10] These conditions increase stress on the iliotibial band (ITB), potentially leading to inflammation and a higher risk of ITBS. Excessive ITB tension contributes to knee instability, affecting weight distribution during running. Consequently, surrounding structures, including the ITB, become more susceptible to injury, thereby increasing ITBS risk. Thus, knee deformities (genu varus and genu valgus), influenced by abnormal Q-angle values, may serve as key risk factors for ITBS in runners.[11]

A previous study by Rais (2022) demonstrated a relationship between knee alignment and ITBS but with a limited study population. Therefore, this study aims to examine the relationship between knee alignment, as measured by the Q-angle, and ITBS incidence among runners in Denpasar, providing broader and more applicable data.[9] Additionally, this study tests the hypothesis that knee alignment, based on Q-angle measurements, is associated with ITBS incidence in this population.

Methods

This study employed an analytical observational method with a cross-sectional approach. The cross-sectional design was chosen as it allows for identifying relationships between knee morphology and the incidence of ITBS at a single point in time while being more time- and cost-efficient compared to cohort studies, which require long-term follow-up. A case-control design was also not utilized because this study focused on the direct measurement of knee morphology rather than the retrospective identification of risk factors. However, this approach may introduce bias as it is difficult to establish a causal relationship between risk factors and ITBS. The study was conducted at the base camp of a running community in Denpasar City from January to August 2024.

Sampling was conducted using a purposive sampling method, involving 99 participants selected based on inclusion and exclusion criteria. Sample size calculation was performed using the formula for cross-sectional studies proposed by Sudigdo Sastroasmoro,[12] 12: $n = Za^2PQ/d^2$, yielding a result of 88.8. To anticipate potential dropouts, the researchers added 10% to the sample size, requiring a minimum of 99 participants. Participant recruitment was conducted by contacting the coordinators of each running community, who then disseminated information about the study to their members. Data collection was performed only once, with no follow-up assessments.

Inclusion criteria included: (1) Subjects aged 30–45 years. This age range was selected because the risk of injury due to abnormal biomechanics increases compared to younger ages. Additionally, this range helps reduce bias from physiological and biomechanical differences between younger and older age groups, ensuring a more focused evaluation of the relationship between Q-angle and ITBS incidence without age-related confounding factors. (2) A regular Body Mass Index (BMI) based on the Indonesian Ministry of Health standard is 18.5–25 kg/m². This classification slightly differs from the WHO standard, where the upper normal limit is 24.9 kg/m², and overweight begins at 25.0 kg/m². The Indonesian standard was chosen for better relevance to the local population. This BMI range was also selected because many runners believe that excess body weight increases injury risk, as individuals with higher body weight are more prone to injuries due to additional physical strain;[13] (3) A minimum running intensity of 15 km per week. (4) Willingness to participate in the study.

Exclusion criteria included: (1) A history of injury or surgery on the lower extremities. Individuals with a history of such conditions often exhibit different biomechanical patterns than those without prior injuries. A study has shown that past injuries can influence running mechanics and adaptation to training, potentially introducing bias in research findings [14]; (2) Uncooperative behavior during the study.

Dropout criteria included withdrawal from the study by the participant. The study commenced with initial observation and coordination with running community representatives in Denpasar City to obtain research approval and communicate study details to potential participants. Subjects meeting the criteria were provided with an informed consent form, which they were required to sign as proof of their willingness to participate. Personal identity data were collected through interviews, while knee morphology was assessed using Q-angle measurements obtained via a goniometer in a standing position. ITBS assessment involved interviews and physical examinations, including inspection and palpation of the lateral knee area. Specific testing included the Noble compression test with passive movement, where the participant lay supine with the knee flexed to 90 degrees. The examiner applied pressure approximately 2 cm proximal to the lateral femoral epicondyle while slowly extending the knee. The test was considered positive if the participant experienced pain at 30 degrees of flexion.

Measurements were performed by trained examiners who had undergone prior briefing to ensure consistency. This study did not include repeat Q-angle measurements by a second examiner. However, all measurements were conducted by trained professionals following standardized methods to ensure reliability. Additionally, the procedures were performed systematically and consistently according to established protocols. While a single examiner conducted an ITBS assessment, the examiner was a specialized physiotherapist adhering to standardized procedures for the Noble compression test.

The study involved multiple running communities in Denpasar City to mitigate potential selection bias from purposive sampling. Community selection was based on their regular group running activities, ensuring a more representative sample of active runners in the area. Although the study may not fully represent the entire running population, this approach aimed to increase the generalizability of the findings. Further, a blinding procedure was implemented to reduce measurement bias: the Q-angle examiner and the ITBS examiner were different individuals, preventing the Q-angle assessment from being influenced by ITBS diagnosis information. Examinations were conducted sequentially, with participants first undergoing Q-angle measurement followed by ITBS assessment. While inter-rater reliability testing was not performed in this study, all examiners received prior training to ensure uniform measurement techniques. Additionally, measurement procedures were carried out systematically according to standardized guidelines.

Collected data were analyzed using univariate and bivariate analyses. Univariate analysis was conducted to describe the characteristics of each variable, including age, gender, weekly running intensity, knee morphology (normal, genu varus, or genu valgus) based on Q-angle values, and the presence of ITBS in the right or left knee. In this study, Q-angle was analyzed as a categorical variable. Participants were classified into three groups based on Q-angle values: normal, varus, and valgus. This classification was based on previous literature, which states that a normal Q-angle range is 10°–14° for males and 14.5°–17° for females.[15] A Q-angle smaller than the normal range indicates genu varus, while a larger Q-angle suggests genu valgus.

Bivariate analysis evaluated the relationship between knee morphology and ITBS incidence. The Chi-Square test was used, followed by Cramer's V analysis, to determine the strength of the relationship between variables. Interpretation of Cramer's V followed Cohen's guidelines, where 0.1 indicates a weak correlation, 0.3 is a moderate correlation, and 0.5 is a strong correlation. Thus, based on these categories, the study results illustrate the extent of the relationship between knee morphology and ITBS incidence.[16]

Confounding factors such as age, BMI, and running intensity were controlled at the study's outset by establishing specific inclusion criteria. This approach ensured the results were more representative and minimized potential bias in the analysis. No missing data were recorded, as data entry was performed systematically and immediately after collection to reduce the risk of data loss. Furthermore, all participants completed the study procedures in sequence, ensuring data completeness. Each participant's data was reviewed before processing to verify accuracy and completeness.

This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Udayana University/Sanglah General Hospital Denpasar, with ethical clearance number 0707/UN14.2.2.VII.14/LT/2024. Before participation, all subjects were given an information sheet and required to sign an informed consent form. Participants had the right to withdraw from the study without any consequences.

Results

The subjects in this study were runners aged 30–45 years who were members of a running community in Denpasar. Sampling was conducted using a purposive sampling technique. Out of a total population of 180, 99 participants met the inclusion criteria and were included in the analysis. A total of 48 individuals did not meet the inclusion criteria for the following reasons: 15 did not meet the age criteria, 11 did not meet the running intensity criteria, and 22 had a BMI outside the specified range. Additionally, 12 individuals met the exclusion criteria due to a history of lower extremity injuries or previous lower limb surgery. A further 21 individuals were unable to participate in the study, either due to absence during data collection or refusal due to personal commitments. There were no dropouts—i.e., participants who met the inclusion criteria but withdrew after the initial data collection.

Data were collected through interviews and measurements. Ninety-nine datasets were analyzed from the collected data, with no missing data. Figure 1 presents the research flowchart.

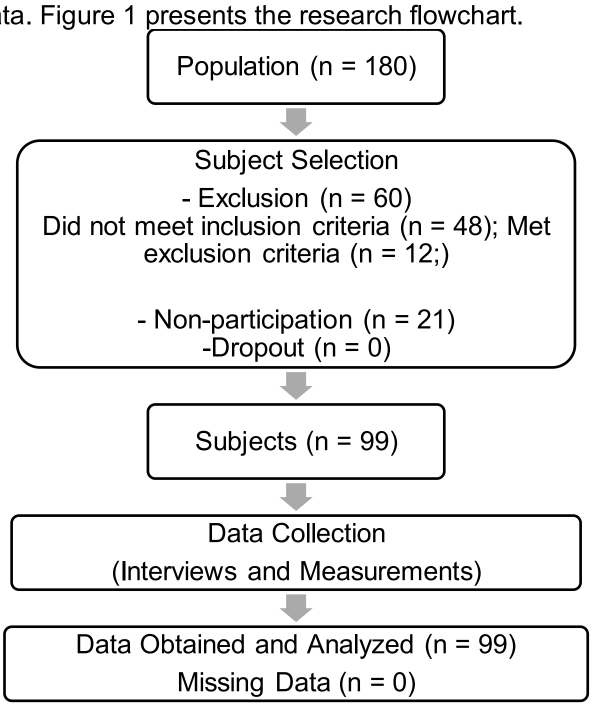

Figure 1. Research Flowchart

The sample characteristics include age, gender, weekly running intensity, knee alignment variations (regular, genu varus, and genu valgus) based on Q-angle measurement, and the presence or absence of iliotibial band syndrome (ITBS) in the right or left knee. The following tables present the descriptive and inferential statistical results of the study. Table 1 displays the frequency distribution of the demographic and physical characteristics of the study subjects. Table 2 outlines the classification of Q-angle measurements used to assess knee alignment. Table 3 shows the frequency distribution of Iliotibial Band Syndrome (ITBS) occurrences in the right and left knees. Table 4 presents the chi-square analysis results examining the relationship between knee alignment and the incidence of ITBS. Lastly, Table 5 summarizes the strength of this relationship using Cramer's V correlation.

Table 1. Frequency Distribution of Study Subject Characteristics

Characteristic	Frequency (N)	Percentage (%)
Age (Years)		
30–33	29	29.3
34–37	19	19.2
38–41	24	24.2
42–45	27	27.3
Total	99	100
Mean ± SD	37.73 ± 4.763	
Gender		
Male	55	55.6
Female	44	44.4
Total	99	100
Running Intensity per Week (km)		
15–30	69	69.7
31–45	23	23.2
46–60	7	7.1
Total	99	100
Mean ± SD	26.16 ± 11.954	
Knee Alignment		
Normal	57	57.6
Abnormal (Valgus)	33	33.3
Abnormal (Varus)	9	9.1
Total	99	100
Mean ± SD	Right Q-angle: 14.40 ± 2.806	
	Left Q-angle: 14.54 ± 2.760	

As shown in Table 1, the age group with the highest number of subjects was 30–33 years, comprising 29 individuals (29.3%), with a mean age of 37.73 years and a standard deviation of 4.763. Of the 99 study subjects, the majority were male (55 individuals, 55.6%), while 44 individuals (44.4%) were female. The data also indicate that the most common running intensity was 15–30 km per week, reported by 69 individuals (69.7%), with an average running distance of 26.16 km and a standard deviation of 11.954.

Regarding knee alignment variation, 57 individuals (57.6%) had normal knee alignment, while 33 individuals (33.3%) had genu valgus, and nine individuals (9.1%) had genu varus. The average Q-angle measurement for the right knee was 14.40° with a standard deviation of 2.806, while for the left knee, it was 14.54° with a standard deviation of 2.760.

Table 2. Q-angle Classification

Category	Q-angle Range	
	Male (°)	Female (°)
Normal	10° – 14°	14,5° – 17°
Genu Varus	< 10°	< 14,5°
Genu Valgus	> 14°	> 17°

Table 2 presents the Q-angle classification based on previously established guidelines, in which a normal Q-angle ranges from 10°–14° in males and 14.5°–17° in females. Individuals with a Q-angle below the normal range were classified as having genu varus. In contrast, those with a Q-angle above the normal range were classified as having genu valgus.

The classification of running intensity in this study was based on weekly distance, categorized as light (<30 km/week), moderate (30–60 km/week), and high (>60 km/week).[13] This study did not conduct subgroup analyses based on age, gender, or running intensity category. However, potential confounding factors such as age, BMI, and running intensity were controlled by establishing specific inclusion criteria at the beginning of the study.

Table 3. Frequency Distribution of ITBS Presence in the Right and Left Knees

ITBS	Frequency	Percentage (%)
Right Knee		
Yes	23	23.2
No	76	76.8
Left Knee		
Yes	21	21.2
No	78	78.8
Both Sides		
Yes	10	10.0
No	65	65.7
ITBS in One Side	24	24.3

As shown in Table 3, 23 individuals (23.2%) experienced ITBS in the right knee, while 21 individuals (21.2%) experienced ITBS in the left knee. Additionally, 10 individuals (10.2%) had ITBS in both knees, 24 individuals (24.2%) had ITBS in only one knee, and 65 individuals (65.6%) did not experience ITBS.

Table 4. Chi-Square Analysis of the Relationship Between Knee Alignment and ITBS Occurrence

Knee Alignment	ITBS Presence		Total	χ²(2)	p-value
	Normal	ITBS			
Normal	46 (46,5%)	11 (11,1%)	57 (57,0%)		
Valgus	15 (15,2%)	18 (18,2%)	33 (33,0%)	13,491	0,001
Varus	4 (4,0%)	5 (5,1%)	9 (9,0%)		
Total	65 (65,7%)	34 (34,3%)	99(100%)		

Table 4 shows a significant relationship between knee alignment and ITBS occurrence among runners in Denpasar, as indicated by a p-value of 0.001 ($p < 0.05$). The $\chi^2(2)$ value of 13.491 suggests that ITBS occurrence is not evenly distributed across knee alignments.

Table 5. Cramer's V Correlation Strength Between Knee Alignment and ITBS

Correlation Test	Variable Correlation	Correlation Coefficient	p-value
Cramer's V	Knee Alignment and ITBS Occurrence	0.369	0.001

Table 5 presents a correlation coefficient of 0.369, indicating a moderate correlation between knee alignment and ITBS occurrence. This interpretation follows Cohen's guidelines, where 0.1 indicates a weak correlation, 0.3 indicates a moderate correlation, and 0.5 indicates a strong correlation.[16]

Discussion

Subject Characteristics

This study employed a purposive sampling technique with a total of 99 subjects. The sample comprised runners from a running community in Denpasar City who met the inclusion criteria and did not have any exclusion criteria. Most of the study subjects were in the 30–33 age group, accounting for 29 individuals (29.3%). These findings align with previous research by Lindarti et al. (2023), which reported that young adult runners, particularly those in their early 30s, dominated participation in running communities.[17] However, age can contribute to injury risk, as older runners tend to experience decreased muscle strength and flexibility, affecting running biomechanics.[18]

The study subjects were also predominantly male (55.6%), consistent with global analyses showing that most runners are male.[19] Most of the runners in this study covered a weekly running distance of 15–30 km. This supports the findings of Wardati and Kusuma (2020), who stated that most runners experience injuries when their weekly running distance is less than 30 km.[13]

According to the study results, 57 out of 99 subjects had normal knee alignment, while 33 had genu valgus and 9 had genu varus. These findings indicate that knee alignment abnormalities are a significant biomechanical risk factor for Iliotibial Band Syndrome (ITBS), as described by Fox et al. (2018).[20] One injury that can result from knee alignment abnormalities is ITBS.

ITBS is a leading cause of pain among runners and ranks second most common running-related complaint.[4] This condition arises from irritation and inflammation caused by friction between the iliotibial band and the underlying tissue. It is typically triggered by repetitive flexion and extension movements associated with overuse during running.[21] In this study, 34 runners (34.3%) experienced ITBS, most of whom had genu varus and genu valgus, while 65 subjects (65.7%) did not develop ITBS. These results support previous research indicating that biomechanical abnormalities, such as genu valgus and genu varus, increase lateral knee pressure, thereby predisposing runners to ITBS.[4]

Relationship Between Knee Alignment and Iliotibial Band Syndrome

Bivariate analysis using the Chi-Square test (Table 4) and correlation analysis using Cramer's V (Table 5) yielded a p-value of 0.001 with a correlation coefficient of 0.369. The p-value ($p < 0.05$) indicates a significant relationship with a moderate correlation between knee alignment and the incidence of ITBS among runners in Denpasar. These findings support the study's objective of determining the relationship between knee alignment and ITBS, demonstrating that runners with knee alignment abnormalities are more susceptible to this injury.

The results align with the findings of Rais (2022), who investigated the relationship between leg shape and length and the occurrence of ITBS among runners in Playon Jogja. That study indicated a positive correlation between knee alignment abnormalities, such as bow-legged or knock-kneed conditions, and ITBS incidence. Additionally, the study found that runners with knee alignment abnormalities tend to experience excessive lateral knee tension, leading to ITBS-related pain. The consistency of these findings strengthens the conclusion that knee alignment is a risk factor for ITBS, particularly among runners.

From a biomechanical and physiological perspective, ITBS does not permanently alter knee bone structure. Instead, ITBS results from soft tissue inflammation around the knee, mainly due to repetitive friction between the iliotibial band and the lateral femoral epicondyle. Consequently, while ITBS can cause short-term biomechanical compensations, it does not lead to structural changes in knee alignment. This study has limitations in controlling confounding factors, as it did not explicitly regulate age, body mass index (BMI), or running intensity. Additionally, the sample was limited to a single-running community, which may reduce the generalizability of the findings.[9]

Biomechanical factors, including knee alignment, influence the relationship between knee alignment and ITBS incidence. Studies indicate that individuals with normal knee alignment have optimal weight distribution across the knee joint, as their body mechanics during running or movement tend to be balanced, thereby reducing the risk of injuries such as ITBS. In this alignment, iliotibial band tension is minimal, and knee and hip movements remain well-coordinated, preventing impingement or compression at the lateral femoral epicondyle. Genu valgus, characterized by inward knee deviation while standing or moving, has been associated with an increased risk of ITBS.[7]

Other studies have shown that female runners with ITBS exhibit increased hip adduction angles and internal knee rotation compared to control groups. This biomechanical alteration elevates stress on the iliotibial band, particularly when the knee is flexed at approximately 30°, the impingement zone. This condition is often accompanied by gluteus medius weakness, crucial in stabilizing the hip and knee and potentially exacerbating the problem. Furthermore, this study employed an advanced biomechanical approach using 3D motion capture technology and force plates, enabling a detailed analysis of the biomechanical differences between runners with and without ITBS. The study also utilized an appropriately matched control group based on age and running distance, enhancing the reliability of the findings in comparing the biomechanical characteristics of both groups. However, a limitation of this research is its retrospective design, which only establishes associations without proving causation. Additionally, the study sample consisted exclusively of female runners, limiting the generalizability of its findings.[22]

Conversely, genu varus, characterized by outward knee positioning, is strongly associated with an increased risk of ITBS. Stickley et al. (2018) reported that individuals with genu varus tend to exhibit a faster inward movement (varus) and a greater knee angle during the stance phase of walking or running. This increases pressure on the iliotibial band, potentially leading to irritation and injury.[23]

When repetitive movements such as knee flexion and extension occur in the presence of genu varus, excessive friction between the iliotibial band and the lateral femoral epicondyle is more likely, leading to inflammation and lateral knee pain. Repeated friction can hinder tissue regeneration. Additionally, weakness in the lateral thigh muscles in individuals with genu varus forces the iliotibial band to work harder to control excessive movement, ultimately exacerbating ITBS. If left untreated, this condition can lead to myofascial restriction due to increased collagen deposition, potentially resulting in trigger points and adhesions.[6] This can cause pain and impair running performance. Research has also shown that individuals with genu varus experience more significant tensile stress on the iliotibial band due to increased activation of the tensor fascia lata (TFL) during running, further stretching the iliotibial band.[24]

Physiotherapy plays a crucial role in managing genu varus and genu valgus, both of which are knee joint deformities that affect lower limb biomechanics. These conditions not only impact knee stability but can also lead to complications such as chronic pain, reduced function, and an increased risk of recurrent injuries, including ITBS. Physiotherapy interventions begin with a biomechanical evaluation to understand the causes and effects of the patient's movement patterns. Assessments include posture analysis, Q-angle measurement, and gait or running pattern observation. These evaluations help determine whether knee deformities contribute to uneven load distribution, which may trigger ITBS.

Individuals with genu varus or genu valgus often experience muscle imbalances, particularly in the hip abductors and adductors. Weakness in the gluteus medius can cause pelvic instability during running, increasing stress on the iliotibial band and elevating the risk of ITBS. Physiotherapy interventions for these conditions include strengthening exercises for the hip abductors and adductors to help correct knee alignment. Exercises such as side-lying hip abductions and wall squats are frequently recommended for patients with these conditions. Additionally, stretching is essential to reduce muscle tightness, contributing to deformities. Regular stretching of the hip abductor and adductor muscles helps maintain flexibility.[25]

ITBS resulting from knee deformities requires serious attention, and physiotherapy is vital in preventing and mitigating injury risks. Physiotherapy interventions include strengthening the hip muscles and focusing on the gluteus medius, critical for maintaining pelvic stability during running. Exercises such as side-lying hip abductions and clamshells help strengthen these muscles. In addition to strengthening, stretching is crucial for reducing tension in the iliotibial band and surrounding muscles. Static stretching techniques, such as trunk side bends, or hip adduction stretches, should be performed regularly to maintain tissue flexibility and prevent stiffness that may contribute to ITBS. These techniques typically involve holding a position for 30 seconds and repeating it three times per session. Soft tissue mobilization, including massage, foam rolling, or myofascial release of the muscles around the ITB, is also beneficial for ITBS management. These techniques help release muscle tension, improve tissue elasticity, and reduce stress that may cause pain or inflammation.[26]

This study has several limitations. The cross-sectional design only allows for data collection at a single point, making it difficult to establish causal relationships between risk factors and ITBS. Additionally, ITBS diagnosis in this study relied solely on interviews, physical examinations, and specific assessments within the sample. The absence of confirmatory diagnostic imaging may have led to the underdiagnosis of mild or asymptomatic ITBS cases and overdiagnosis of other knee pain conditions with similar symptoms. More accurate ITBS diagnosis could be achieved through supplementary imaging, such as MRI. Another limitation is potential selection bias due to purposive sampling, which may not fully represent the broader running population. To mitigate this, the study included multiple running communities in Denpasar to capture a more diverse sample; however, the findings may still not be generalizable to runners outside of Denpasar. Recall bias is another potential concern, as pain data are subjective and depend on respondents' memory. Variations in the ability to recall or report pain experiences could affect data accuracy and influence study results.

Recommendations for future research include expanding the study area to encompass all regions of Bali in order to obtain a more comprehensive understanding of ITBS prevalence across varying environmental, activity, and cultural contexts, thereby enhancing the generalizability of the findings. In addition, the use of more suitable research methods is suggested; since the current study employed a cross-sectional design, which limits causal inference, future studies should consider longitudinal designs to observe biomechanical parameters over time and gain deeper insight into the development and risk factors of ITBS. To improve diagnostic accuracy, future research should also utilize more advanced measurement tools, such as magnetic resonance imaging (MRI), in addition to interviews and physical examinations, to gather detailed structural data on the knee. Finally, incorporating subgroup or sensitivity analyses is recommended to explore the influence of individual risk factors and to ensure the consistency and robustness of findings across different population groups.

By addressing these recommendations, future research can provide more relevant findings regarding the relationship between knee deformities and ITBS and other contributing factors. Runners are also advised to implement balanced training programs and maintain knee health as preventive measures against ITBS. Preventive strategies include regular iliotibial band stretching, strengthening exercises for knee-supporting muscles, and selecting appropriate running shoes.

This study's findings indicate that runners with varying knee alignments (normal, genu varus, and genu valgus) are at risk of developing ITBS. However, because the study sample was limited to running communities in Denpasar, these results may not apply to other locations where biomechanical factors may differ. It is essential to consider potential confounding factors beyond biomechanics, such as extrinsic factors (e.g., running distance, overtraining, downhill running, and inappropriate footwear) when assessing ITBS occurrence. One environmental characteristic in Denpasar that may influence runners' biomechanics and ITBS risk is the running terrain. Runners in Denpasar typically train on paved roads or flat tracks, whereas in other areas, running terrain may be more varied, such as hilly paths or uneven surfaces. Thus, these findings cannot be directly generalized to runners in different locations.

This study did not focus on differences between professional and recreational runners. However, given the inclusion criteria requiring a minimum running distance of 15 km per week, the study primarily targeted runners with consistent training patterns, regardless of professional or recreational status. This criterion ensured that the sample comprised individuals who train regularly and face relevant ITBS risks, making the study findings more reflective of active runners. To improve external validity, future studies should include a broader geographic scope, encompassing various cities or districts in Bali. This expansion would enhance the representativeness and applicability of the findings to the larger running population.

Conclusion

The analysis using the Chi-Square test and Cramer's V yielded a p-value of 0.001 ($p < 0.05$) with a correlation coefficient of 0.369, indicating a significant relationship with a moderate correlation strength between knee alignment and the incidence of ITBS among runners in Denpasar. The study findings reveal that runners with genu varus and genu valgus deformities risk developing ITBS more than those with normal knee alignment. These findings suggest that knee alignment is associated with ITBS incidence, highlighting the importance of evaluating knee structure in ITBS prevention.

This study is a reference for future research, particularly those adopting a longitudinal or interventional approach to assess whether training modifications can reduce ITBS incidence. Furthermore, these findings contribute to runner education, emphasizing the importance of knee alignment assessments and consultations with physiotherapists or coaches to tailor training programs for runners with specific knee structures to prevent ITBS.

Acknowledgments and Additional Information

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