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LITERATURE REVIEW

A LITERATURE REVIEW AND CLINICAL COMMENTARY ON THE DEVELOPMENT OF ILIOTIBIAL BAND SYNDROME IN RUNNERS

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ABSTRACT

Background and Purpose: Iliotibial Band Syndrome (ITBS) is the second leading cause of pain in runners and there are a number of theories related to its etiology. Multiple theories exist for the etiology of ITBS related symptoms including anterior-posterior friction of the IT band on the lateral femoral condyle during knee flexion and extension activities, compression of a layer of fat near the IT band distal attachment, and inflammation of the IT band bursa. The purpose of this literature review and clinical commentary was to explore the potential factors that contribute to ITBS development in runners.

Description of Topic with Related Evidence: A literature review was performed to gather relevant evidence related to the topic and then categorized according to prospective and retrospective results. The electronic databases PubMed, EBSCOhost, CINAHL, and SportDiscus were utilized with the search terms iliotibial band, iliotibial band syndrome, iliotibial pain, and runners. The inclusion criteria included English-language, peer-reviewed journals; adult male or female runners, whether competitive or recreational with regard to mileage; subjects that either had a previous or existing diagnosis of ITBS or were at risk for developing ITBS; retrospective and prospective designs were included and the majority of studies reviewed were cohort or case-control designs.

Discussion/Relation to Clinical Practice: The literature was either contradictory or inconclusive to support a link between ITBS and decreased muscle strength or endurance. A weak correlation existed between strain rate of the hip abductor muscles with hip adduction and knee internal rotation, increased knee internal rotation during the stance phase of gait, and a diminished rearfoot eversion angle at heel strike. Additionally, decreased hip adduction angles during stance phase were observed in individuals without active symptoms but who had a previous history of ITBS. Finally, the female gender may be a predisposing factor.

Keywords: Iliotibial band, iliotibial band pain syndrome, runners

Level of Evidence: 5

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BACKGROUND AND PURPOSE

Recreational running has been a popular form of exercise since the 1970's due to its potential health benefits and convenience, but the risk for incurring a running related injury ranges from 24% to 85%.[1,2,3] Iliotibial Band Syndrome (ITBS) is the second leading cause of pain in runners only behind patellofemoral pain syndrome and accounts for roughly 10% of running-related injuries.[4,5] Pain with ITBS can be reported anywhere along the iliotibial (IT) band from the lateral thigh to the lateral femoral condyle and Gerdy's tubercle.[6,7] Pain is often reported as being the most intense at approximately 30 degrees of knee flexion.[8,9]

Multiple theories exist regarding the etiology of ITBS related symptoms including anterior-posterior friction of the IT band on the lateral femoral condyle during knee flexion and extension activities, compression of a layer of fat near the IT band distal attachment, and inflammation of the IT band bursa.[9] The anterior-posterior friction theory is based on the creation of an impingement zone as the IT band moves over the lateral femoral condyle at approximately 30 degrees of knee flexion.[6,9] The 30-degree knee flexion angle occurs at heel strike or during the early portion of the stance phase of running.[8] This repetitive impingement theoretically creates an inflammatory response and subsequent pain.[10] Another popular theory for the etiology of ITBS related pain is compression of a layer of fat between the IT band and the femoral condyle. Changes occur in the amount of tension in the anterior and posterior fibers of the IT band during knee flexion which causes compression against the lateral femoral condyle, producing pain at the lateral knee.[11] Finally, the IT band bursa theory identifies a potential space between the IT band and the tibiofemoral joint capsule that contains a bursa which becomes inflamed from repeated friction of the IT band over the femoral lateral condyle.[9,12] Additionally, other authors have described an expansion of the synovial joint capsule capable of being compressed by fibers of the IT band.[13,14] However, the presence of the IT band bursa is inconsistent based on cadaver studies.[11,15]

Due to the potential number of factors contributing to overuse of the IT band, the purpose of this clinical commentary was to explore the factors that contribute to the development of ITBS in runners.

METHODS

A literature review was performed to gather relevant evidence related to the topic and then categorized according to prospective and retrospective designs. PubMed, EBSCOhost, CINHAL, and SportDiscus were searched using the search terms iliotibial band, iliotibial band syndrome, iliotibial pain, and runners.

The inclusion criteria included English-language, peer-reviewed journals; adult male or female runners, whether competitive or recreational with regard to mileage; subjects that either had a previous or existing diagnosis of ITBS or were at risk for developing ITBS; retrospective and prospective designs were included and the majority of studies reviewed were cohort or case-control designs. Outcome measures included but were not limited to motion analysis, muscle strength measured with a dynamometer, and joint angles with an inclinometer; finally, all studies selected involved factors associated with the development of ITBS in a running population. The exclusion criteria included non-English language publications, studies without control groups or insufficient data to evaluate the methodology, and studies that solely focused on treatment and not the examination of ITBS.

Methodological rigor was evaluated using the Quality Assessment Tool for Quantitative Studies.[46] It was developed by the Effective Public Health Practice Project (EPHPP) and has proven to be reliable, valid, and is simple when assigning grades, using qualifiers of "weak", "moderate", or "strong" to assess the following categories: 1. selection bias, 2. Study design, 3. confounders, 4. blinding, 5. data collection methods, 6. withdrawals and dropouts, 7. intervention integrity, and 8. analysis. Table 1 provides a global guide to the rating system according to the EPHPP.

RESULTS

The original search generated a total of 204 articles. Once the inclusion and exclusion criteria were applied to the titles and abstracts, and all duplicates were removed, 23 articles remained. Once the full-text articles were read, six additional articles were removed for not meeting all inclusion criteria, leaving 17 articles that met the inclusion and exclusion criteria. Three articles were prospective by design and their results are included in Table 2 while 14 articles were retrospective by design and their results are included in Table 3. The search strategy used to ascertain the articles included for the final review is depicted in Figure 1.

Table 1. *Categories of Methodological Strength According to the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies.*

STRONG	Four STRONG ratings without any WEAK ratings in the first six categories
MODERATE	Less than four STRONG ratings and no more than one WEAK rating in the first six categories
WEAK	Two or more WEAK ratings in the first six categories

Prospective Evidence

The majority of the studies reviewed were retrospective by design, with only three studies being prospective.[16,17,18] Noehren et al.[16] compared 18 healthy adult female recreational runners to matched controls using a Vicon 6 camera motion capture system with 3D analysis and a force plate. They concluded runners with larger hip adduction angles, internal rotation at the knee, and inversion of the foot at the stance phase of gait were more likely to develop ITBS. Hamill et al.[17] compared 17 adult female recreational runners with ITBS to uninjured controls also using a 6 camera motion capture system with 3D analysis and a force plate. They concluded a weak

Table 2. *Description of Prospective Studies.*

Authors	Study Design	Quality Rating	Population	Outcome Measure	Results
Noehren et al.[16]	Prospective Case Control	Moderate	n= 36 females (18 with ITBS and 18 uninjured controls matched for gender, age, and mileage)	- Motion analysis with force plate	Group with history of ITBS exhibited increased hip adduction, hip abductor weakness, and increased knee internal rotation.
Hamill et al.[17]	Prospective Case Control	Moderate	n= 34 females (17 with ITBS and 17 uninjured controls with average mileage of 20 per week	- Motion analysis with force plate	ITB strain, impingement, and symmetry indexes were determined and strain rate may be a predictive factor of ITBS.
Hein et al.[18]	Prospective Case Control	Moderate	n= 36 (18 females with ITBS and 18 healthy female controls)	- Barefoot running on foam runway using a 6-camera infrared system	Although there was not a statistical significance, runners with ITBS exhibited more inconsistency with joint coupling during the first half of the stance phase.

ITBS= iliotibial band syndrome

Table 3. *Description of Retrospective Studies.*

Authors	Study Design	Quality Rating	Population	Outcome Measure	Results
Messier et al.[20]	Retrospective Case Control	Moderate	n= 32 unmatched male and female runners (13 with ITBS and 19 uninjured controls)	- High speed photography using Locam Model 51	Runners with ITBS exhibited increased pronation, a leg length difference, and propensity for running on hills.
Messier et al.[21]	Retrospective Case Control	Moderate	n= 126 male and female runners (56 with ITBS and 70 uninjured controls)	- Isokinetic dynamometer - Motion analysis with force plate	Risk factors include calcaneal to vertical touchdown angle, maximum inversion velocity, and maximum breaking force.
Orchard et al.[8]	Retrospective Case Control	Moderate	Male and female runners with history of ITBS> 6 month n= 9 subjects; the uninvolved side served as the control	Motion analysis with force plate	The posterior edge of the IT band became impinged on the lateral femoral epicondyle at an average knee flexion angle of 21° near foot strike.
Fredericson et al.[22]	Retrospective Case Control	Moderate	n= 54 collegiate distance runners (30 uninjured control subjects: 14 females, 16 males) (Experimental group 24 subjects: 10 males, 14 females)	- Hip abduction strength with a hand-held dynamometer	Regardless of gender, subjects in the experimental group had weaker hip abduction strength in the affected leg.
Miller et al.[23]	Retrospective Case Control	Weak	n=16 (8 with ITBS and 8 uninjured controls matched for age)	- Motion analysis with force plate	Adjustments include increased hip internal rotation and increased knee flexion at heel strike.

Table 3. *Description of Retrospective Studies. (continued)*					
Miller et al.[24]	Retrospective Case Control	Weak	n= 16 runners (8 with ITBS and 8 uninjured controls matched for age)	- Motion analysis with force plate	Runners with ITBS use abnormal segmental coordination patterns, particularly with hip ad/abduction and tibia internal/external rotation.
Grau, Krauss, et al.[19]	Retrospective Case Control	Moderate	n= 20 male and female runners (10 with ITBS and 10 uninjured controls matched for gender, weight, and height)	- Hip abductors and adductor strength using an isokinetic dynamometer	Both groups showed the same strength differences between hip adduction and abduction, and increased strength in hip adduction.
Grau, Maiwald, et al.[26]	Retrospective Case Control	Moderate	n= 36 male and females (18 with ITBS and 18 uninjured controls matched for gender and weight)	- Motion analysis with force plate	Data matching of experimental and control groups is important for understanding overuse injuries in running.
Ferber et al.[27]	Retrospective Case Control	Moderate	n= 70 females (35 with history of ITBS and 35 uninjured controls matched for age and mileage per week)	- Motion analysis with force plate	Runners with history of ITBS demonstrate increased hip adduction, knee internal rotation and rear foot inversion compared to controls.
Grau et al.[20]	Retrospective Case Control	Moderate	n= 36 male and female runners (18 with ITBS and 18 uninjured controls matched for age, gender, and mileage)	- Motion analysis with force plate	Runners with ITBS have a decrease in hip abduction, flexion, and extension velocities.

Table 3. *Description of Retrospective Studies. (continued)*

Foch & Milner[28]	Retrospective Case Control	Moderate	n= 40 females (20 with previous history of ITBS and 20 uninjured controls)	- Motion analysis with force plate	Smaller hip adduction angle in stance phase of running may reduce strain on iliotibial band and be used as a compensatory strategy.
Noehren et al.[29]	Retrospective Case Control	Moderate	n= 34 males (17 with ITBS and 17 uninjured controls matched for age, height, weight, and mileage per week)	- Hip strength with a handheld dynamometer - ITB length with an inclinometer during the Ober test - Motion analysis with force plate	The ITBS group had a significantly lower Ober test measurement, weaker hip external rotators, greater hip internal rotation, and greater knee adduction compared to the control group.
Foch et al.[1]	Retrospective Case Control	Moderate	n= 27 males and females (9 currently with ITBS, 9 with previous history of ITBS, and 9 uninjured controls)	- Motion analysis with force plate - ITB flexibility with an inclinometer during the Ober test - Hip abductor strength with a hand-held dynamometer	Greater ipsilateral trunk flexion may be a result of ITBS, leading to decreased hip abductor strength.
Phinyomark et al.[30]	Retrospective Case Control	Moderate	n= 96 male and females (48 with ITBS and 48 uninjured controls matched for gender and age)	- Motion analysis with force plate	Female ITBS runners exhibited significantly greater hip external rotation compared with male ITBS and female healthy runners. Male ITBS runners exhibited significantly greater ankle internal rotation compared with healthy males.
IT= iliotibial, ITBS= iliotibial band syndrome					

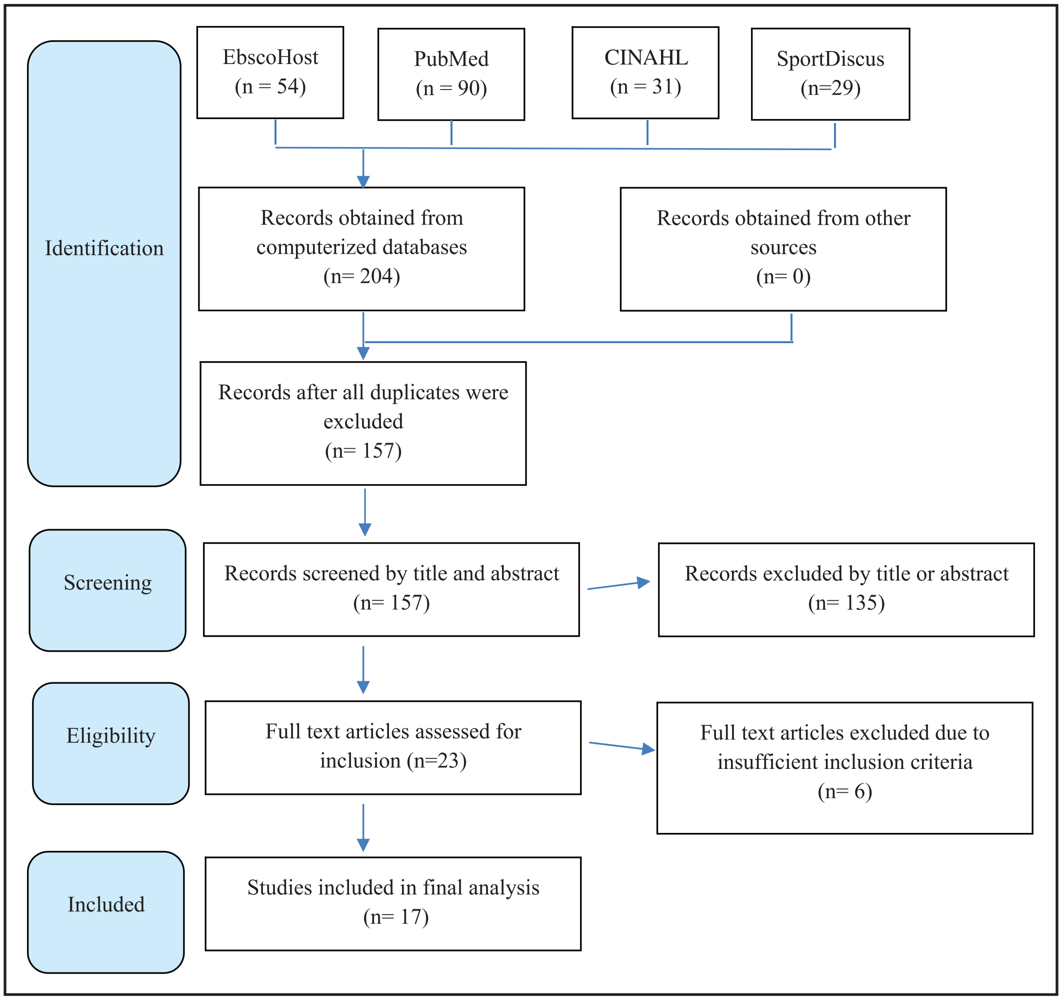

Figure 1. Search Strategy Results

correlation between maximum strain and strain rate with hip adduction and knee internal rotation in runners who eventually develop ITBS versus healthy controls. Table 2 contains a description of the prospective studies used for this review.

Retrospective Evidence

The retrospective studies revealed inconclusive or weak evidence to state adult male or female recreational runners with a previous history of ITBS were more likely than healthy runners to exhibit reduced hip adduction angles, tibial internal rotation angles, or rearfoot eversion at heel strike.[19] The most common method of evaluation was the combination of a multi camera motion analysis system and force plate with the inclusion of reflective markers on the pelvis, thigh, leg, and foot for 3 dimensional motion capture. Additionally, there was weak or inconclusive evidence that runners with a previous history of ITBS exhibited decreased hip flexion and abduction velocities measured with 3D motion analysis systems or force plates while reaching a maximum hip flexion angle earlier than healthy controls.[20,25] Table 3 includes a description of the retrospective studies used for this review.

DISCUSSION

Muscle Strength and Endurance

The literature is either contradictory or inconclusive to support a link between ITBS and decreased muscle strength or endurance. For example, when Fredericson et al.[23] measured hip abduction strength isometrically with a handheld dynamometer, significant weakness was found in subjects with ITBS. In contrast, Grau et al.[26] found no significant difference in hip abduction strength as measured with an isokinetic dynamometer. Studies involving other athletic populations have also not found a significant correlation between hip abduction weakness and ITBS.[31,32] The different results could be due to the variability in reliability of handheld dynamometers vs. isokinetic testing.[23,26,31] Handheld dynamometry is typically expressed as a singular or limited number of contractions in a static position. This type of testing does not mimic the activity of running since the hip abductors have to contract isometrically, concentrically, and eccentrically. Dynamometry and isokinetic testing assess muscle strength but the hip abductors require muscular endurance when running. The fact these types of testing are presumed to relate to function could account for the discrepancy.

Some authors have suggested the gluteus maximus possibly plays a role in ITBS development due to its insertion into the IT band.[33,34] According to Fetto when the gluteus maximus contracts it may contribute to the abduction moment being exerted by the hip abductor muscles since the majority of the gluteal maximus fibers insert along the ITB with the tensor fasciae latae.[33] Plastaras hypothesized that the action of the gluteus maximus and TFL in addition to the static involvement of the ITB during the mid and late portions of the stance phase of gait maintains stability of the pelvis, which helps to reduce tension on the IT band.[34]

Increased fatigue of the knee flexor and extensor muscle groups is another reported factor related to ITB irritation. The hypothesis is that knee flexion puts increased tension on either the layer of fat close to the IT band's distal attachment, iliotibial bursa, or lateral condyle. These effects supposedly become more prevalent with fatigue.[24] However, the endurance of these muscle groups is not significantly different when runners with ITBS are compared to healthy controls.[22]

ITB Strain Rate

Although a correlation exists between strain rate of the IT band and hip adduction and knee internal rotation in runners with ITBS, this should be viewed with caution. Often the IT band is assumed to be a passive structure[17] but the potential for the tensor fascia latae, gluteus maximus, or vastus lateralis to place tension on the IT band to assist in controlling joint angles should be taken into account.[16,33,35,36]

Position of the Knee

A correlation between increased internal rotation at the knee during the stance phase of gait has been proposed as a cause of ITBS in runners.[16,27] Noehren[16] hypothesized that the increased internal rotation at the knee was due to an increase in external rotation at the femur which was theorized to occur because of insufficient strength or timing of the hip internal rotators. Unfortunately, this hypothesis has not been studied at the present time.

Excessive friction of the IT band over the lateral femoral condyle at 30° of knee flexion is proposed to be the angle of greatest compression and is a prevailing theory related to the etiology of ITBS;[8] however, the results of multiple studies demonstrated no significant difference in the angle of the knee at heel strike into the stance phase between the affected and unaffected leg in healthy controls and individuals with ITBS when measured while running on a treadmill using a motion analysis system such as a Vicon.[8,17,20,24,37] These results were found in males, females, and recreational runners of various distances.

It is likely multiple factors are related to the development of friction at this area of knee and the observation of knee flexion by itself is insufficient to generate symptoms. An analogy for the upper extremity would be shoulder impingement where many factors contribute to the pathology and they are complex in their interaction.[8]

Position of the Foot

Another theory related to the occurrence of ITBS is the position of the foot, especially rearfoot eversion, which can cause the tibia to internally rotate, and therefore place an excessive tensile force on the iliotibial band.[27] However, a 2014 systemic review did not contain any prospective studies that demonstrated differences in rearfoot eversion angles between healthy, matched controls, and runners with ITBS.[38] Fredericson[22] and Grau[26] found individuals with ITBS had a diminished inversion angle at heel strike, which might be coupled with diminished tibia internal rotation.

Taunton et al.[39] reviewed 2,002 running injuries and found a higher incidence of ITBS in runners with pes planus foot posture than those with pes cavus foot posture. The authors used visual inspection to classify the arch position as "low", "normal", or "high" but did not provide any additional information. However, an additional retrospective study by Williams et al.[40] found a higher incidence of ITBS in runners with pes cavus foot posture. In their study an arch ratio was used to classify participants as either low or high arched. The authors defined the arch ratio as the height to the dorsum of the foot from the floor at 50% of the foot length divided by the individual's truncated foot length. Truncated foot length was determined by taking the length from the 1st metatarsal phalangeal joint to the most posterior aspect of the calcaneus. The discrepancies between these studies may be due to the fact that different methods of measuring foot posture were utilized and measuring foot posture is not reliable, especially via visual observation, and, foot posture does not relate to performance during functional activities.

Position of the Pelvis

Aberrant pelvis and trunk motion may be a contributor to ITBS due to increased trunk ipsilateral side bending to the affected side or loss of pelvic control in the frontal plane during the stance phase of running. This compensatory strategy diminishes the workload on the hip abductors[41,42] and may be related to a leg length discrepancy.[39] However, a systematic review of the incidence and determinants of lower extremity running injuries in long distance runners did not list static hip and pelvic position as a significant factor in the development of ITBS.[3] It should be noted the focus of that systematic review was on types of lower extremity injuries as well as lifestyle and health factors. There was not an emphasis on biomechanical factors.

Barefoot Running

Barefoot runners typically exhibit decreased range of motion at the hip, knee, and ankle during running gait, as well as decreased stride length, increased stride rate, and landing in a plantar flexed position.[43] This may alter lower extremity kinematics, especially hip adduction angles, which could relate to decreased strain on the IT band.[20,26,27]

Influence of Subject Matching in Studies

Grau and colleagues examined lower extremity kinematics and pressure distribution in healthy adult runners and adult runners with ITBS matched for weight, height, and gender.[26] Frontal plane motion, transverse plane motion, and pressure distribution had the largest statistical difference between groups. The authors stated the results may mean that matching subjects may help account for different running styles which could be useful in understanding overuse running injuries.

Acuity of Symptoms

Symptom acuity could also affect the results of research studies. For example, if participants were not actively experiencing symptoms at the time of testing, the differences between groups could be due to compensatory strategies adopted to avoid pain as a result of the initial injury.[44] Therefore a cause and effect relationship cannot be inferred, especially when looking at retrospective studies. Additionally, decreased hip adduction angles during the stance phase of running are observed in individuals without active symptoms but who also have a previous history of ITBS. A learned, compensatory strategy may persist after symptoms have abated as a means of limiting strain on the iliotibial band.[28]

Role of Gender

Females with a diagnosed case of ITBS display larger hip adduction and knee internal rotation angles compared to healthy controls.[16,28] Studies by Noehren,[16] Ferber,[27] and Foch[28] concluded that increased angles at the hip and knee caused greater demand on the hip abductor musculature eccentrically, which could contribute to overuse during running.[45] These factors could lead to compression of the ITB against the greater trochanter or lateral femoral condyle, potentially making female runners more likely to develop symptoms.[39]

CONCLUSIONS

The purpose of this literature review and clinical commentary was to examine the literature for factors related to ITBS in runners. The results suggest that some of the conventionally held ideas regarding the etiology of ITBS may not be accurate. The literature was either contradictory or inconclusive regarding a link between decreased muscle strength or endurance and ITBS. A weak correlation exists between strain rate of the hip abductor muscles, increased knee internal rotation during the stance phase of gait, and diminished rearfoot eversion angle at heel strike. Additionally, decreased hip adduction angles during stance phase were observed in individuals without active symptoms but who had a previous history of ITBS. Finally, the female gender may be a predisposing factor. So while there are multiple potential factors associated with ITBS, information regarding the cause and effect relationship of these factors is still lacking in the literature.

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