ANALYSIS OF ARM SWING IN ASYMPTOMATIC AND SYMPTOMATIC MALE AND FEMALE RECREATIONAL RUNNERS WITH ANTERIOR KNEE PAIN-AN OBSERVATIONAL STUDY.

By

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Under the guidance of

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Bhubaneswar, Odisha

2023-2025

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled **Analysis of Arm swing in Asymptomatic and Symptomatic Male and Female Recreational runners with Anterior knee pain-an observational study** is a bonafide and genuine research work carried out by me under the guidance of Dr. DEEPAK KUMAR PRADHAN(PT), Associate Professor, Abhinav Bindra Sports Medicine & Research Institute, Bhubaneswar, Odisha.

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LIST OF ABBREVIATIONS USED

1. AG – Asymptomatic group
2. AKP – Anterior Knee Pain
3. BMI – Body Mass Index
4. EMG – Electromyography
5. IQR – Interquartile Range
6. PFJ – Patellofemoral Joint
7. PFP – Patellofemoral Pain
8. PFPS – Patellofemoral Pain Syndrome
9. RRIs – Running Related Injuries
10. SD – Standard Deviation
11. SG – Symptomatic group
12. SPSS – Statistical Package for the Social Sciences
13. VAS – Visual Analogue Scale
14. WHO – World Health Organization

ABSTRACT

Background: Anterior knee pain, largely linked with patella-femoral pain syndrome (PFPS), is a prevalent injury in recreational runners, impacting performance and quality of life. Although much research has explored lower extremity biomechanics in running, the role of upper limb movement, specifically arm swing, in knee mechanics has been under investigated

Purpose: This study will compare and analyze mechanics of arm swing in asymptomatic and symptomatic gender recreational runners who experience anterior knee pain. The study aimed to identify variations in arm movements linked to knee pain and to examine gender-based differences that could help in designing targeted rehabilitation strategies.

Methods: A comparative observational study was carried out among recreational runners aged 19–25 years. Based on clinical evaluation of knee pain history, participants were categorized into symptomatic and asymptomatic groups. Arm swing kinematics were recorded using a motion analysis system while participants ran on a treadmill. The collected data were analyzed to identify variations in arm swing amplitude, phase, and symmetry across groups and between genders. Statistical tests were applied to determine significant differences and examine correlations with knee pain severity.

Results: There were 45 recreational runner. Which mean age of 23.8±1.47.the sample was evenly distributed with mean angular velocity of right upper limb was 67.7±32.6 and 74.8±31.3 for left arm. There was considerable variability ranging in right arm angular velocity from 14.7 to 150.6 and left arm angular velocity from 20.0 to 158.6.

Conclusion: Comparisons of symptomatic versus asymptomatic subjects indicated no statistically significant differences in arm swing angular velocity; the symptomatic. The identification of specific changes can assist practitioners in creating focused intervention programs to normalize gait patterns, minimize stress on the knee, and enhance running efficiency.

Keyword: Arm swing; Anterior knee pain; Patellofemoral pain syndrome; Recreational runner

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INTRODUCTION

Sports activities and exercises have been proven to have a positive impact on one's physical well-being, including lowering the occurrence of obesity, cardiovascular illnesses, and numerous other chronic illnesses. Running is one of the most liked sports activities all over the world, both for the sports and nonathletic individuals.[1] Essentially the word "running" implies a high-intensity and low-cost training in which a person's body structure can be utilized.[1]

Endurance running has been proposed to be a biological adaptation linked to the survival of our species. Indeed, our species may be among the best examples of natural endurance runners, with neurobiological processes supporting the pursuit of habitual aerobic exercise, especially running. Hence, it is not difficult to realize why millions of individuals compete each weekend in road endurance running competitions of varying distances, from 5 km up to marathon races, worldwide .[2] Presently, a large number of recreational runners prepare each day in various locations .[2] The popularity of this recreational sport may be because it is easy and accessible with an emphasis on health development and the social contact and leisure activity that it provides to the majority of individuals, irrespective of level or age.[2]

WHO defines adolescents as individuals between 10 and 19 years of age; however, in the context of running-related injuries (RRIs), biological age or maturational status may be a more critical factor than chronological age, as it better reflects the physiological development relevant to injury risk.Tissues such as bone, tendon, muscle, cartilage, and growth plates develop at different rates and locations during rapid growth .[3] This process is influenced by hormones, genetics, and environmental factors, all of which can affect biomechanics, load tolerance, and risk of running-related injuries (RRIs) in youth. Early sport specialization further increases injury risk by repeatedly stressing the same underdeveloped tissues through uniform movement patterns.[3]

Arm swing is a key and observable part of human gait, typically moving opposite to the legs (e.g., right leg forward, left arm forward). Although arms don't swing as simple pendulums, the role of shoulder muscles and the impact of arm swing on stability and energy efficiency are not fully understood. [4] This study uses a simplified five-segment model with damped spring linkages to represent the upper body. [4] Despite its simplicity, the passive mass-damping model effectively predicts pelvis, shoulder, and arm movements, suggesting it offers useful insights into upper body mechanics during walking and running.[4]

Running without arm swing (e.g., arms held behind the back) has been shown to increase the energetic cost of treadmill running by approximately 4%. Similarly, crossing the arms in front of the chest during running leads to an 8% rise in net metabolic power compared to running with natural arm swing. .[5] Although restricting arm movement does not affect average step width, it significantly increases variability in step width by 9% and step frequency by 2.5% compared to running with normal arm swing.[5]

Anterior knee pain (AKP), often referred to as patellofemoral pain syndrome (PFPS), is a common diagnosis among young, active women. [6] Both terms describe pain on the anterior aspect of the knee, which may result from patellar dislocation, subluxation, or sometimes occur without trauma. [6] Diagnosis of

AKP is typically based on the patient's symptom history rather than specific clinical or functional tests.[6]

Competitive athletics is among the most unambiguous expressions of high-stakes human performance, in that athletes, researchers and coaches attempt to maximize human physical capacity. [7] Time, money and effort is committed with the goal of athletes achieving the maximum level of physical ability and beating each other in sporting events. In this context, the differences in performance between men and women, referred to here as the "sex gap," have been examined over sporting competitions, among them athletics, swimming, cycling and rowing. [7] The top-performing men always dominate their female counterparts, with the size of this sex difference being generally in the range 5 to 17%, as determined by sporting event discipline, event duration and competitive level. In track the sex difference is typically smaller for sprints than for middle- and long-distances. [7]The sex difference in ultra-endurance events is as low as 4.4% for ultra-marathon. Lastly, the sex difference is less between elite women and men.[7]

Recreational and competitive distance running is linked to an array of physiological advantages. [8]But although running is also associated with very high rates of overuse injury, it also contributes to many physical improvements. Patellofemoral pain (PFP) is a frequent atraumatic knee condition that usually presents as retropatellar or peripatellar pain and redness, worsening with activities that consistently load the joint. [8] The incidence of PFP among runners has been reported as high as 21%, with a much higher prevalence in females. [8] The long-term outcome is grim, with 71–91% of patients having symptoms 20 years following diagnosis. Symptoms of PFP can subsequently occur with radiographic findings of osteoarthritis at this joint, and pain symptoms are compelling many to scale down or even abandon running training, leading many to develop secondary psychological disorders.[8]

Patellofemoral joint kinematics, on the order of 5° of femoral internal rotation, have been demonstrated to augment osteochondral shear stress, and thus augmented patellofemoral lateral patella facet contact pressures. [9] Vertical loading rates (and resultant patellofemoral reaction forces) are also elevated in runners with PFP. [9] The etiology of PFJ stress and abnormal kinematics in PFP has been deemed multifactorial, with several intrinsic and extrinsic factors postulated to play roles. One or more of the following kinematic factors, among others, have been postulated to be responsible for increasing loading forces on the lateral facet of the patella: excessive frontal/transverse plane motion of the lower limb (dynamic knee valgus). Rearfoot eversion, knee external rotation and hip adduction were elevated in runners with PFP .[9]

The sex-specific bony structure morphology could contribute to variations in running-related injury due to the higher hip-width to femoral length ratio in female runners relative to male runners. [10] Sex-related differences in pelvic and thigh morphology can result in variation in biomechanical parameters. [10] Furthermore, abnormal mechanics have been implicated as a significant cause of running-related injury. [10] When compared with male runners, female runners exhibit larger frontal and transverse planes of motion of the lower extremity during running. [10] In particular, female runners have more hip internal rotation and adduction, and more peak knee abduction, than male runners. [10]

Arm swing motion when running have established that arm swing helps to generate lift to enable the runner to have steady horizontal velocity and to balance the angular momentum generated by the swinging legs. [11] Physiologically, normal arm swing motion is a mechanism of enhancing running economy . [11] Running while not swinging the arms makes the metabolic cost higher and decreases the lateral balance which can increase muscle activity and energy cost. Most of the arm swing studies examine bilateral motion restriction. The influence of bilateral suppression of arm swing on overall measures of lower extremity biomechanics, spati otemporal measures, and muscle activity while running has been explored. [11] Suppressing the two arms while running leads to increased variability in step width, and step frequency, and a reduction in step length. [11] Bilateral arm swing restriction has also been found to reduce ground reaction forces, enhance contact times, and alter peak lower extremity joint angles but not joint timing Greater peak knee valgus angle during running seems to be an important biomechanical parameter linked with PFP in recreational runners, and reducing knee valgus angle during running seems to be an adaptation for lowering symptoms of PFP. [11] Greater peak knee flexion angle during running seems to be a further biomechanical parameter linked with PFP that is sex specific in male recreational runners.[11]

Running is a common mode of physical exercise leading to a healthy life. Furthermore, running happens to be one of the most widely popular physical exercises in the world, with participants who come from a heterogeneous and diversified group of people.

Anterior knee pain (AKP) or patellofemoral pain syndrome or runner's knee is a frequent musculoskeletal syndrome with diffuse retropatellar or peripatellar pain, exacerbated by loading the knee in flexion on running, descending stairs or squatting.[12] AKP is one of the most frequent causes of knee pain in all age groups, predominantly between 19 and 25 years.[12]

Experiments that have been conducted on arm swing movement during running have revealed that arm swing contributes to providing lift in an attempt to assist the runner in sustaining constant horizontal velocity and to counteract the vertical angular momentum generated by the swinging legs.

Physiologically, normal arm swing movement is a mechanism to enhance running economy. Running without arm swing has been shown to contribute to greater metabolic cost and decreased lateral balance, leading to higher muscle activity and greater energy expenditure It has been shown through various studies that females with PFP have abnormal hip and knee mechanics.

these abnormal mechanics have also been shown in females with PFP during a range of activities, including running and in a single leg squat. females with PFP had increased hip adduction and internal rotation during running, but the only males with PFP in the group had reduced hip adduction when they ran. The reduced hip adduction would suggest that the males ran with more knee varus. Research indicates that men with PFP ran and squatted with greater knee adduction. Females with PFP, on the other hand, ran and squatted with greater hip adduction and less knee adduction. These sex-differentiated mechanics indicate that men and women with PFP might require different interventions.

The study of arm swing mechanics in recreational runners with anterior knee pain is crucial due to the high prevalence of conditions like patellofemoral pain syndrome (PFPS), which necessitates effective injury prevention strategies. Understanding the relationship between arm movements and knee mechanics can provide insights into how arm swing influences running efficiency and contributes to knee pain. Additionally, notable biomechanical differences between male and female runners highlight the need for tailored interventions based on gender-specific responses to arm swings.

Current research is limited in addressing the impact of arm swings on symptomatic versus asymptomatic runners, indicating a significant gap that requires exploration. Findings from this study could inform coaching and rehabilitation practices, optimizing running form to enhance performance and reduce injury risk

AIM & OBJECTIVE OF THE STUDY

AIM OF THE STUDY

To analyze and compare arm swing mechanics in asymptomatic and symptomatic male and female runner with knee pain to uncover compensatory patterns and gender-specific differences.

OBJECTIVE OF THE STUDY

The study mentioned compares the mechanics of arm swings between individuals who do not have any knee pain (asymptomatic) and those who experience pain in the front of their knee (symptomatic) while running. The objective is to determine if there are variations in arm swing between these groups and how these variations may be connected to the presence or absence of symptoms related to anterior knee pain. This study may offer valuable insights into the biomechanical patterns that could be used to develop injury prevention or rehabilitation strategies.

HYPOTHESIS OF THE STUDY

HYPOTHESIS OF THE STUDY

Null Hypothesis: There will be no meaningful variation in arm swing patterns between runners who experience knee pain and those who do not.

Alternative Hypothesis: There will be a meaningful variation in arm swing patterns between runners with knee pain and those without symptoms.

REVIEW OF LITERATURE

Review of literature

1.Ekta Kapri, Manju Mehta, and Kiran S. (2021) conducted a review to summarize the biomechanics of the running gait cycle. The article examined running gait characteristics, underlying anatomy of the upper and lower body, and the role of muscles and joints throughout the gait cycle. Motion characteristics such as position, velocity, acceleration, and force were explained through kinematic and kinetic perspectives. Methods of running gait analysis, including motion capture, force plate assessments, and electromyography, were discussed. The review concluded that understanding running biomechanics is essential for identifying performance factors and optimizing motor techniques. An important insight is the significance of integrating kinematic, kinetic, and EMG data to comprehensively evaluate running mechanics.

2.Boullosa et al. (2020) reviewed existing literature to examine the main factors influencing training and performance among recreational endurance runners. The authors explored aspects such as training periodization, methods, monitoring tools, performance prediction, running technique, and injury prevention. They concluded that although endurance running is highly popular, evidence-based recommendations for recreational athletes are limited due to differences from elite populations. The review emphasized the importance of individualized training, effective monitoring, and targeted injury management for optimizing recreational running performance.

3..McSweeney et al. (2021) reviewed the biomechanics of adolescent running with a focus on injury prevention and rehabilitation. They reported that overuse injuries, particularly bone stress injuries and tendinopathies, are common among young runners as global participation increases. Unlike adults, adolescents face unique challenges due to growth-related changes, yet most available evidence is derived from adult populations. The authors concluded that more age-specific research is required, and emphasized the importance of tailored preventive and rehabilitative strategies for adolescent runners.

4.

Pontzer et al. (2009) examined whether arm swing during walking and running is actively controlled by shoulder muscles or functions passively as a stabilizing mechanism. Ten healthy adults performed treadmill trials under normal, arms-crossed, and weighted-arm conditions while locomotor cost, deltoid activity, and kinematics were recorded. Results showed that arm swing minimized torso and head rotation without increasing energy expenditure, and deltoid activation patterns did not support active driving of the arms. The study concluded that arm swing primarily serves as a passive mass-damping mechanism, powered by lower body movement to aid stability.

5.Koo et al. (2025) examined the effects of active arm swing on torso stability and metabolic efficiency during running. They used full-body musculoskeletal simulations with 150 muscles to compare three arm conditions: active, passive, and fixed. The study found that active arm swing reduced torso rotation and overall energy expenditure, even though upper limb muscles consumed more energy. The authors concluded that arm swing plays an active role in stabilizing the upper body and enhancing running efficiency, highlighting its importance for performance improvement and rehabilitation strategies.

6.van Oeveren et al. (2021) synthesized the biomechanics of running to examine how commonly measured parameters relate to different running styles. They focused on spatiotemporal measures, ground reaction forces, and whole-body kinematics to understand body center of mass (BCoM) movement. The study concluded that running styles can be captured using just step frequency and duty factor, forming a Dual-axis framework that categorizes styles as ‘Stick,’ ‘Bounce,’ ‘Push,’ ‘Hop,’ and ‘Sit.’ This framework offers a practical approach for analyzing and interpreting running biomechanics.

7.Roush and Bay (2012) examined the prevalence of anterior knee pain (AKP) in women aged 18 to 35. A total of 724 participants completed the Anterior Knee Pain Questionnaire (AKPQ) to assess symptoms and functional limitations. The study reported prevalence rates of 12% in the left knee and 13% in the right knee, substantially lower than the commonly cited 25%. The authors concluded that AKP may be less frequent than previously assumed, providing a more accurate representation of young adult females. This highlights the importance of using empirical data to inform prevalence estimates and guide clinical understanding.

8.Zhang et al. (2020) conducted a systematic review to examine knee joint biomechanics under both healthy and pathological conditions, aiming to guide rehabilitation and the design of assistive devices. They reviewed 138 studies published between 2000 and 2019, focusing on normal knee movements during activities like walking, running, stair climbing, and sit-to-stand, as well as the biomechanical impact of musculoskeletal and neurological knee disorders. The authors concluded that knee pathologies can substantially alter joint mechanics and that current understanding of normal and diseased knee biomechanics is still limited. The study highlights the need for further research to improve rehabilitation protocols and optimize assistive technologies.

9.Hallam and Amorim (2021) investigated sex differences in running performance and how the performance gap between males and females has changed over time. They analyzed top 20 athlete performances across standard running distances over the past two decades, examining both absolute performance and competitive depth. The study found that although the sex gap narrowed during the 20th century, it has since stabilized, with larger differences seen among lower-ranked elite athletes. The authors concluded that physiological, biomechanical, sociocultural, and sport-specific factors contribute to these differences. An important insight is that improving equality in opportunities, support, and representation could help reduce the performance gap and allow females to reach their full potential.

10.Sinclair, Chockalingam, and Taylor (2022) examined lower limb biomechanics in runners with patellofemoral pain (PFP) compared to healthy controls, highlighting sex-related differences. Using musculoskeletal simulations, they analyzed 40 PFP runners (15 females, 25 males) and 40 controls (15 females, 25 males) running at self-selected speeds. The study found that PFP runners exhibited higher patellofemoral joint stress, altered foot strike patterns, increased rearfoot eversion, and greater contralateral pelvic drop, with female PFP runners showing greater peak hip adduction than males. The authors concluded that PFP is associated with distinct biomechanical patterns and that sex-specific differences should be considered in designing targeted interventions to reduce injury risk.

11.Dierks, Manal, Hamill, and Davis (2010) examined lower extremity kinematics in runners with patellofemoral pain (PFP) during a prolonged treadmill run. Twenty PFP runners and 20 healthy controls ran at self-selected paces while kinematic data were collected at the start and end of the run. The PFP group showed reduced peak knee flexion, hip adduction, eversion excursion, and joint velocities compared with controls, suggesting a strategy to limit movement and reduce pain. Kinematic variables increased toward the end of the run as pain intensified. The study identified three distinct PFP subgroups, each exhibiting unique movement patterns, indicating that multiple kinematic mechanisms may contribute to PFP. An important insight is that individualized assessment of running mechanics may be necessary for effective PFP management.

12.Neal et al. (2016) conducted a systematic review and meta-analysis to examine biomechanical factors and intervention effects in runners with patellofemoral pain (PFP). Analyzing 28 studies, they found that increased peak hip adduction, internal rotation, contralateral pelvic drop, and reduced hip flexion are associated with PFP, particularly in female runners, with some evidence also linking altered foot kinetics. Intervention studies indicated that running retraining and proximal strengthening improved pain and function, with running retraining specifically reducing peak hip adduction. The authors concluded that targeted interventions can modify maladaptive biomechanics, emphasizing the need for high-quality prospective studies to understand underlying mechanisms and enhance treatment strategies.

12.Xie, István, and Liang (2022) conducted a systematic review and meta-analysis to examine sex-specific differences in running biomechanics and their relation to the higher prevalence of patellofemoral disorders in female runners. Thirteen studies on lower limb mechanics in healthy runners were analyzed, focusing on dynamics, muscle activation, and kinematics. While no consistent differences were found in kinetic measures or muscle activation due to limited data, female runners demonstrated greater hip flexion, hip adduction, and hip internal rotation, along with reduced knee flexion compared to males. These kinematic differences may help explain the increased injury risk in female runners and provide guidance for individualized training and injury prevention programs.

13.Agresta, Ward, Wright, and Tucker (2017) examined the impact of restricting one arm on lower limb mechanics associated with injury risk during running. Fifteen healthy participants ran at self-selected speeds under three conditions: normal arm swing, one arm restrained, and both arms restrained. The study showed that unilateral arm restriction led to increased frontal plane knee and hip angles, reduced foot strike angle and vertical displacement of the center of mass, and changes in stride length and step frequency compared to normal or bilateral arm restriction. The authors concluded that running with one arm restrained produces distinct kinematic alterations that could increase the risk of knee injury, emphasizing the importance of arm swing for safe running mechanics.

14. Ferber, Davis, & Williams (2003) investigated sex-related differences in hip and knee biomechanics among recreational runners. Using gait analysis on 20 males and 20 females, they found that women displayed greater hip adduction, hip internal rotation, knee abduction, and increased hip negative work in the frontal and transverse planes compared to men. The findings suggest that female runners exhibit unique lower limb mechanics, which may contribute to their higher susceptibility to injuries, emphasizing the importance of considering gender in biomechanical assessments and injury prevention programs.

15.Hiruma & Kariyama (2023) aimed to examine sex differences in the influence of arm swing direction on ground reaction forces and trunk movements in track and field athletes. The study found that under longitudinal arm swing, females demonstrated greater trunk twist range of motion and lower mean acceleration force compared to males. The authors concluded that both arm swing direction and body shape should be considered in training and performance optimization.

16. Martinez-Cano et al. (2021) To examine the incidence and factors contributing to anterior knee pain in runners following a half-marathon race.Conclusion - Anterior knee pain was the most frequent new injury in the half-marathon runners after the competition. Spending more than 2 hours to finish the race and stretching the hamstrings by less than 70° in the supine position were risk factors for anterior knee pain. create rol over procedure

17. Pontzer et al. (2009) aimed to examine whether arm swing in walking and running is actively driven or passive. Ten healthy adults walked and ran on a treadmill under three conditions (normal, arms folded, arm weights), with locomotor cost, deltoid activity, and kinematics measured. Results showed that altering arm inertia affected trunk and pelvis rotation, while deltoid muscles contracted simultaneously rather than alternately, supporting the passive arm swing hypothesis. The study concluded that arms function as passive mass dampers reducing torso and head rotation, with upper body movement primarily powered by the lower body. Insights highlight that arm swing plays a stabilizing rather than propulsive role in locomotion.

18. Debertin, Wargel, & Mohr (2024) aimed to evaluate the reliability of Xsens IMU-based lower extremity joint angle measurements during running on stable and unstable surfaces. Seventeen recreational runners completed trials across five test days, and intraclass correlation coefficients (ICCs) and minimal detectable changes (MDCs) were calculated for ankle, knee, and hip joint angles. Results showed good-to-excellent within-day reliability (ICCs > 0.9) and generally lower between-day reliability, especially for ankle and hip angles in the frontal plane (ICCs 0.38–0.83). The type of running surface had minimal impact. The study concluded that Xsens is reliable for within-day assessments but should be used cautiously for longitudinal tracking of certain joint angles. Insight: Xsens offers strong short-term consistency, though variability in frontal plane measures limits its utility for long-term monitoring.

19. Yang, Best, Liu, & Yu (2022) aimed to investigate knee biomechanical factors associated with patellofemoral pain (PFP) in recreational runners. Fifteen male and fifteen female runners with PFP and thirty matched controls were tested during running; reflective markers and ground reaction force data were collected to analyze knee kinematics and kinetics under pain and pain-free conditions. Results showed that both male and female PFP runners exhibited increased peak knee valgus angles compared to controls, with a reduction in valgus when running with pain, suggesting a protective adaptation. Male PFP runners also displayed higher peak knee flexion angles, which remained unchanged with pain. No significant differences were found in knee joint moments. Conclusion: Elevated peak knee valgus is a key biomechanical factor linked to PFP, with valgus reduction serving as a symptom-mitigating adaptation, while increased knee flexion appears as a male-specific factor. Insight: Understanding sex-specific knee mechanics may guide targeted interventions to prevent or manage PFP in runners.

TABLES OF ROL

Ekta Kapri, Manju Mehta, et al.	2021	To provide a comprehensive summary of literature on running gait biomechanics.	Narrative review of gait types, posture, and anatomical influences during running.	Running biomechanics help explain differences in performance and identify factors linked to efficient movement.	Enhances understanding of gait and its role in optimizing running performance.
Daniel Boullosa, Jonathan Esteve-Lanao, et al.	2020	To highlight scientific evidence for endurance training in recreational runners.	Review of training approaches including periodization, monitoring, technique, and injury prevention.	Offers practical guidance for structuring training in recreational runners.	Encourages evidence-based training and injury-preven

					tion practices.
Simon C. McSweeney, Karin G. Silbernagel	2020	To examine epidemiology and causes of running-related injuries in adolescents.	Perspective review considering physiological changes during puberty.	Adolescent runners face injury risks due to ongoing physical development.	Prevention and rehabilitation must consider age-specific biomechanics.
Herman Pontzer, Daniel E. Lieberman	2009	To test whether arm swing is a passive stabilizer in running and walking.	Treadmill trials under control, arms-restricted, and weighted-arm conditions.	Findings support arm swing as a passive mechanism reducing torso rotation.	Arms serve as stabilizers powered by lower

					body motion , not active muscle drive.
Young-Jun Koo, Naomichi Ogihara, Seungbum Koo	2025	To assess if active arm swing reduces torso motion and energy use.	Biomechanical and metabolic testing during running.	Active arm swing improves stability and lowers energy demands.	Arm swing functions as an energy - saving mechanism.
Ben T. van Oeveren, Cornelis J. de Ruiter	2024	To classify running styles using spatiotemporal measures and COM trajectory.	Literature review and development of Dual-axis framework.	Five running styles were identified: Stick, Bounce, Push, Hop, and Sit.	Provides a frame work for studying efficie

					ncy, injury risk, and performance.
James R. Roush, R. Curtis Bay	2012	To estimate prevalence of anterior knee pain in young females.	Cross-sectional population-based study.	Prevalence was 12–13%, lower than commonly reported values.	Offers updated, more accurate prevalence data for anterior knee pain.
Li Zhang, Geng Liu, Bing Han, Zhe Wang	2021	To review knee biomechanics in healthy and diseased states.	Systematic review of kinematics and kinetics.	Diseased knees showed reduced mobility and	Supports rehabilitation strateg

				increased joint loading.	ies and device design for knee pathologies.
Lydia C. Hallam, Fabiano T. Amorim	2022	To analyze sex-based differences in running performance.	Review of physiological, psychological, and sociocultural factors.	Despite narrowing, performance differences between sexes persist.	Calls for multidisciplinary approaches to address sex gaps in running.
Jonathan Sinclair, Nachiappan Chockalingam	2022	To evaluate biomechanics of runners with patellofemoral pain (PFP).	Retrospective musculoskeletal simulation study.	PFP runners showed altered hip and knee mechanics.	Identifies sex-specific risk

					factors and guides rehabilitation.
Tracy A. Dierks, Kurt T. Manal, Joseph Hamill	2010	To study prolonged running kinematics in runners with PFP.	Biomechanical subgroup analysis.	Different PFP subgroups displayed distinct compensatory strategies.	Suggests individualized rehabilitation based on kinematic patterns.
Bradley S. Neal, Rosa Gallie	2016	To synthesize biomechanical evidence in PFP runners.	Systematic review and meta-analysis.	Increased hip adduction was a consistent risk factor.	Guides clinicians toward targeted

					interventions.
Ping-Ping Xie, Bíró István	2022	To compare male and female biomechanics in running.	Systematic review with meta-analysis.	Female runners exhibited greater hip adduction linked to higher injury risk.	Highlights need for sex-specific injury prevention programs.
Cristine Agresta, Christian R. Ward, et al.	2020	To investigate effects of unilateral arm swing restriction on running mechanics.	Treadmill experiments with restricted arm swing.	Restriction altered hip and knee mechanics and stride patterns.	Arm motion restrictions may elevate injury risk in athletes.

Ferber R. et al.	2003	To explore gender differences in running mechanics.	Experimental kinematic study.	Females showed greater hip adduction, knee abduction, and rotation than males.	Explains higher injury prevalence in female recreational runners.
Kosuke Hiruma, Yasushi Kariyama	2023	To analyze sex differences in arm swing direction and trunk mechanics.	Experimental study on track athletes.	Females showed greater trunk twist and lower mean acceleration forces.	Suggests body shape and swing style should be considered in training.

Juan Pablo Martinez-Cano, et al.	2021	To determine anterior knee pain incidence post half-marathon.	Observational study on race participants.	Anterior knee pain was the most common injury, linked to flexibility and race time.	Emphasizes injury prevention in endurance events.
Debertin D. et al.	2024	To assess reliability of Xsens IMU for joint angle measurement.	Reliability testing using ICC and MDC statistics.	High reliability within a single day, moderate between days.	Xsens is valid but variability should be considered in research.
Chen Yang, Thomas M. Best	2022	To examine knee biomechanics associated with PFP in	Biomechanical motion analysis.	Increased knee valgus and altered flexion linked to PFP.	Suggests rehabilitation targeti

		recreational runners.			ng knee alignment and mechanics.

METHODOLOGY

METHODOLOGY

Study design: Comparative Observational Study

Study population: Recreational Runners

Study setting: ABSMARI OPD

Sampling Design: Propulsive sampling

Sampling Criteria:

Inclusion: The inclusion criteria for this study were as follows: Participants were recreational runners aged 19-25 years.

The asymptomatic group included runners with no history of knee pain or lower extremity injuries in the past six months.

The symptomatic group comprised runners with self-reported or clinically diagnosed anterior knee pain that had persisted for at least three months.

These criteria ensured the selection of participants who were representative of the target population while accounting for their symptomatic or asymptomatic status.

Exclusion: The exclusion criteria for this study were as follows: Participants with a history of surgery or major injury to the lower extremities within the past year were excluded.

Additionally, individuals with neurological or musculoskeletal conditions that could affect gait or running biomechanics were not included.

The use of orthotic devices that significantly alter running mechanics was also a basis for exclusion.

Furthermore, runners involved in professional or elite-level competitive running were excluded to minimize biomechanical variability unrelated to the focus of the study.

Sample Size:45 calculated by using G POWER Software.

Duration: 6months

Materials to be used:

-Consent form

- Pen and Paper

Outcome Measures: Motion capture system

Outcome Measures:

MVN Awinda Xsens

Reliability - Stride time : n = 38; ICC = 0.92

Stride length : n = 38; ICC = 0.94

Stance time : n = 38; ICC = 0.85

Swing time : n = 38; ICC = 0.89

Instruments to be used for outcome measures

XSENS (MVN Awinda) - 3D motion tracking technology

3D motion tracking technology is a system that captures and analyzes the movement of objects or individuals in three-dimensional space using sensors and cameras. Reflective markers or motion sensors are placed on key body points, and multiple high-speed cameras record their movement from different angles. The data is then processed by specialized software to reconstruct the motion in 3D, providing detailed information on joint angles, limb movements, and other biomechanical parameters. This technology is widely used in fields such as sports biomechanics, rehabilitation, and ergonomics to study human movement and optimize performance or prevent injuries.

Treadmill- In this study, a treadmill is likely used as a controlled environment for participants to perform running tasks, allowing for precise monitoring of their biomechanics. The treadmill enables researchers to standardize the running speed and surface conditions, ensuring that all participants run under similar conditions. It also provides a safe, repeatable setting for capturing 3D motion data and other kinematic and kinetic measurements. By using the treadmill, the study can focus on the specific analysis of running mechanics, including arm swing and lower extremity movement, without the variability introduced by outdoor running conditions.

PROCEDURE

Ethical permission was sought from the institutional ethical committee. Sample selection was carried out following the inclusion and exclusion criteria after IEC clearance. Informed consent was obtained from all included participants.Participants were placed with the Xsens motion capture suit, which consisted of wireless sensors placed on major body parts (e.g., head, torso, arms). Sensors were properly positioned on limbs and joints to measure arm swing. The participants were quickly calibrated by having them stand in a T-pose (with arms stretched out) to adjust the sensors. Participants could warm up on the treadmill for 5 minutes to get to a comfortable, natural running speed. Participants were asked to run at a pace they could sustain for the remainder of the trial. Motion capture data was obtained for 5 minutes while the participants ran, with a focus on arm swing and lower body mechanics. Where needed, several trials were used to achieve consistent data collection in all subjects. Data was also gathered at varying speeds (comfortable pace and brisk pace) where needed.Rest between trials was given in sufficient amounts to avoid fatigue.Arm swing amplitude (range of motion) was measured. Symmetry between left and right arm was evaluated. Arm frequency of swing and coordination between lower body and arms were compared.. Knee joint angles, gait cycle, and any compensatory movement patterns in the lower limbs were recorded. In symptomatic runners, levels of knee pain were measured using a standardized pain scale (e.g., VAS) during and after running

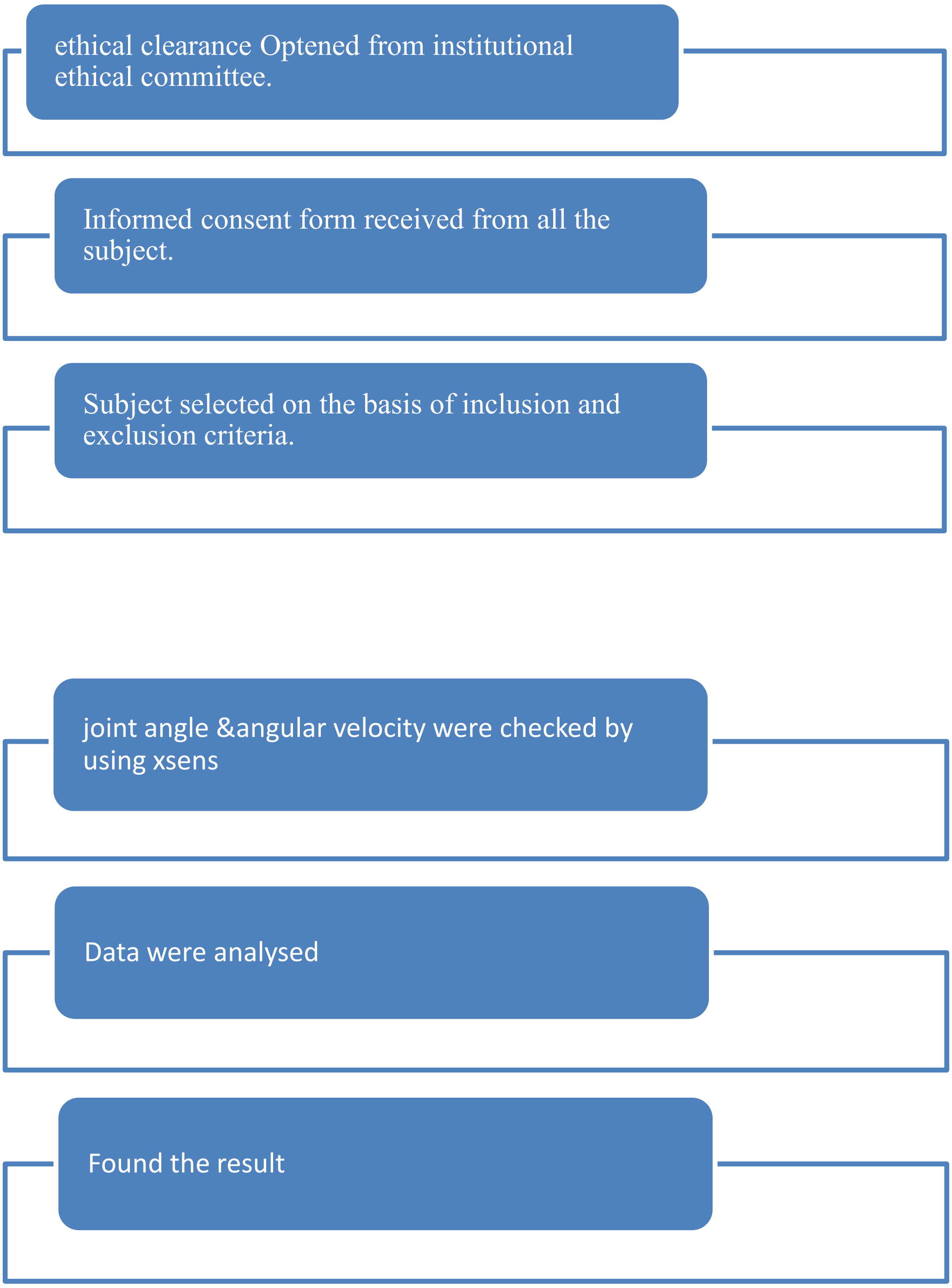

ethical clearance Optened from institutional ethical committee.
Informed consent form received from all the subject.
Subject selected on the basis of inclusion and exclusion criteria.
joint angle &angular velocity were checked by using xsens
Data were analysed
Found the result

Fig-1

Fig-2

Fig-3

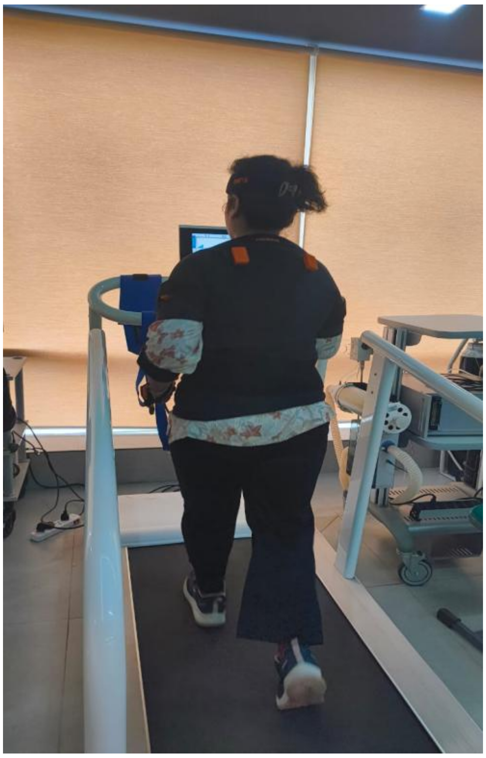


Fig-4

Fig-5

Fig-6

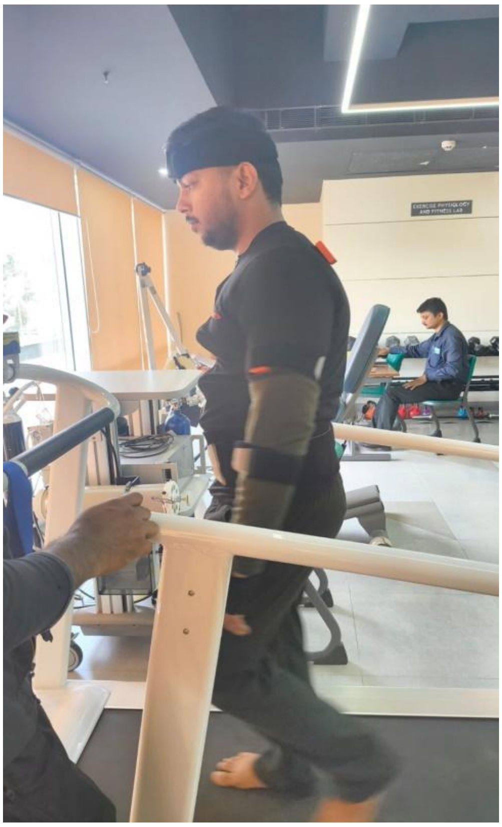


Fig-7


SHREEJAGANNATH HEALTH
ଶ୍ରୀଜଗନ୍ନାଥ ହେଲଥ
GYM-YOGA-ZUM
Mob :9778039

Fig-8

STATISTICAL ANALYSIS

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 27.0, with the level of significance set at $p < 0.05$. The Shapiro–Wilk test was applied to assess normality. Baseline demographic variables (such as age,Gender,BMI) did not follow a normal distribution ($p < 0.05$) and were presented as median and interquartile range (IQR). The outcome measures shoulder joint angle did not follow a normal distribution ($p < 0.05$) and results were presented as median and interquartile range (IQR). Within-group comparisons were performed using the Wilcoxon Signed-Rank test, and between-group comparisons were analysed for joint angle using the Mann–Whitney U test. A p-value < 0.05 was considered statistically significant. Angular velocity follow a normal distribution ($p>0.05$) and results were presented as mean and standard deviation.Within-group comparisions were performed using the dependent t-test and between group comparisions were analysed for joint angle using the independent t-test.

RESULTS

RESULTS

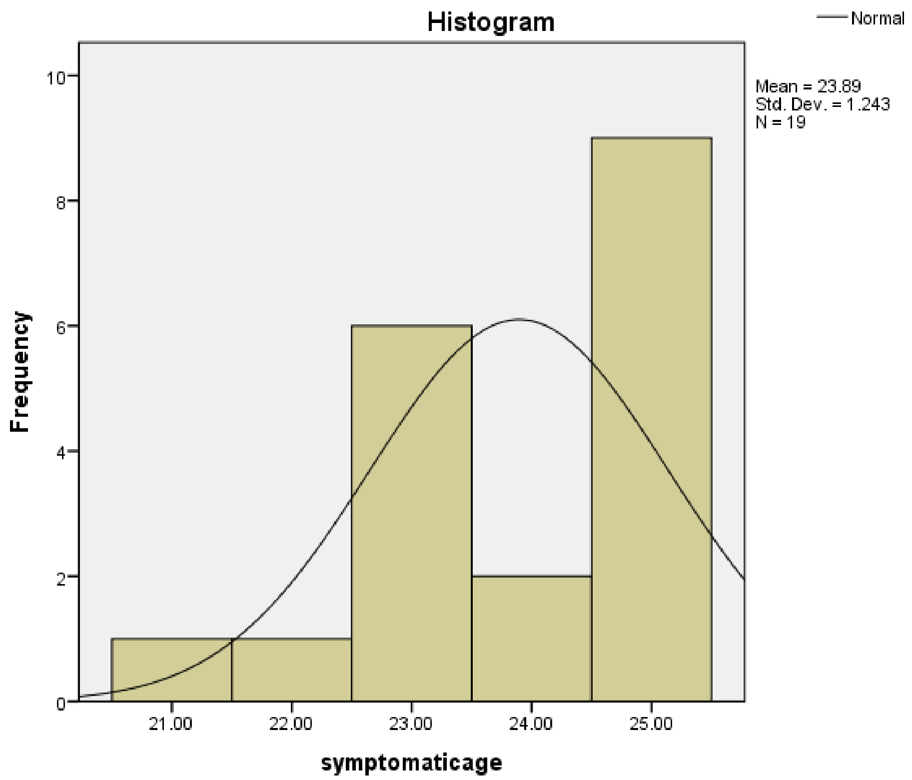
45 recreational runners (mean age 23.8 ± 1.47 years, range 19–25years) participated, with 19 classified as symptomatic and 26 as asymptomatic.Shoulder kinematics in the sagittal plane showed wide variability. The right shoulder angle averaged 11.8° ± 13.9 (−10.5° to 52.7°), and the left averaged 17.3° ± 13.7 (−2.1° to 50.6°). Symptomatic runners had slightly lower mean ranks than asymptomatic runners, but Mann–Whitney U tests found no significant group differences (right: $p = 0.168$; left: $p = 0.566$).Angular velocity was 67.7 ± 32.6 for the right arm and 74.8 ± 31.3 for the left, both with high inter-individual variation. Group means were similar (right: 66.9 ± 39.0 vs. 68.2 ± 28.0; left: 76.6 ± 35.2 vs. 73.5 ± 28.7), with no significant differences ($p > 0.05$).

Normality testing showed angular velocity was normally distributed, while BMI, shoulder angles, and demographics were not, informing test selection. Overall, anterior knee pain did not significantly affect shoulder kinematics, indicating arm swing remains stable in symptomatic runners.

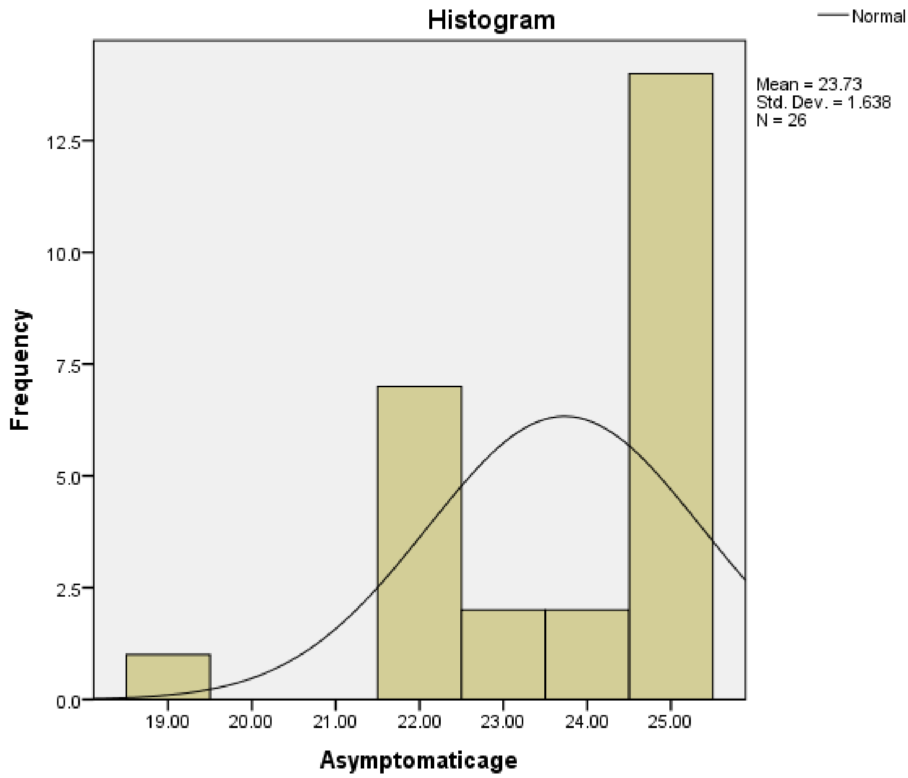
TEST OF NORMALITY

Variables	Symptomatic runner MEAN ±SD	Asyptomatic runner MEAN ±SD	p-value symptomatic	p-value asymptomatic
N	19	26	0.00(p<0.05)	0.00(p<0.05)
Age	23.89±1.24	23.73±1.63	0.000(P<0.05)	0.000(p<0.05)
Gender	1.57±0.507	1.50±0.509	0.223(p>0.05)	0.052(p>0.05)
BMI	25.06±2.78	24.96±3.51	0.288(p>0.05)	0.547(p>0.05)

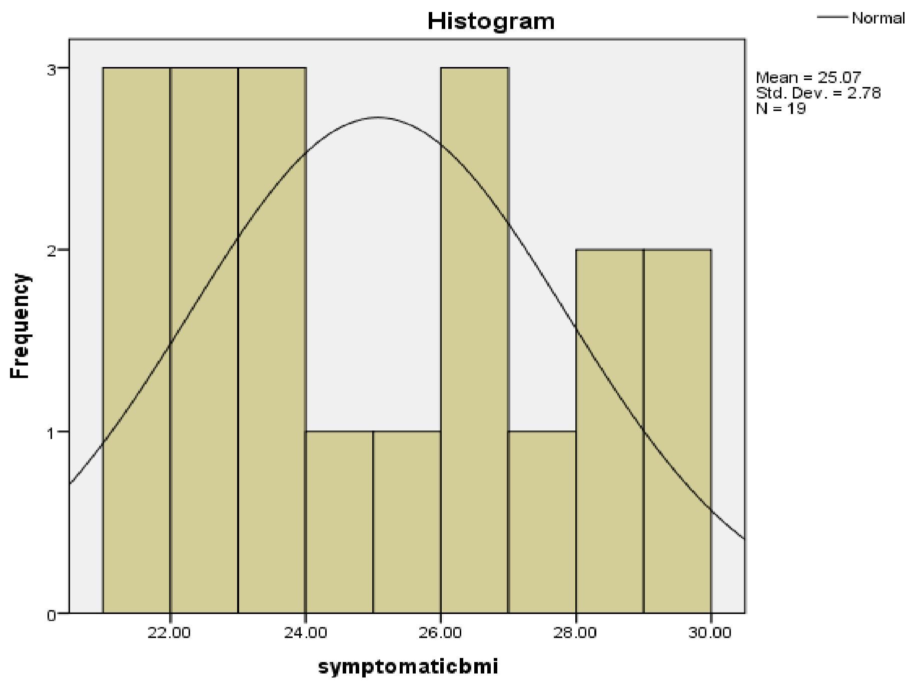
(TABLE-1)



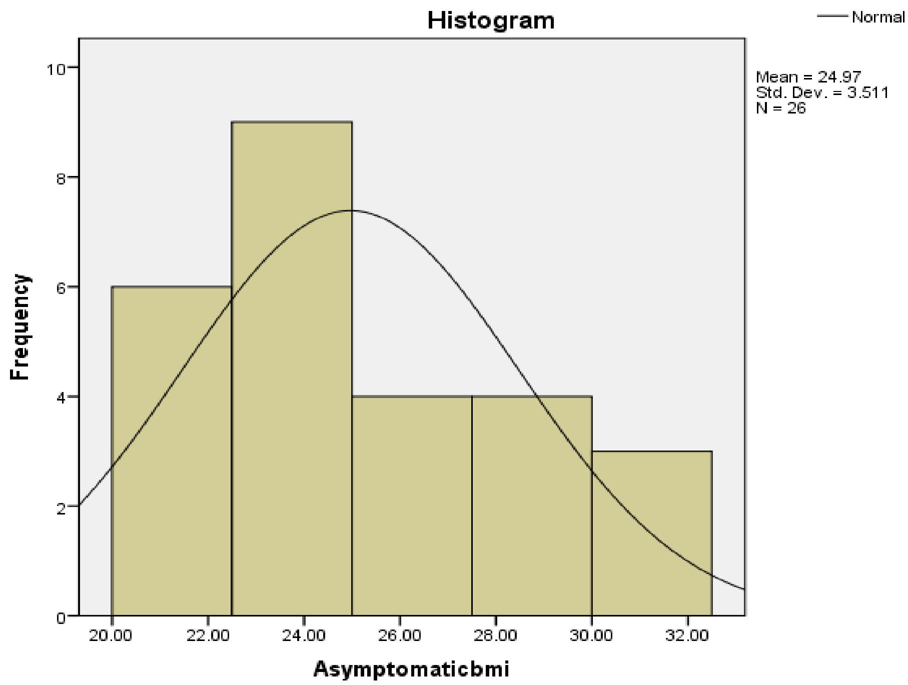
Graph-1 Normality plot of Symptomatic group age



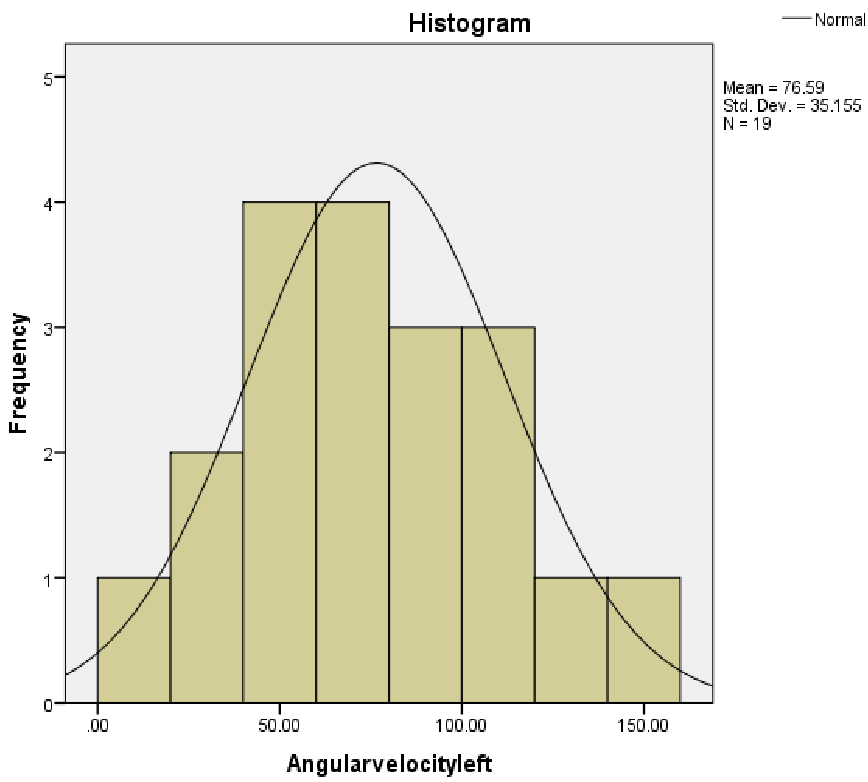
Graph-2 Normality plot of Asymptomatic group age



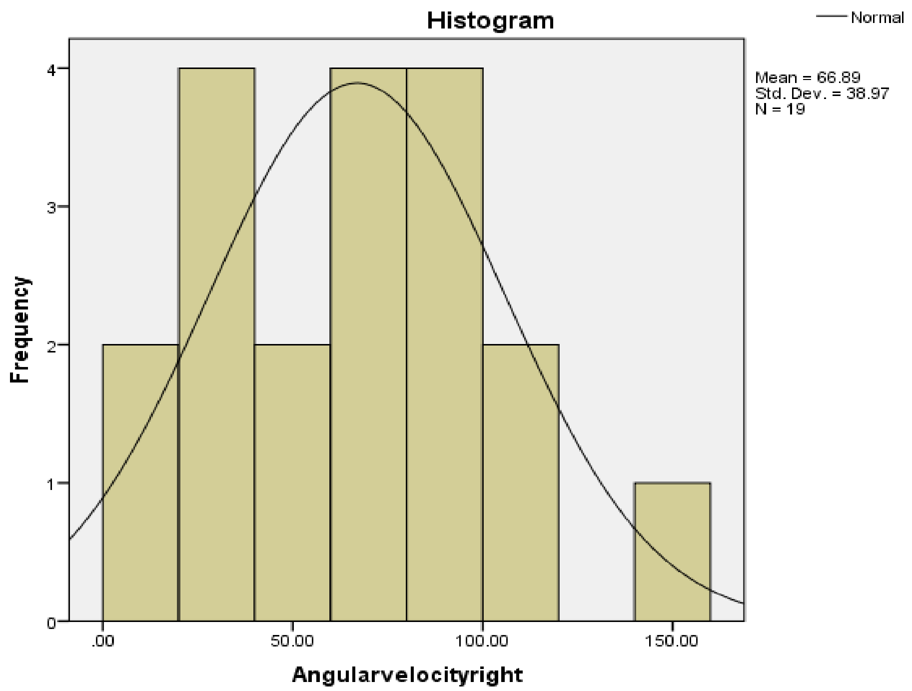
Graph-3 Normality plot of symptomatic group BMI



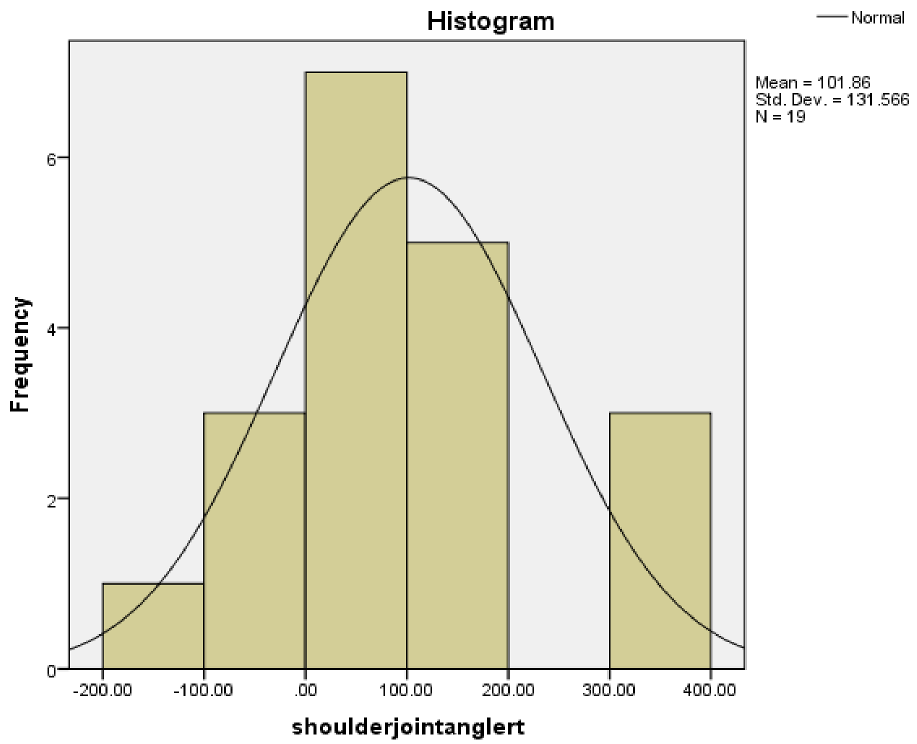
Graph-4 Normality plot of Asymptomatic group BMI



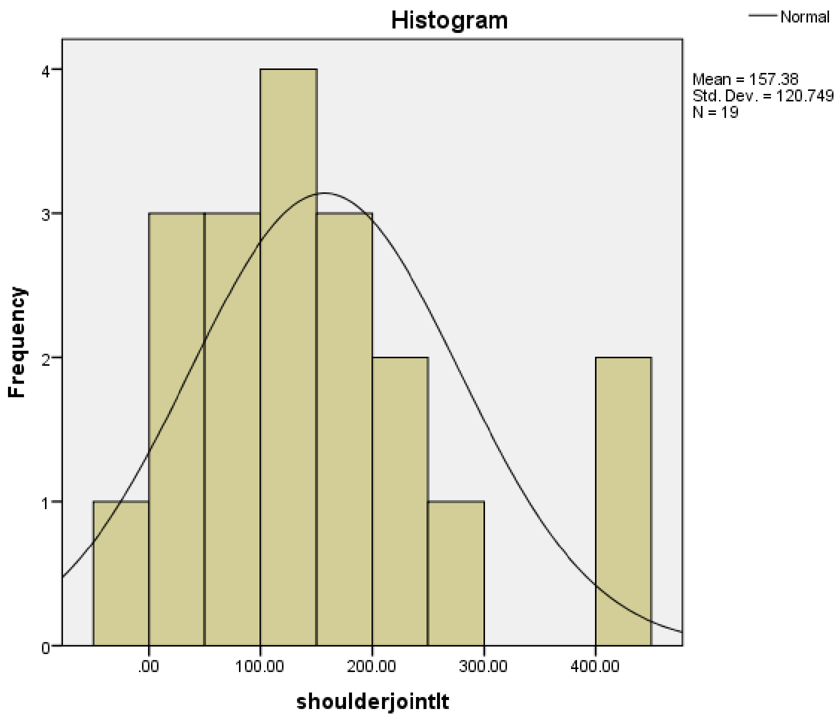
Graph-5 Normality plot of symptomatic group left side Angular velocity



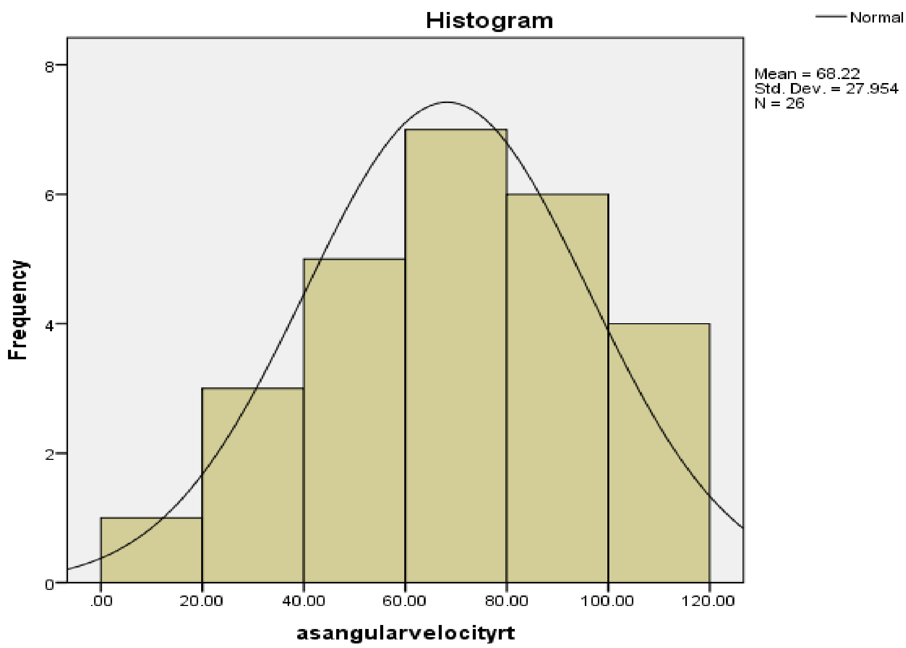
Graph-6 Normality plot of symptomatic group Right side Angular velocity



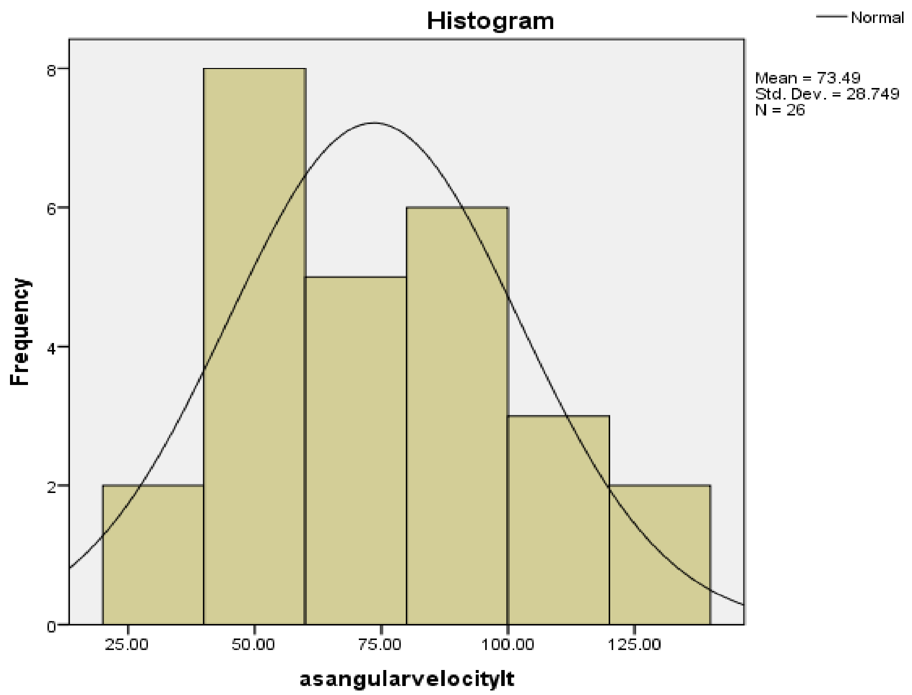
Graph-7 Normality plot of symptomatic group Right side Shoulder joint angle



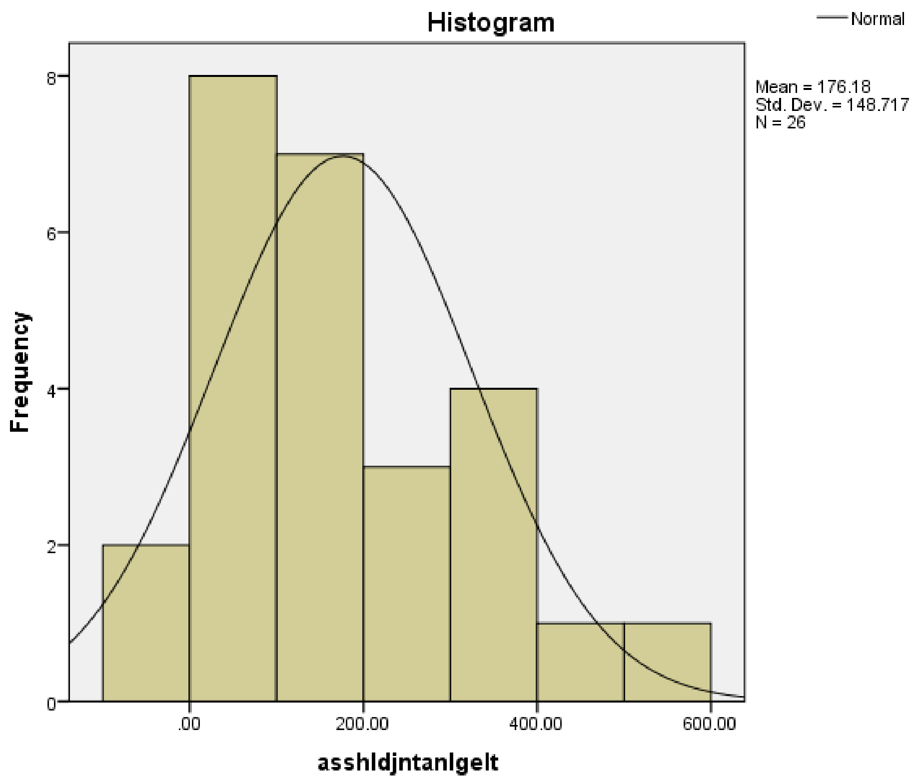
Graph-8 Normality plot of symptomatic group Left side Shoulder joint angle



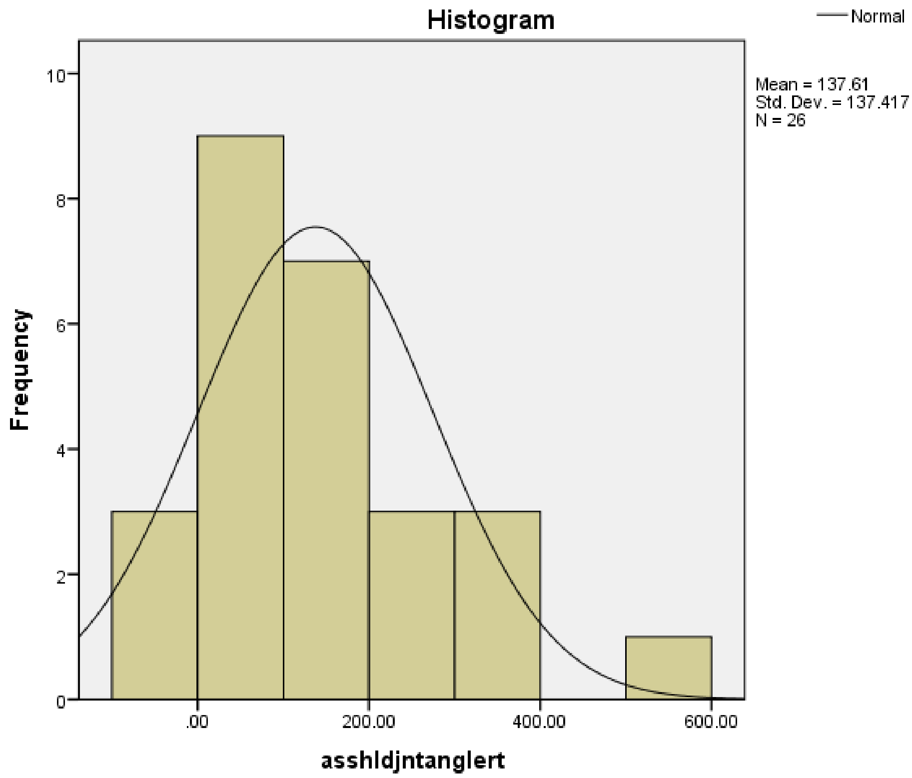
Graph-9 Normality plot of Asymptomatic group Angular velocity right side.



Graph-10 Normality plot of Asymptomatic group Angular velocity left side.



Graph-11 Normality plot of Asymptomatic group shoulder angle left side.



Graph-12 Normality plot of Asymptomatic group shoulder angle right side.

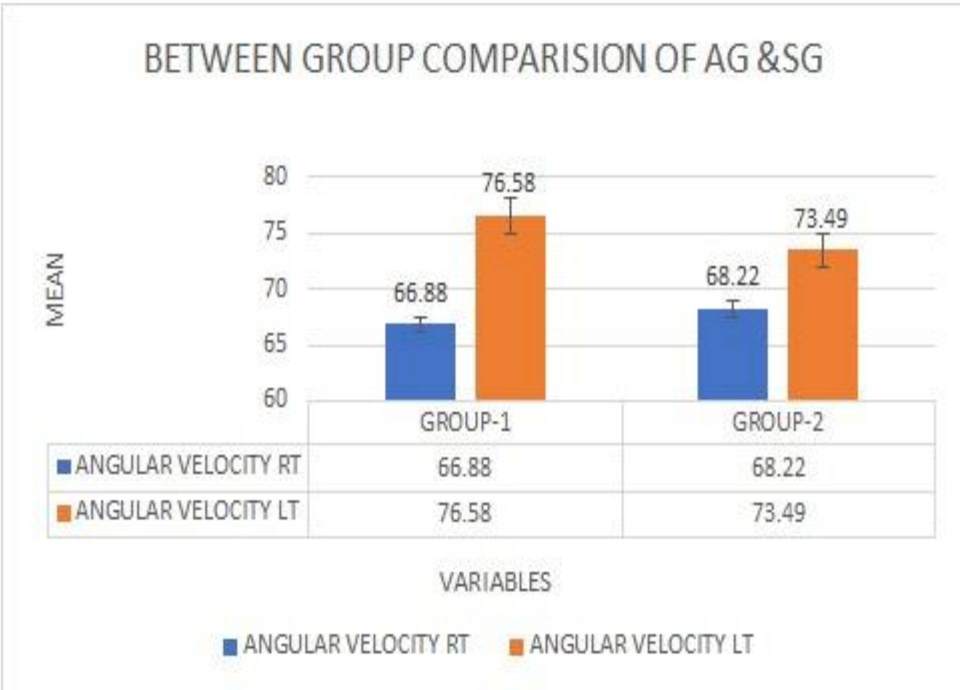
DESCRIPTIVE STATISTICS

DESCRIPTIVE STATISTICS		
variables	mean± SD	p-Value
ANGULAR VELOCITY RIGHT	67.65±32.64	.253
ANGULAR VELOCITY LEFT	74.79±31.26	.395
SHOULDER ANGLE RIGHT	11.83±13.92	.009
SHOULDER ANGLE LEFT	17.30±13.73	.025

(TABLE-2)

PARAMETRIC TEST			
BETWEEN GROUP			
VARIABLES	GROUP-1 mean± SD	GROUP-2 mean± SD	P-VALUE
ANGULAR VELOCITY RIGHT	66.88±38.96	68.22±27.95	.894
ANGULAR VELOCITY LEFT	76.58±35.15	73.49±28.74	.747

(TABLE-3)


BETWEEN GROUP COMPARISION OF AG &SG
MEAN
80
75
70
65
60
76.58
73.49
66.88
68.22
GROUP-1
GROUP-2
ANGULAR VELOCITY RT
ANGULAR VELOCITY LT
66.88
68.22
76.58
73.49
VARIABLES
ANGULAR VELOCITY RT
ANGULAR VELOCITY LT

Graph-13

NON-PARAMETRIC TEST			
BETWEEN GROUP			
VARIABLES	GROUP-1 MEAN RANK	GROUP-2 MEAN RANK	P-VALUE
SHOULDER ANGLE RT	19.84	25.31	.168
SHOULDER ANGLE LEFT	21.68	23.96	.566

Table-4

Graph-14

DISCUSSION

DISCUSSION

This study set out to investigate whether anterior knee pain influences the mechanics of arm swing in recreational runners, with particular focus on angular velocity and shoulder angles. Much of the existing research on anterior knee pain has primarily concentrated on the lower limbs, emphasizing altered knee alignment, hip muscle weakness, and abnormal patellofemoral joint loading. Far fewer studies have explored whether lower limb discomfort or dysfunction might extend its impact to the upper body, particularly the way the arms contribute to running. By examining this relationship, the current study introduced a novel perspective, aiming to connect knee-related pathology with potential changes in arm swing and thereby broadening the understanding of running as a coordinated, whole-body activity rather than a movement driven only by the legs.

The results demonstrated that there were no statistically significant differences in angular velocity or shoulder angles between symptomatic and asymptomatic runners. Participants with anterior knee pain exhibited arm swing patterns that were nearly identical to those without symptoms. Physiologically, this outcome is understandable. Arm swing plays a crucial role in locomotion by maintaining balance, counteracting rotational forces from the legs, and optimizing running efficiency. Because these roles are fundamental, they appear to be preserved even in the presence of knee pain. While adaptations to anterior knee pain often occur at the hip, knee, or ankle joints, the upper limbs appear to remain stable, ensuring that gait efficiency is maintained. This consistency suggests that arm swing is a deeply ingrained element of running mechanics and less prone to alteration by localized injury.

While these findings provide useful insights, some limitations must be considered. First, the study involved a relatively small sample of 45 runners, which may limit generalizability and reduce statistical power. A larger sample might have allowed for subgroup comparisons, such as differences between male and female runners or across varying experience levels. Second, only recreational runners were studied, so the findings may not apply to elite or highly trained athletes, whose biomechanics and compensatory adaptations could differ. Third, the variables examined were limited to angular velocity and shoulder angle, which, although informative, may not fully capture the complexity of upper body coordination, trunk involvement, or muscle activation. Finally, the cross-sectional design provided only a snapshot in time, preventing any conclusions about how arm swing may change with symptom progression or rehabilitation.

Future research should seek to address these limitations by including larger and more diverse populations across age, gender, and competitive levels. Employing more advanced biomechanical tools such as three-dimensional motion capture, electromyography (EMG), and wearable sensors could reveal subtle compensatory strategies that are not evident with simpler measures. Longitudinal research would also be beneficial in determining how arm swing patterns may evolve over time, either as symptoms worsen, resolve, or respond to rehabilitation. Moreover, studies that evaluate the interaction between arm swing, trunk rotation, and lower limb mechanics could provide a more holistic view of running biomechanics. Such work could ultimately support the development of comprehensive rehabilitation strategies that target the entire kinetic chain instead of focusing exclusively on the knee.

In summary, this observational study showed that anterior knee pain does not significantly influence arm swing mechanics in recreational runners. Both symptomatic and asymptomatic individuals demonstrated comparable angular velocities and shoulder angles, suggesting that upper limb movement remains a consistent and stable component of running despite the presence of knee pain. These findings add a new dimension to current knowledge, highlighting that while anterior knee pain affects lower extremity function, upper limb mechanics remain largely unchanged. Clinically, this emphasizes the importance of focusing rehabilitation on the hip, knee, and ankle, while recognizing that arm swing does not typically require direct intervention. Overall, this study contributes to a broader understanding of running biomechanics and lays the foundation for future work exploring how arms, trunk, and legs work together to maintain efficient and coordinated movement in the presence of injury.

CONCLUSION

CONCLUSION

This study explored an underexamined aspect of running biomechanics by analyzing the effect of anterior knee pain on arm swing patterns in recreational runners. While previous research has largely concentrated on lower limb mechanics, this work investigated whether pain in the knee could influence upper limb kinematics, specifically angular velocity and shoulder motion.

The findings indicate no significant differences in angular velocity or shoulder angle asymmetry between runners with and without anterior knee pain. This suggests that arm swing remains largely unaffected by the presence of pain, even though compensatory strategies may still occur in other unmeasured aspects such as movement patterns or range of motion. Overall, despite potential adaptations in multi-joint coordination to preserve lower limb function, arm swing appears to be stable in recreational runners regardless of knee pain.

LIMITATION AND RECOMMENDATIONS FOR FUTURE STUDY

LIMITATION

The first limitation of this study is its observational design, which restricts the ability to determine a direct cause-and-effect relationship between anterior knee pain and arm swing alterations. The second limitation arises from the use of controlled or laboratory-based settings, as these conditions may not fully capture the natural biomechanics of running in real-world environments. Finally, the relatively small and uneven sample size reduces the generalizability of the findings, making it difficult to apply the results to the broader population of recreational runners.

RECOMMENDATIONS FOR FUTURE STUDY

This study provides an initial understanding of how anterior knee pain may affect arm swing in recreational runners, but there are several areas that need further exploration:

- **Future Scope 1:** Studies with larger and more diverse groups of runners—covering different ages, training levels, and experience—

would make the findings more widely applicable and allow comparisons between subgroups, such as younger versus older runners or recreational versus competitive athletes.

- **Future Scope 2:** Using more advanced tools, like 3D gait analysis, electromyography (EMG), or wearable sensors, could give a clearer picture of how muscles, trunk, and arms work together, and reveal subtle compensations that basic measurements might miss.
- **Future Scope 3:** Research conducted over longer periods would help show whether arm swing changes over time due to knee pain or following rehabilitation. Studying arm swing alongside trunk rotation, elbow, and leg mechanics could provide a more complete understanding of running movement and help guide better rehabilitation approaches.

SUMMARY

SUMMARY

This study investigated the relationship between anterior knee pain and arm swing mechanics in recreational runners. Most studies into runner biomechanics have examined lower limb mechanics, and therefore, a unique approach of examining upper limb kinematics (e.g., angular velocity, shoulder angles) was applied to determine if knee pain influences these variables.

The sample included 45 runners (19 with anterior knee pain, n=19 and 26 with no symptoms, n=26) and demographics (age and body mass index) were taken, as well as variables associated with upper limb motion. Statistically, there were no significant differences between the groups for either angular velocity or shoulder angle. Additionally, symptomatic and asymptomatic runners displayed similar arm swing patterns, indicating symptoms in the knee did not substantially change upper limb mechanics while running. As a result, compensatory mechanisms in response to anterior knee pain may more likely occur in the lower limbs and not impact the arms. This study builds a further understanding of running biomechanics, and sets a basis for future work examining multi-segmental coordination and rehabilitation in response to individuals with anterior knee injury.

STATEMENT OF FUNDING

STATEMENT OF FUNDING

No outside funding was reported associated with the work featured in this thesis.

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ANNEXURES

ANNEXURES-1 INFORMED CONSENT

INFORMED CONSENT

Study Title: Analysis of arm swing in Asymptomatic and Symptomatic Male and Female Recreational runners with Anterior knee pain – An observational study

Study Number: ABS-IEC-2025-PHY- 066

Subject 's Name: ________________ Subject 's Initials:

Date of Birth / Age:

Address of the Subject

Qualification ________________________

Occupation: Student/Self-Employed/ Service/Housewife/Others (Please tick as appropriate)

Annual Income of the subject ____if applicable Name and address of the nominee(s) and his relation to the subject

_________________________(for the purpose of compensation in case of trial related death).]

(i) I confirm that I have read and understood the information sheet dated ________for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

(iii) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s)

(iv) I agree to take part in the above study

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:

____

Date: ______/ ____/

Signatory 's Name:

Signature of the Investigator:

ANNEXURES-2 ETHICAL CLEARANCE

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

ABSMARI

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/193

Date: 21/05/2025

APPROVAL LETTER
APPENDIX- VIII

MEMBERS

Dr. Smaraki Mohanty Clinician
Dr. Satyajit Mohanty Scientific Member
Mr. Shib Shankar Mohanty Legal Expert
Ms. Annie Hans Social Scientist
Ms. Subhashree Samal Lay Person
Mr. Deepak Ku. Pradhan Scientific Member

IEC-SECRETARIAT
Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

To,

ROJALIN HUSNEARA
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: **Analysis of Arm swing in Asymptomatic and Symptomatic Male and Female Recreational runners with Anterior knee pain-an observational study.**

Protocol ID.: ABS-IEC-2025-PHY-066

Subject: Approval for the conduct of the above referenced study

Dear Mr./**Ms.**/Dr **Rojalin Husneara**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 25/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	25/04/2025
2	Informed Consent Form	25/04/2025
3	Undertaking form PI	25/04/2025
4	CRF	25/04/2025
5	COI from the Investigators	25/04/2025

The following members were present at meeting held on 25-04-2025

ABSMARI ETHICS COMMITTEE BHUBANESWAR Dt. 21/05/25

1

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ANNEXURES-3 ASSESSMENT PROFERMA

Recreational Runner Assessment Form

SECTION A: GENERAL INFORMATION

NAME: ______________________________

AGE: ________ GENDER: ☐ MALE ☐ FEMALE ☐ OTHER

HEIGHT: ________ CM WEIGHT: ________ KG

BODY MASS INDEX (BMI): ________

OCCUPATION: ______________________________

CONTACT: ______________________________

SECTION B: RUNNING HISTORY

1. RUNNING EXPERIENCE: ☐ <1 YEAR ☐ 1–3 YEARS ☐ >3 YEARS
2. AVERAGE WEEKLY RUNNING DISTANCE: ☐ <10 KM ☐ 10–30 KM ☐ >30 KM
3. FREQUENCY: ☐ 1–2 DAYS/WEEK ☐ 3–4 DAYS/WEEK ☐ 5–7 DAYS/WEEK
4. TYPICAL RUNNING SURFACE: ☐ ROAD ☐ TRAIL ☐ TRACK ☐ TREADMILL
5. FOOTWEAR PREFERENCE: ☐ NEUTRAL ☐ STABILITY ☐ MINIMALIST ☐ OTHER ________
6. COMPETITIVE PARTICIPATION: ☐ NONE ☐ RECREATIONAL EVENTS ☐ COMPETITIVE RACES

SECTION C: INJURY / PAIN PROFILE

1. HISTORY OF ANTERIOR KNEE PAIN: ☐ YES ☐ NO
   - IF YES:
     - DURATION: ________
     - ONSET: ☐ SUDDEN ☐ GRADUAL
     - SIDE AFFECTED: ☐ RIGHT ☐ LEFT ☐ BOTH
     - PAIN INTENSITY (VAS 0–10): ________
     - AGGRAVATING FACTORS: ☐ RUNNING ☐ STAIRS ☐ SQUATTING ☐ SITTING LONG PERIODS
     - RELIEVING FACTORS: ______________________________
2. PREVIOUS LOWER LIMB INJURIES: ☐ YES ☐ NO (SPECIFY: ____________________)

Section D: Biomechanical / Physical Examination

Posture & Alignment: ☐ Normal ☐ Altered (describe: ____________)

Lower Limb Strength (Manual Muscle Test):

- Hip abductors: ☐ Normal ☐ Weak
- Quadriceps: ☐ Normal ☐ Weak
- Hamstrings: ☐ Normal ☐ Weak

Flexibility: ☐ Adequate ☐ Restricted (specify: ___________)

Functional Tests:

- Single-leg squat: ☐ Normal ☐ Knee valgus observed ☐ Painful
- Step-down test: ☐ Normal ☐ Abnormal ☐ Painful

Arm Swing Observation:

- Right side angular velocity: _________
- Left side angular velocity: _________
- Shoulder angles: Right _______° | Left _______°
- Symmetry: ☐ Symmetrical ☐ Asymmetrical

Section E: Training Load & Lifestyle

Warm-up routine: ☐ Yes ☐ No

Strength training: ☐ Yes ☐ No

Cross-training (cycling, swimming, gym): ☐ Yes ☐ No

Sleep per night: ☐ <6 hrs ☐ 6–8 hrs ☐ >8 hrs

Stress level: ☐ Low ☐ Moderate ☐ High

Section F: Outcome Measures

Pain Scale (VAS): 0–10 _________

Functional Score (e.g., Kujala Anterior Knee Pain Scale): _________

Gait Observation Notes: ____________________________

ANNEXURES-4 MASTER CHART

AGE	GENDER	BMI	ANGULAR VELOCITY (RIGHT) X	Y	Z	ANGULAR VELOCITY(LEFT) X	Y	Z	RIGHT SHOULDER	LEFT SHOULDER	RIGHT	LEFT
25	M	23.9	59.02	86.76	50.98	54.21	89.73	38	329.008	339.047	33.26	33.9
22	M	23.1	59.34	41.83	51.83	54.91	41.92	28.57	137.87	69.159	13.78	6.91
25	M	20.4	56.81	103.62	31.1	49.13	94.042	30.61	135.64	21.461	13.56	2.14
24	M	31.2	39.76	77.71	27.06	24.92	88.41	39.48	53.468	188.866	5.36	18.88
25	M	26.8	201.04	63.79	81.814	159.92	44.49	33.55	19.62	15.97	1.962	1.59
19	M	27	38.32	40.02	32.35	34.19	46.62	30.24	-28.63	21.15	-2.863	2.115
25	M	22.5	41.14	86.87	46.16	36.56	61.5	34.05	257.58	363.75	25.75	36.37
22	M	23.9	82.91	54.15	32.67	12.7	48.26	26.22	-31.211	93.348	-3.121	9.334
25	M	22	80.33	73.89	44.5	99.24	49.54	56.23	52.092	-21.044	5.209	-2.104
23	M	23.4	29.52	19.6	18.08	82.113	70.78	41.56	6.3	177.966	6.3	17.79
22	M	22.7	91.6	66.92	47.033	48.12	95.35	48.39	91.876	172.61	9.187	17.26
22	M	28.7	73.64	32.14	27.43	14.78	40.259	24.07	-7.655	2.9742	-0.76	0.297
25	M	32	92.53	108.74	28.18	127.95	82.5	44.6	59.129	135.27	5.912	13.52
25	F	27.6	93.7	82.32	69.54	36.77	116.03	43.97	19.472	87.4437	1.947	30.57
25	F	22	50.35	113.77	95.99	70.16	76.21	57.75	48.309	99.151	4.83	9.91
23	F	22.9	37.13	91.21	71.04	58.36	90.37	58.68	526.87	-15.236	52.68	-1.52
25	F	20	55.31	86.72	68.77	72.47	69.86	44.57	274.61	338.08	27.76	33.8
22	F	21	10.94	40.88	28.13	16.41	39.19	26.47	115.67	142.63	11.56	14.21
25	F	28	79.93	27.61	39.94	118.79	45.99	91.83	146.79	164.49	14.679	16.44
25	F	22	63.12	41.33	45.85	79.73	51.58	38.68	318.3	246.94	31.83	24.69
25	F	32.4	68.83	85.71	62.08	69.05	114.39	67.83	191.77	208.32	19.17	20.83
24	F	28.2	52.26	61.6	55.45	53.61	102.089	78.9	322.036	506.06	32.2	50.6
22	F	23.6	82.11	119.7	71.46	40.43	124.47	60.53	131.86	145.65	13.18	14.56
25	F	25.4	46.41	71.05	54.02	44.56	126.45	91.086	266.29	482.024	26.62	48.2
25	F	25.2	25.25	34.63	30.3	12.78	31.96	32.34	38.73	220.23	3.87	22.02
22	F	23.2	55.28	61.19	65.95	55.02	68.81	40.32	102.16	374.45	10.21	37.44

AGE	GENDER	angular velocity(RIGHT) X	Y	Z	ANGULAR VELOCITY (LEFT) X	Y	Z	RIGHT SHOULDER	LEFT SHOLDER	BMI	RIGHT	LEFT
23	M	31.9	15.12	19	87.59	57.19	43	37.362	82.441	21.8	3.7	8.24
25	F	55.198	20.811	29.392	87.0954	58.852	29.621	-4.6602	-0.02725	21.2	-4.6	-0.027
22	F	64.26	110.34	65.7	88.31	102.63	54.46	130.137	177.155	23.8	13.01	17.71
25	F	88.33	150.62	209.12	113.61	158.57	193.03	376.933	411.79	23.8	37.69	41.17
25	M	40.89	66.36	31.31	31.97	74.72	31.9	79.81	189.74	29.4	7.981	18.97
24	F	120.35	79.58	95.94	60.62	74.57	77.087	304.65	424.23	26	30.46	42.42
21	M	67.88	33.93	35.78	49.78	19.97	42.5	-1.732	14.7654	23.7	-0.173	1.476
25	F	60.91	117.05	62.4	40.28	125.87	63.81	95.453	168.327	28.8	9.54	16.83
25	F	43.42	54.56	68.62	42.66	45.81	43.38	52.927	112.216	22.8	5.29	11.22
23	F	50.02	94.65	31.18	29.34	94.3	34.24	104.5	41.6	26	-10.45	4.16
25	M	52.8	90.39	43.57	38.88	106.63	35.5	124.58	96.188	27	12.45	9.61
25	M	29.51	77.92	36.03	44.69	75.77	42.45	-5.759	141.8	22.5	-0.575	14.18
24	M	63.13	82.62	45.9	65.15	94.37	28.82	24.852	134.34	22.3	2.48	13.43
25	M	21.57	25.6	18.41	49.77	86.99	39.98	37.177	93.05	29.8	3.717	9.305
25	M	32.61	78.79	27.59	27.02	63.95	24.74	120.85	244.41	28.7	12.08	24.44
23	F	83.24	94.5	83.02	58.28	51.92	34.6	-101.81	23.58	21.6	-10.18	2.358
23	F	51.006	41.88	32.68	62.79	34.44	40.13	3.3043	113.8	26.8	0.33	11.31
23	F	53.16	21.43	39.38	131.61	25.07	62.82	398.253	288.059	24.8	39.82	28.8
23	F	7.802	14.69	11.88	38.61	103.55	42.33	158.44	232.68	25.5	15.84	23.26

ANNEXURES-5

Rojalin Husneara

Analysis of Arm swing in Asymptomatic and Symptomatic Male and Female Recreational runners with Anterior knee pain-an o...

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Rojalin Husneara

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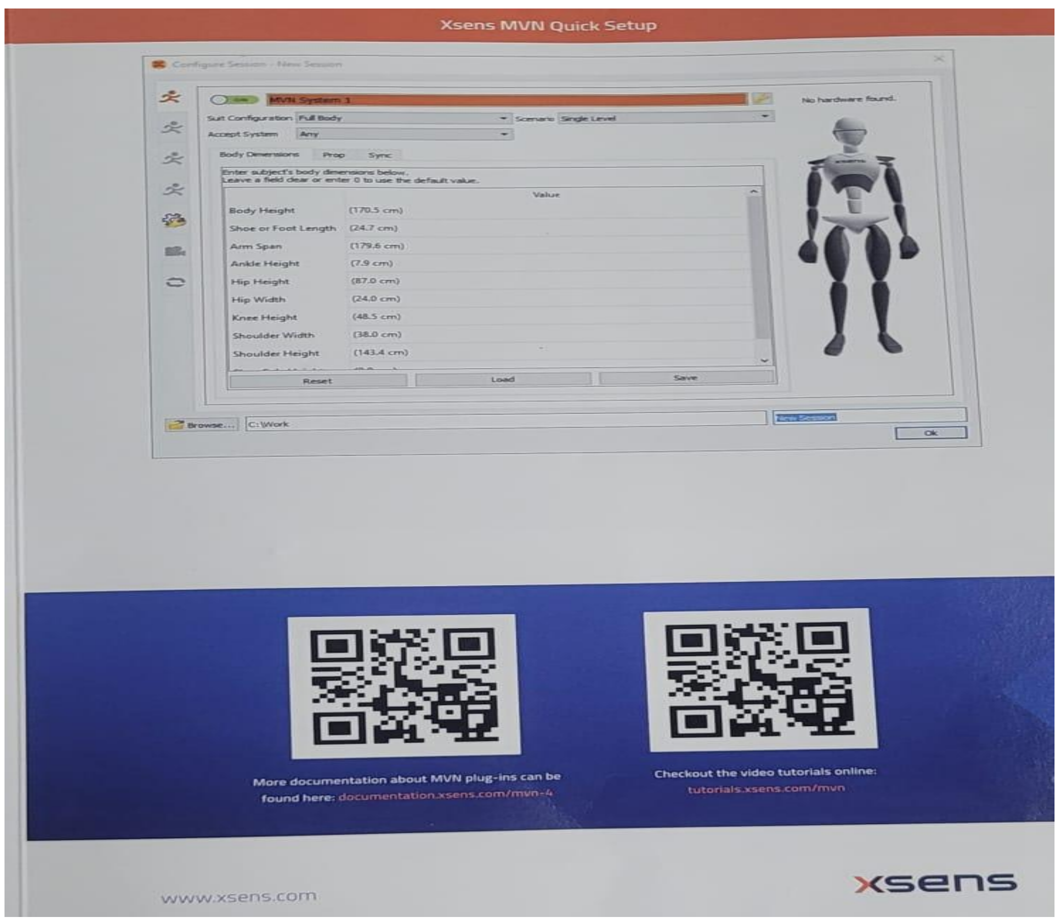
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Prop
Sync
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Leave a field clear or enter 0 to use the default value.
Value
Body Height (170.5 cm)
Shoe or Foot Length (24.7 cm)
Arm Span (179.6 cm)
Ankle Height (7.9 cm)
Hip Height (87.0 cm)
Hip Width (24.0 cm)
Knee Height (48.5 cm)
Shoulder Width (38.0 cm)
Shoulder Height (143.4 cm)
Reset
Load
Save
Browse...
C:\Work
New Session
Ok
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