International Journal of Physical Education, Sports and Health 2019; 6(2): 21-25

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2019; 6(2): 21-25

www.kheljournal.com
Received: 16-01-2019
Accepted: 20-02-2019

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Prevalence of hyperpronation of ankle and foot complex in sportspersons having a history of ACL injury with significance to Q-angle

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Abstract
Introduction: 60% - 80% of ACL injuries occur in non-contact sports. ACL injuries are more in age group 18 to 35 years. Typically, in persons with history of ACL injury, there will be uncontrolled internal rotation of tibia leading to hyperpronation at the ankle and foot complex along with changes in Q-angle.
Need of study: To determine the prevalence of hyperpronation of ankle and foot complex in sportspersons having a history of ACL injury with significance to Q-angle. As a result of ACL injury, there is weakness of vastus medialis oblique muscle which directly leads to alterations in Q-angle and lateral shift of patella along with tightness in lateral retinaculum.
Methodology: Convenient sampling of 42 sportspersons with ACL injury. Dorsal arch height was measured in both weight bearing positions using a foot platform and Q angle measured with help of goniometer.
Statistical analysis: Dorsal arch height and Q-Angle measurements were tabulated to know about the distribution and later the significance was analyzed by using percentage, frequency and chi-square test. SPSS-16 was used for analyzing collected data.
Conclusion: This study emphasises that hyperpronation of ankle and foot complex has to be taken into concern in clinical perspective as it is been related to sportspersons having a history of ACL injury which further results in an altered Q-angle.

Keywords: anterior cruciate ligament, q angle, dorsal arch height, hyperpronated foot

1. Introduction
ACL is the ligament prone to serious injuries in sportspersons especially in sports like basketball, football and in athletics (runners). 60% - 80% of ACL injuries occur in non-contact sports [1]. ACL injuries are more in age group 18 to 35 years.
Anterior Cruciate Ligament (ACL) originates from the anterior part of intercondylar area of tibia, running upwards, backwards and laterally to get attached on the posterior part of the medial surface of lateral condyle of femur [2]. It consists of three distinct bundles that prevent anterior displacement of tibia on the femur, knee hyper extension and excessive internal rotation of the tibia. The anteromedial bundle is tautest in flexion while posterolateral bundle is tautest in full extension [3]. The intermediate bundle checks in anterior and anteromedial stability.
There is high percentage of injuries to the ACL during non-contact sports. Typically, in persons with history of ACL injury, there will be uncontrolled internal rotation of tibia leading to hyperpronation at the ankle and foot complex along with changes in Q-angle. These are more evident in sportsperson who are more prone to recurrent ACL injuries.
As majority of all functional activities are executed in closed kinematic chain, related motions occur in the foot and hip joints accompanying knee joint.
Foot is one of the most important linkages of body with ground during upright static and dynamic postures. The structural integrity of arch of foot is very important in distributing the forces placed on foot during weight bearing activities and in maintaining balance. Mobility of the foot arch concerns more in day to day activities involving non-weight bearing position to weight bearing postures.
Following ACL injury, weakness develops in VMO muscle resulting in alteration in the Q-angle. Mal-tracking of patella occurs due to tightness of lateral patellar retinaculum.

Accompanying these changes, internal tibial rotation leads to excessive pronation at the ankle complex. This results in lowering of the medial longitudinal arch and increasing torque of GRF at the ankle complex.

Functional changes that occur more predominantly in ACL injured sportspersons are to be taken into much of concern as all these changes limit the level of performance, exposing the joints to increased stresses and altered mechanics of the lower limb. These forces impair the congruity of the joints speeding up the joint erosion process ending in arthritic changes. Altered kinematic changes stresses the surrounding muscles causing abnormal muscular forces and altered kinetics further enhancing the structural changes.

1.1 Need of study

The need of this study is to determine the prevalence of hyperpronation of ankle and foot complex in sportspersons having a history of ACL injury with significance to Q-angle. As a result of ACL injury, there is weakness of vastus medialis oblique muscle which directly leads to alterations in Q-angle and lateral shift of patella along with tightness in lateral retinaculum[3]. Moreover, hyperpronation of ankle and foot complex causes reduced knee extensor torque which in turn leads to recurrent ACL injury.

2. Methodology

2.1 Study Design - Observational Study.

2.2 Sampling Technique - Convenient sampling. Total of 42 sportspersons with ACL injury.

2.3 Selection criteria

Inclusion Criteria

- Age-18 to 32 years [6].
- Gender- both male and female.
- Willingness to participate.
- Early diagnosis of ACL injury (with lachmann's or anterior drawers test positive).
- ACL injury undergone conservative management.
- Persons with VAS score pain intensity not more than 54 mm [8].

Exclusion Criteria

- Limb length discrepancy more than 1 cm or pelvic drop.
- History of congenital deformity in the lower extremity or foot [9].
- Previous history of any lower extremity or foot fracture affecting lower extremity alignment or foot posture [9].
- History of flat foot before ACL injury.
- Any neuromuscular disease of lower extremity.
- Low back (lumbosacral) pain within 1 year of duration [9].
- Any diseases like rheumatoid arthritis or tuberculosis [14].
- Congenital flat foot (vertical talus), Genu valgum, Intertarsal bar, Obesity [14].

2.4 Method

The subjects were screened based on the inclusion and exclusion criteria and signified their voluntary decision to participate. Demographic data was obtained from all the subjects.

The purpose and procedure of the study was explained to all the subjects. Information about the importance of arch height, its role in lower extremity alignment and in sports performance was also explained.

Informed consent was obtained from all the subjects.

Measuring dorsal arch height: Each subject was asked to stand on a foot measurement platform so that total foot length and dorsal arch height are measured in bilateral lower limb weight bearing. Prior to obtaining the standing measurements, each subject was positioned on the foot measurement platform with both heels positioned 15.24 cms apart [5].

Once the subject was properly positioned on the platform, the subject was instructed to place equal weight on both feet and the weight bearing measurements were taken. Total foot length was first measured by the centered metal ruler attached to the platform and was calculated from heel to the longest toe, usually the hallux, of the foot. To determine the point of 50% of total foot length, the previously measured total foot length was divided into half and the dorsum of foot was marked at the 50% length point using a water soluble marker.

Next, the dorsal arch height at 50% of total foot length was measured using the vernier caliper. The vernier caliper was positioned over the 50% length mark and the vertical height from the top of the platform to the dorsum of the foot was measured.

Following the completion of the weight bearing measurements, each subject was asked to sit on the end of a table or couch so that both lower legs were hanging in a perpendicular position to the floor with the feet non-weight bearing and the ankles slightly plantar-flexed. In this position, the non-weight bearing measurement of dorsal arch height was measured.

To assess dorsal arch height in non-weight bearing, the portable platform was positioned under the lower extremity and then the portable plastic platform was moved upward to make contact with the plantar surface of the foot. Each subject was instructed to state as soon as they sensed the portable platform just touch the plantar surface of the heel, lateral forefoot and medial forefoot of the foot simultaneously. The subject was informed to indicate the examiner if it felt that the portable platform is forcibly pushing the foot into ankle dorsiflexion.

If that happened, the procedure was stopped and repeated so that the subject only senses the portable platform just touching the plantar surface of the foot. When the subject indicated that the portable platform was just touching the plantar surface of the foot, the vernier caliper was used to measure the vertical height from surface of the portable platform to the dorsum of the foot over the 50% foot length mark on the dorsum of the foot.

If difference of arch height between non-weight bearing and weight bearing positions at 50% foot length mark was more than 13.1mm, it was considered as hyperpronation of ankle and foot complex [5].

Measuring q-angle with goniometer- The subjects were dressed in shorts, decently exposed to show the landmarks and made to stand barefoot. The measurement of the Q angle was performed with the subject standing in the erect, weight-bearing position. The feet were placed in a position of neutral rotation, such that the toes were pointing directly forwards. The outline of the patella was drawn with a marker pen, after palpating the borders and making sure that the skin was not stretched in doing so. The Centre of Patella was defined as the point of intersection of the maximum vertical and transverse diameters of the patella. The point of maximum prominence was defined as the centre of the Tibial Tubercle.

The anatomical landmarks including the border of the patella, tibial tubercle and anterior superior iliac spine (ASIS) were palpated and the centre of the patella was marked by water

soluble skin marker. One line was drawn from the Centre of Patella towards the ASIS using the straight edge of a measuring tape and represented the longitudinal axis of the femur. Another line joined the centre of the Tibial Tubercle and the Centre of Patella. The second line was extended upwards. The angle formed between the above two lines was defined as the Q-angle.
The fulcrum of universal goniometer was placed on the midpoint of the patella with its stationary arm aligned towards the ASIS and the movable arm aligned to the tibial tubercle.
The quadriceps muscle was kept relaxed (without voluntary quadriceps contraction) throughout the measurement. All measurements were taken by the same investigator. Q-angle of 15^0 was considered normal[3].

2.5 Statistical methodology
The subjects included for the study were 42 sportspersons with ACL injury. Dorsal Arch Height and Q-Angle measurements were tabulated to know about the distribution and later the significance was analyzed by using percentage, frequency and chi-square test. Statistical Package for Social Sciences, Version-16 (SPSS-16) was used for analyzing collected data.

3. Results and Discussion

Table 1: Shows the sex distribution of subjects

Male	Female
27	15

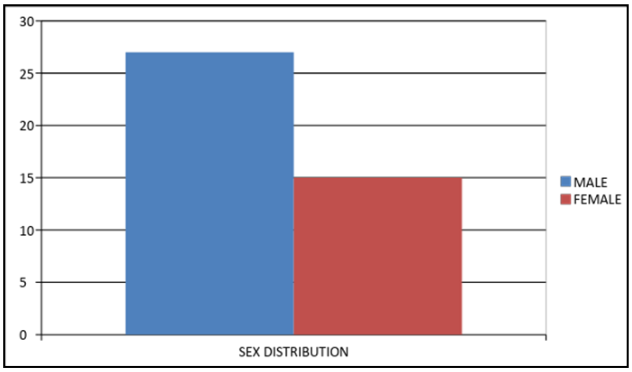

Fig 1: Shows the sex distribution of subjects

Table 2: Shows the age distribution among subjects.

Age (Years)	Male	Female
18-22	9	9
23-27	12	4
28-32	6	2
TOTAL	27	15

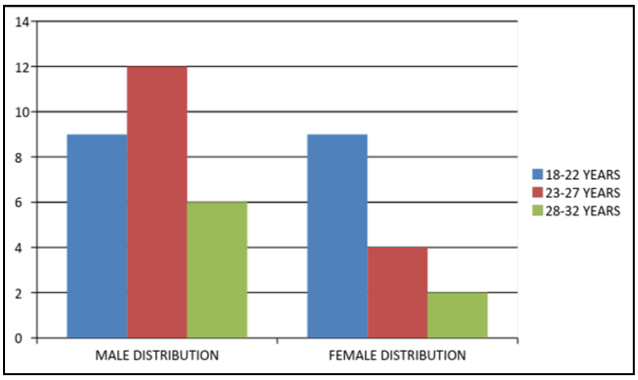

Fig 2: Shows the age distribution among subjects

Table 3: Shows descriptive statistics between arch height and Q angle

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Arch height Difference	42	12.00	10.00	22.00	15.3571	3.19925	10.235
Q-Angle	42	18.00	11.00	29.00	19.1905	4.95953	24.597
Valid N	42						

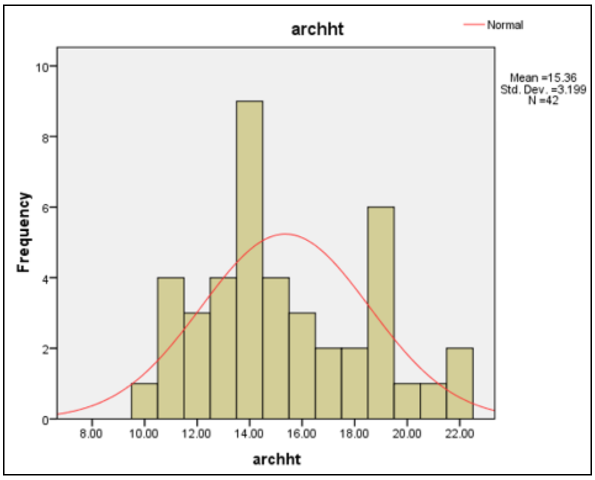

Fig 3: Bar graph representation mean and standard deviation for arch height

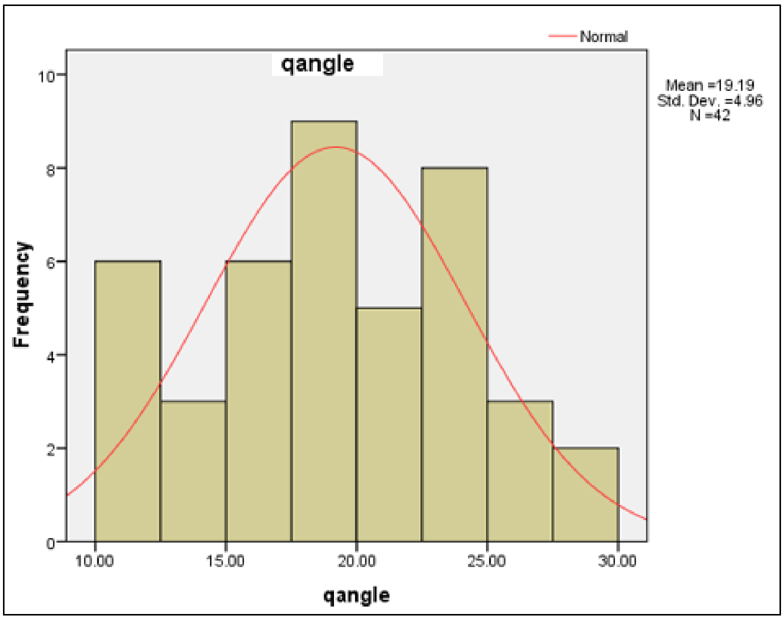

Fig 4: Bar graph representation for Q angle in mean and standard deviation

Table 4: Correlation between arch height anf Q angle

		Arch height	Q-angle
Arch Height	Pearson Correlation	1	.052
	Sig. (2-tailed)		.741
	N	42	42
Q-Angle	Pearson Correlation	.052	1
	Sig. (2-tailed)	.741	
	N	42	42

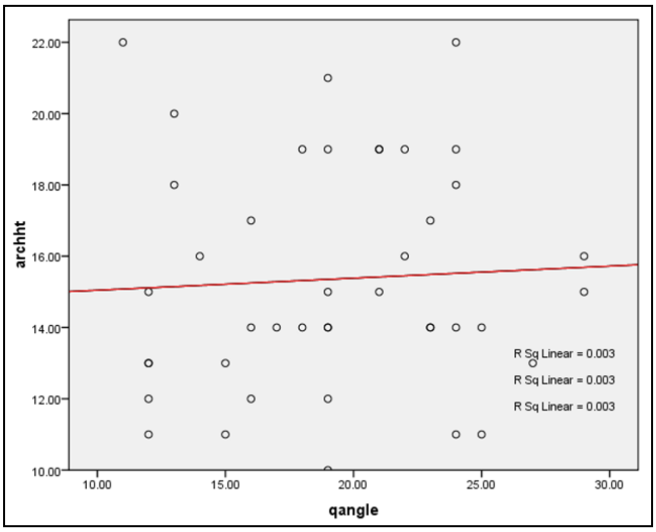

Fig 5: Correlation graph between arch height and Q angle

The implication of the study justifies the efficacy of taking into concern about the relative changes that occurs in the associated ankle and hip joints in relation to the previously injured ACL of the knee joint.
ACL injury is a self- limiting condition that needs attention and emphasis of physiotherapy intervention particularly towards the knee joint along with the hip and ankle joints. Physiotherapy is the mainstay treatment for ACL injury but is limited to only the knee joint. Focussing on all the three joints helps to improve function so as to reduce overall restrictions in sports participation.
Arch height is very much important and specific not only to the sports participation but also to the performance. Low-arched foot is considered to be more mobile as compared to high-arched foot. Arch height was gradually decreased in loading phase but suddenly increased in push-off phase during level walking, vertical jump and sprint start. Vertical jump and sprint start requires significantly greater ranges of arch height change than level walking. Emphasis of foot should be taken into concern while treating a sportsperson keeping in mind the sports being participated and role of foot arch in the particular sport.
The result of this study led to the inference that structural changes along the lower limb occur accompanying an ACL injury. Result indicates alteration in the arch height difference between non-weight bearing and weight bearing positions following ACL injury. Arch height difference between non-weight bearing and weight bearing positions is increased in sportspersons with ACL injury. This increased arch height difference between non-weight bearing and weight bearing positions led to hyperpronation of ankle and foot complex.
Q-angle tends to increase with hyperpronation. This increases the compressive loading around the knee joint. It leads to altered muscular force due to which motor recruitment pattern changes. It results in more loading and increased muscular activity leading to early fatigue hampering sports performance. Sports participation requires rapid changes in arch height especially during loading phase and push off phase. Thus, it draws into light regarding it's applicability in clinical implications while treating an ACL injury cases in the clinical settings.
Further studies could focus on other determining components of hyperpronation like mid-foot width difference between non-weight bearing and weight bearing positions and can be compared with other approaches.

4. Conclusion

This study emphasises that hyperpronation of ankle and foot complex has to be taken into concern in clinical settings as it is been related to sportspersons having a history of ACL injury which further results in an altered q-angle.

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