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ORIGINAL RESEARCH

The relationship of quadriceps (Q) angle and body mass index with non-contact anterior cruciate ligament injury among male athletes

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Abstract

Introduction: The aim of this study was to identify the relationship of Quadriceps (Q) angle and Body Mass Index (BMI) with non-contact Anterior Cruciate Ligament (ACL) injury among collegiate male track and field athletes. **Methods:** A case control study done at Sports Medicine Unit, National Hospital of Sri Lanka and Ministry of Sports Sri Lanka recruited collegiate male track and field athletes aged 15-25 years with non-contact ACL injury (n=35) as cases and age matched healthy athletes as controls (n=70). Stadiometer, electrical weighing scale and goniometer were used to measure height, weight and Q angle respectively. **Results:** Mean age of the cases and controls were 20.63±2.98 years and 20.67±2.98 years respectively. The mean BMI in cases group was 23.79±1.91 kg/m2 and control group was 21.85±1.27 kg/m^2 ($p<0.05$). The mean value of the Q angle in case group was 15.93° ± 1.34 and control group was 14.29° ± 0.84 ($p<0.05$). **Conclusion:** This group of male track and field athletes with non-contact ACL injury had a significantly higher BMI and Q angle compared to the non-injured athletes. These factors have to be considered with other risk factors associated, during the development of management and preventive strategies.

Keywords: ACL injury, BMI, Q angle

Introduction

The Anterior Cruciate Ligament (ACL) injury is a common sports related injury in the athletic population, carrying significant short-term and long-term morbidity [1]. Out of all ACL injuries 70% are non-contact ACL injuries [2], where the most common mechanism of injury is the hyper-extension of knee with rotation or torsion of the knee joint during a non-contact event [1, 3].

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The risk factors for non-contact ACL injuries are environmental, anatomical, hormonal biomechanical and neuromuscular [2,4]. Anatomical differences are increased tibial plateau slope, shallow medial tibial plateau depth [5], decreased intercondylar notch width, lower extremity malalignment including increased navicular drop, anterior pelvic tilt and Quadriceps (Q) angle [4, 6].

Quadriceps angle or Q angle is an anatomical feature defined as “the angle formed by a line from the anterior superior iliac spine (ASIS) to the patella center and a line from the patella center to the tibial tuberosity" [7, 8]. The Q angle in males is between 8° and 14°, and in females ranges from 11° to 20°, where it typically increases in degree with weight bearing owing to a valgus adaptation of the knee [9]. In general patients with Q angles greater than 14° are vulnerable to patellar conditions [10], particularly abnormal tracking and instability and indicates an excessive lateral quadriceps force resulting in disproportionate lateral patellar displacement during dynamic activities involving quadriceps muscle activity [11]. It is associated with increased knee valgus and this mechanical consequence is described to adversely influence the ACL [12]. Females have a higher Q angle than males due to their wider pelvis [2, 4] whereas some researchers have documented males and females of equal height having similar Q angles, with taller people having slightly smaller Q angles [7]. Females suffer ACL injury more frequently than males [13], possibly due to their higher Q angle [14], smaller ligament size, lower mass density and ligament laxity [15]. It is proposed that the hormone estrogen causes ligamentous laxity and can affect the composition and structure of the ligament where the strength of the ACL can differ in different phases of the menstrual cycle [16]. However there is limited evidence in the literature to predict an increased Q angle as a risk factor for non-contact ACL injuries [15,17].

Body mass index (BMI) is a simple index of weight-for-height. World Health Organization (WHO) defines BMI as the weight in kilograms divided by the square of the height in meters (kg/m^2). Higher BMI can increase the compression forces applied to a knee, which could further increase the risk of ACL injury combined with other risk factors [12]. ACL injury has enormous adverse health impact in the athletic population [18, 19], as it is associated with complications including reduction in return to play, training lord, competition performance and potential long-term knee osteoarthritis [20]. Treatment is costly and not always successful at returning to pre-injury activity level [2,21]. Therefore prevention is considered the ideal approach to address the negative effect of ACL injury. Better understanding of the risk factors is beneficial in the development of improved therapeutic interventions and ACL injury prevention strategies [5]. Hence the purpose of this study was to identify the relationship of Q angle and BMI with non-contact ACL injury among male athletes using a case control study design.

Methods

Young male track and field athletes aged between 15-25 years were selected for a case-control study. Ethics approval was obtained from the Ethics Review Committee of Faculty of Medicine, University of Colombo. Informed written consent was obtained from all study participants.

Study population and sampling

The 105 males who were registered at the Sports Medicine Unit of National Hospital, Colombo, Sri Lanka (NHSL) and the Institute of Sports Medicine at Ministry of Sports, Colombo, Sri Lanka were recruited. Athletes who were diagnosed with non-contact ACL injury were consecutively selected for the case group (n=35) and healthy athletes were selected through convenient sampling to the control group (n=70). The participants did not have other comorbidities.

Data collection and measurements

A self-administered questionnaire was used to collect demographic data, injury mechanism and duration of injury of the athlete. A goniometer (Madan), a digital weighing scale (Nippotec) and a standard stadiometer (Seca) were used to measure the Q angle, weight and height respectively. All the measurements were taken by the investigator in 3 separate rounds (3 measurements) and average was computed and used for analysis.

1. Measurement of the Q angle

The quadriceps (Q) angle measurement was taken manually from a goniometer. All the measurements were taken with participants in the erect weight bearing position with knee exposed in full extension (not hyperextension). First a line was drawn by using removable marker pen from ASIS to midpoint of the patella and from midpoint of the patella to the tibial tubercle. Then the proximal arm of the goniometer was aligned to the ASIS; the axis at the midpoint of the patella and the distal arm was aligned with the tibial tubercle. The resultant angle formed by the crossing of these two lines was measured (22,23) and recorded to the resolution of the goniometer; i.e. nearest millimeter.

2. Measurement of weight

The scale was placed on a hard-floor surface. A carpenter's level was used to verify that the surface on which the scale was placed is horizontal. Participants were asked to remove their heavy outer garments, shoes and stand on the center of the platform, as weight to be distributed evenly to both feet. The weight was recorded to the resolution of the scale (the nearest 0.1 kg or 0.2 kg).

3. Measurement of height

Participants were asked to remove their shoes and hair ornaments and stand on the stadiometer, facing forward as tall and straight as possible with their arms hanging loosely on their sides. The head piece of the stadiometer or the sliding part of the measuring rod was lowered so that the hair was pressed flat. Height was recorded to the resolution of the height rule (i.e. nearest millimeter).

Body mass index (BMI) was calculated as weight in kilograms (kg) divided by height squared in meters (kg/m^2).

Statistical analysis

The statistical analysis was done by using SPSS 23. Mean and standard deviation (SD) were used to describe socio-demographic characteristics, distribution of Q angle and BMI among the study population. Independent sample t-test compared means of BMI and Q angle among cases and controls. Statistical significance level was considered as $p<0.05$.

Results

The mean age of the participants was 20.68±2.9 years, where majority (n=63; 60%) were between 21-25 years. Baseline mean ages of both groups were similar. Quadriceps (Q) angles varied from 13° to 25° among cases (Mean/SD $15.93^{\circ} \pm 1.34$) and from 13° to 20° among controls (Mean/SD $14.29^{\circ} \pm 0.84$). The difference was statistically significant ($p<0.05$). Body mass index (BMI) varied from 19.79 to 27.97 kg/m^2 among cases (Mean/SD 23.79 ± 1.91 kg/m^2) (Table 2) and from 19.10 to 25.75 kg/m^2 among controls (Mean/SD 21.85 ± 1.27 kg/m^2). The difference was statistically significant ($p<0.05$).

Discussion

Our study investigated the mean Q angle and its relationship with ACL injury in a group of Sri Lankan collegiate male track and field athletes with and without ACL injury which revealed the baseline values of this clinically important anatomical feature. Al-Tarawneh et al. who studied healthy Jordanians (Mean age 32.7 ± 10.1) with no ACL injury , showed that the mean Q angle in men and women was 14.40˚ (± 1.9) and 18.40˚ (± 1.8) respectively and stated that Q angle can differ from population to population attributing to variations in life styles [22]. Murat Şen et al. who studied footballers and wrestlers from Turkey showed mean right and left knee Q angles of male athletes were 15.08° ± 1.79° and 14.49° ± 1.82° in the standing position [23]. Our sample of athletes also showed similar range of mean Q angles.

The athletes with ACL injury had a significantly higher Q angle compared to the athletes with healthy knees (Table 2), attributing to the positive association of Q angle with non-contact ACL injury. While acknowledging this significance of Q angle for knee injury, previous studies have reported inconsistent findings. Emami et al.[24],who studied Q angles of patients from Iran with anterior knee pain (Male : Female : total; 15.2°: 20.1°: 18.0°) and healthy knees (Male : Female : total; 12.1°: 16.7°: 14.9°) stated that the higher Q angle alone might not be responsible for knee injuries as 16% of the males and 20% of the females with abnormally high Q angle did not present with knee pain. It was discussed that a unique combination of alignment characteristics will collectively contribute to this injury where a dynamic alignment combination of hip adduction, internal rotation and knee valgus has been observed to be the mechanism [17]. The impact of rotational alignment on Q angle was low compared with alignments in the frontal plane and it may be that a combination of static alignment characteristics increases the valgus and rotational positions common to ACL injuries [17].

As the Q angle is not the only but a significant contributor for ACL injury, it is justified to identify this anatomical feature early in an athlete to develop prevention strategies [25]. For example the vastus medialis oblique (VMO) muscle which helps to stabilize and correctly position the patella during patellofemoral tracking shown to be weaker in knees with larger Q angles, which will benefit from specific muscle strengthening programs [26]. In addition, other static and dynamic features which contribute to non-contact ACL injury knee has to be further explored.

The association between ACL injury and higher BMI was significant compared to athletes who did not have an ACL injury in this group. Elevated weight and BMI values have been found to be significantly associated with ACL injuries, especially in male individuals and associated with other intra-articular injuries observed during ACL reconstructions [13, 27]. Further observational studies have shown that taller or heavier subjects are at a greater risk for injury because of the greater forces acting on the muscles, bones, and the connective tissues [28]. Other associated anatomical factors which were studied with BMI like the lateral tibial slope (LTS), medial tibial slope (MTS) and posterior tibial slope (PTS) were also predictive of ACL injury risk [27, 28]. Our data confirms that BMI as a modifiable risk factor that should be improved and included in non-contact ACL injury prevention strategies.

Conclusions

This group of Sri Lankan colligates male track and field athletes with non-contact ACL injury had a significantly higher BMI and Q angle compared to the non-injured athletes. These factors have to be considered with other dynamic and static risk factors associated with non-contact ACL injury, during developing management and preventive strategies.

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Conflicts of interest:

Authors declare no conflicts of interest.

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