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Q-angle static or dynamic measurements, which is the best choice for patellofemoral pain?

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ABSTRACT

Background: The elevated Q-angle seems to be one of the most suggested factors contributing to patellofemoral pain. Females with patellofemoral pain are often evaluated through static clinical tests in clinical practice. However, the adaptations seem to appear more frequently in dynamic conditions. Performing static vs. dynamic evaluations of widely used measures would add to the knowledge in this area. Therefore, the aim of this study was to determine the reliability and discriminatory capability of three Q-angle measurements: a static clinical test, peak dynamic knee valgus during stair ascent and a static measurement using a three-dimensional system.
Method: Twenty-nine females with patellofemoral pain and twenty-five pain-free females underwent clinical Q-angle measurement and static and dynamic knee valgus measurements during stair ascent, using a three-dimensional system. All measurements were obtained and comparisons between groups, reliability and discriminatory capability were calculated.
Findings: Peak dynamic knee valgus was found to be greater in the patellofemoral pain group. On the other hand, no significant effects were found for static knee valgus or clinical Q-angle measurements between groups. The dynamic variable demonstrated the best discriminatory capability. Low values of reliability were found for clinical Q-angle, in contrast to the high values found for the three-dimensional system measurements.
Interpretation: Based on our findings, avoiding or correcting dynamic knee valgus during stair ascent may be an important component of rehabilitation programs in females with patellofemoral pain who demonstrate excessive dynamic knee valgus. Q-angle static measurements were not different between groups and presented poor values of discriminatory capability.

1. Introduction

Patellofemoral pain (PFP), described as anterior or retropatellar pain, comprises a large portion of orthopedic practice (Witvrouw et al., 2014). Taunton and colleagues (Taunton et al., 2002) reported that the knee joint was the most commonly injured joint in runners in 2002 and almost half of these occurred due to PFP. The estimated prevalence of PFP among females aged 18–35 years is 13% (Roush and Bay, 2012) and it is 2.23 times more common than in males (Boling et al., 2010). Moreover, it has been shown that PFP can limit participation in sports and daily activities, such as stair negotiation, prolonged sitting with flexed knees, jumping and squatting (Powers et al., 2012).

Several contributing factors, such as elevated Q-angle, have been cited in order to explain the etiology of PFP, however, its pathological implications have not yet been established (Garcia et al., 2010; Witvrouw et al., 2014). The Quadriceps-angle or Q-angle was initially described by Brattstrom. It is an index of the vector for the combined pull of the extensor mechanisms and the patellar tendon (Huberti and Hayes, 1984). Clinically it is taken by drawing imaginary lines from the anterior superior iliac spine to the center of the patella, and from the tibial tuberosity through the center of the patella, and measuring the acute angle in between (Caylor et al., 1993). Normal values are reported to range from 10° to 14° for male subjects and 14.5° to 17° for females (France and Nester, 2001). This measurement has been used extensively by researchers and clinicians to identify patellar malalignment in females with and without PFP, however, substantial controversy has arisen regarding its clinical utility (Park and Stefanyshyn, 2011), reliability (Smith et al., 2008) and relationship with patellofemoral kinematics (Freedman and Sheehan, 2013; Freedman et al., 2014).

The relationship between Q-angle and PFP is based on the model that an increased Q-angle would translate the patella laterally increasing the retropatellar pressure and, therefore, causing pain (Herrington and Nester, 2004). Nonetheless, these findings call into question the long-held assumption that patellar lateralization is the result of the

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patella moving on the femur. Although it seems to be a reasonable explanation, during weight-bearing activities the patellar lateralization may be a result of femur rotation underneath the patella (Powers, 2010). In fact, femur internal rotation can occur without any patellar motion (Powers, 2010). Thus, to analyze Q-angle in a non-weight-bearing activity (i.e., during knee extension in the supine position), as performed in other studies (Örtqvist et al., 2011; Sheehan et al., 2010), might be a potential source of bias due to the femur remaining fixed during the movement (Powers, 2010). Additionally, the majority of the studies which aimed to evaluate the relationship between Q-angle and PFP used only static clinical measurements (Freedman et al., 2014; Örtqvist et al., 2011; Park and Stefanyshyn, 2011), which have been advocated as non-reliable measurements (Smith et al., 2008).

While clinical Q-angle measurements do not appear to be related to PFP, biomechanical dynamic parameters have been largely proposed with respect to PFP development (De Oliveira et al., 2015; Witvrouw et al., 2014). Several studies (De Oliveira et al., 2015; Graci and Salsich, 2014) have reported that PFP mechanisms can be better observed in dynamic instead of static situations due to the higher muscular and mechanical demands needed to perform the activity. Dynamic knee valgus (DKV), the dynamic correspondent of the Q-angle, has been proposed to contribute to the development of PFP (Powers, 2010) and may be a useful approach to determine the contribution of the Q-angle during dynamic tasks in females with PFP. For instance, Graci and Salsich (Graci and Salsich, 2014), in a kinematic study, reported that females with excessive DKV were asked to correct it and, after correction, femur adduction and femur internal rotation decreased, factors highly related to PFP (Powers, 2003). However, in clinical practice the most commonly available tools to identify such alterations are static clinical tests; therefore, it is important to understand whether this alteration occurs only in dynamic situations or can be identified by clinical tests.

In this context, providing some clarification about the precise relationship between static and dynamic Q-angle measurements in PFP appears to be mandatory. To answer this question, it is necessary to evaluate reliability, precision, sensitivity and specificity of these measurements. As such, a study that analyzes three different measurements (two static and one dynamic), regarding their reliability and capability to discriminate females with PFP versus pain-free females, would add greatly to the knowledge in this area.

Thus, the aim of this study was to determine the reliability, precision and discriminatory capability of three Q-angle measurements: a static clinical test, peak dynamic knee valgus during stair ascent and a static measurement using a 3D system. We hypothesized that females with PFP would exhibit elevated peak DKV in comparison with pain-free females and that this parameter would present the best discriminatory capability, whereas, in contrast, static Q-angle measurements would not be different between groups with poor values of discriminatory capability.

2. Methods

2.1. Participants

Twenty-nine females with PFP and twenty-five pain-free females were recruited from the graduate student population at the university, parks and gyms of the city. Mean (SD) age, height and mass for the PFP group were 21.7 (2.72) years, 1.65 (0.05) m and 65.72 (10.76) kg respectively and 22.07 (3.67) years, 1.65 (0.04) m and 62.3 (7.3) kg for the control group (CG). Power calculations for this study were performed using preliminary data (10 females) from our laboratory for peak DKV, static Q angle clinical test and static DKV measurement using a 3D system. The kinematic parameter with the highest standard deviation and the smallest difference between groups was used, in this case, the DKV. Sample size was determined based on predicted power to detect a difference of 2.1° (4.69° SD) between the groups with an alpha of 0.05 and 80% power. Based on calculations performed in Samplepower (SPSS Inc. Chicago, IL, USA), a minimum sample size of 25 subjects per group was indicated. The study was approved by the University of Sao Paulo State Human Ethics Committee, and each participant gave written informed consent prior to participation.

Diagnosis of PFP was completed following consensus from two experienced clinicians (>5 years experience) and based on definitions used in previous PFP studies (Briani et al., 2015; Ferrari et al., 2014). The PFP group inclusion criteria were (1) anterior knee pain during at least 2 of the following activities: remaining seated, squatting, running, stair negotiation and jumping; (2) pain during patellar palpation; (3) symptoms for a minimum of 1 month with an insidious beginning; (4) worst pain level in the previous month up to 3 on a 10 cm visual analog scale (VAS); and (5) 3 or more positive clinical signs in the following tests: Clarke's sign, McConnell test, Noble compression and the patella in the medial or lateral position. Prospective participants were required to fulfill all 5 requirements to be included in the PFP group and could not present any signs or symptoms of PFP or other musculoskeletal conditions to be included in the control group. Any condition besides PFP was considered as an exclusion criterion, such as: events of patellar subluxation or dislocation, lower limb inflammatory process, osteoarthritis, patellar tendon tendinitis, meniscus tears or ligament tears. Those who had undergone knee surgery or knee treatments such as arthroscopy, steroid injections, oral steroids, opiate treatment, acupuncture or physiotherapy during the preceding 6 months were excluded from this study.

2.2. Clinical measurement (Q-angle)

Q-angle measurements were performed during the sample evaluation (inclusion and exclusion criteria) by two investigators. Q-angle evaluation included lower limb evaluation of each participant's symptomatic limb. Only females with unilateral symptoms were included in this study. Subjects were positioned in the supine position with the quadriceps fully relaxed. The subject's knee was maintained bent at 15° by placing an adjustable cushion under the knee, to better engage the patella within the sulcus groove which may strengthen the Q-angle's relationship to in vivo patellar kinematics and improve its reliability and utility (Guerra et al., 1994). A widely proposed technique was used to perform the measurement (Freedman and Sheehan, 2013; Freedman et al., 2014). The evaluators were isolated in a separate room at the moment of assessment, thereby avoiding potential bias which could influence the reliability of the measurement.

2.3. Kinematic measurements

Motion analysis was collected using a three-dimensional motion analysis system (VICON MX, Vicon Motion Systems Inc.; Denver EUA) combined with 4 cameras (type Bonita®B10) operating at a sampling frequency of 100 Hz with a resolution of 1 megapixel. Ground reaction forces were collected using a force plate (AMTI, OR6, Watertown, MA, USA) at a sampling frequency of 2000 Hz.

For the purpose of static calibration, retroreflective markers were placed on anatomic landmarks respecting the Vicon's Plug-in-Gait model. The markers were positioned by the same investigator for all participants: right and left ASIS; top of the sacrum (L4-L5), over the greater trochanter, lateral aspect of the femur, lateral and medial ankle at the level of the lateral malleolus, first and fifth metatarsal heads and the tip of the toe. Additional measurements taken to facilitate kinematic measurements included participant height, leg lengths (ASIS to medial malleolus), inter-ASIS distance, inter-epicondylar distance at the distal thighs and intermalleolar distance at the distal shanks (Kadaba et al., 1990). A relaxed standing calibration trial was then captured and, from this data, it was possible to establish the static Q-angle from the system. The calibration trial was performed according to Guerra and colleagues (Guerra et al., 1994). In the standing position,