Relationship between Clinical Measures of Generalized Joint Hypermobility and Uniplanar and Multiplanar Knee Laxities

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INTRODUCTION

Generalized joint hypermobility (GJH) is associated with a variety of musculoskeletal injuries including rupture of the anterior cruciate ligament (ACL). Given its association with musculoskeletal injuries, several clinical measures have been developed to quantify GJH. One such measure is the Beighton Score, which quantifies GJH primarily in the plane of flexion and extension and requires about three minutes to complete. Other more extensive measures include the Hospital Del Mar Score (HDMS) and Lower Limb Laxity Assessment Score (LLAS) [1-3], which evaluate GJH in all three anatomical planes, but require more time to conduct than the Beighton Score. Interestingly, the propensity to have loose joints throughout the body is related to laxity of individual joints such as the knee [4]. However, the relationship between these different clinical measures of GJH and laxity of the knee in specific anatomic planes is not well understood. Establishing whether these different clinical measures of GJH are related to knee laxity could help guide use of the least time-consuming clinical measure of GJH that is also related to knee laxity in all anatomical planes. Moreover, identifying these relationships could help inform decision making regarding interventions in patients with GJH to reduce risk of injury and improve surgical outcomes. Therefore, we asked the following question: which of these three clinical measures of GJH (Beighton Score, HDMS, and LLAS) are correlated with anterior-posterior (AP), varus-valgus (VV), and internal-external rotation (IER) laxities and a multiplanar simulated pivot shift exam?

METHODS

With IRB approval, 20 healthy, uninjured volunteers (10 males, 10 females; mean age: 27.8 ± 6 years) with no history of prior knee injury or surgery were consented into the study. A custom knee arthrometer was used to assess uniplanar and multiplanar knee laxities (Figure 1). The arthrometer consisted of a five degrees of freedom (DOF) instrumented linkage mechanism with applied loads measured using a six DOF load cell fixed to the arthrometer behind the subject's proximal tibia. To conduct a test, the subject sat reclined in a chair with their leg aligned and secured to the arthrometer at 20° of flexion. The examiner manually applied four cycles of AP forces (-50 N posterior to 135 N anterior), VV moments (±6 Nm), and IER moments (±2.5 Nm) to the tibia and the respective translations and rotations were recorded. The examiner also performed a simulated clinical pivot shift exam. First, an 8 Nm valgus moment was applied and held constant; then, cyclic anterior-posterior (AP) forces of -10 N to 70 N were applied to the lateral aspect of the tibia to subluxate and reduce the lateral compartment. AP translation of the lateral compartment was measured in response to these multiplanar loads. Two examiners each conducted two independent tests on both knees; these eight tests were then averaged together. Beighton Score, HDMS, and LLAS testing protocols were followed to evaluate GJH in volunteers. Briefly, Beighton Score is a 9-point clinical scale characterizing GJH in the sagittal plane [2], HDMS is a multiplanar 10-point clinical scale evaluating GJH in the sagittal, coronal, and transverse planes [3], and LLAS is a multiplanar 12-point clinical scale evaluating hypermobility in the lower extremities [4]. As both the HDMS and LLAS scales have separate laterality-based scores (one score for each side of the body), the scores from the left and right sides were averaged to yield the mean HDMS and LLAS for each volunteer. Each measure of GJH was assessed by a single examiner. Simple linear regression was used to measure relationships between GJH scores from each clinical assessment and laxities of each volunteer. Coefficients of determination (R^2), the regression coefficients (β) along with their standard deviations, and p-values (α=0.05) were reported.

RESULTS

The Beighton Score in the cohort averaged 3.2 ± 2.4 (range: 0-9) and had a positive correlation with AP laxity (R^2=0.22, p=0.04). The HDMS averaged 4.8 ± 2.2 (range: 0-8) and had a positive correlation with all four of the measured laxities (R^2>0.30, p<0.005). The LLAS averaged 5.6 ± 1.7 (range: 2-8) and also had a positive correlation with all four of the measured laxities (R^2>0.30, p<0.01) (Table 1).

DISCUSSION

The Beighton Score was solely correlated with AP laxity of the knee, while both the HDMS and LLAS were correlated with all three uniplanar laxities and our multiplanar assessment of the simulated pivot shift. Therefore, there is a clinical tradeoff to consider. Namely, the Beighton Score is less time-consuming to administer (~3 minutes), but it is less comprehensively related to knee laxity. In contrast, the HDMS (~5 minutes) and LLAS (~7 minutes) are more time-consuming to administer but are correlated with knee laxity in all anatomic planes. This disparity between the clinical assessments of GJH may arise because the Beighton Score evaluates GJH primarily in the sagittal plane as opposed to the HDMS and LLAS, which assess GJH in all three anatomical planes [3,4]. Our findings support the use of HDMS and LLAS as more comprehensive assessments of GJH than the Beighton score at the expense of increased usage of clinical time.

SIGNIFICANCE/CLINICAL RELEVANCE: The HDMS and LLAS assessments of GJH, although more time-consuming to administer than the Beighton Score, may help identify those who are at increased risk of knee injury due to elevated multiplanar knee laxity or who may benefit from adjunctive surgical procedures following ligamentous knee injuries such as rupture of the ACL.

REFERENCES: [1] Malek. Rheumatol Int 2021. [2] Bulbena. J Rheum 1992. [3] Meyer BMC MSK Disord 2017. [4] Marshall. Med Sci Sports Exerc 1980.

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Table 1: Regression Analysis of Beighton Score, HDMS, and LLAS with Knee Laxity

	AP			IE			VV			Pivot Shift		
	β	**R2**	**p-value**	**β**	**R2**	**p-value**	**β**	**R2**	**p-value**	**β**	**R2**	**p-value**
Beighton Score	0.98 ± 0.44	0.22	**0.038**	1.45 ± 0.87	0.10	0.114	0.44 ± 0.22	0.18	0.062	0.26 ± 0.18	0.10	0.164
HDMS	1.38 ± 0.42	0.38	**0.004**	2.60 ± 0.79	0.38	**0.004**	0.68 ± 0.20	0.38	**0.004**	0.52 ± 0.16	0.30	**0.005**
LLAS	2.10 ± 0.45	0.54	**<0.001**	2.94 ± 1.06	0.30	**0.0125**	0.98 ± 0.23	0.49	**<0.001**	0.78 ± 0.18	0.51	**<0.001**

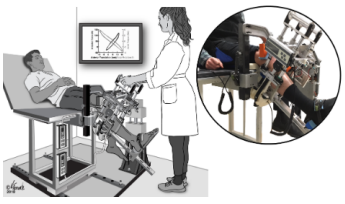

Figure 1: Novel knee arthrometer to assess uniplanar and multiplanar knee laxities