INTRODUCTION:
Several lower extremity alignment (LEA) measures have been either directly or indirectly linked to non-contact ACL injury risk. Prior investigations have implicated rear foot angle, tibial torsion, quadriceps angle (Q-angle), pelvic tilt, navicular drop, hip (femoral) anteverision and genu recurvatum as significant contributing factors to non-contact ACL injuries [1-5]. Previous studies have also suggested anterior knee laxity, as measured by the KT 1000 device, is predictive of ACL injuries [5,8]. Due to limitations of traditional motion capture techniques, no study has been able to directly link passive anterior knee laxity or these various lower extremity alignments to knee translations occurring in vivo during a high demand activity such as the drop landing.

The purpose of this study was to utilize high-speed, bi-plane fluoroscopy to determine the relationships between select lower extremity alignments and anterior knee laxity with 3D knee rotations and translations measured in vivo during a stiff drop landing motion in healthy male and females. It was hypothesized that individuals who possess higher passive anterior knee laxity scores as measured via KT 1000 will also exhibit greater anterior tibial translation during the drop landing.

METHODS:
16 athletes (10 females; 6 males) volunteered and gave informed consent to participate in this study. Seven measures of lower extremity alignment (pelvic tilt, hip anteverision, Q-angle, genu recurvatum, tibial torsion, navicular drop and rear foot angle) were collected by a single examiner. All measures were collected using previously established methods [1-6]. Anterior knee laxity was evaluated at 30° of knee flexion with KT 1000/177N [10]. For testing, all subjects were spandex-like shorts, a tightly fit top and a standardized court shoe. Subjects performed a drop-landing by stepping off a 40 cm high platform onto a force plate. The subjects were verbally instructed to land in a "stiff" manner by "trying not to bend at the hip, knee or ankle during the fall nor at or after ground impact while bi-plane fluoroscopy images were captured at 500 Hz (Figure 1). Bone geometries reconstructed from CT scans were matched onto the calibrated fluoroscopy images after their contours were detected semi-automatically using model based RSA (Medis Specials, Leiden, Netherlands). Knee rotations and translations were calculated using methods described by Grood & Suntay [9]. Normalization to knee extension was achieved by subtracting the translation and rotation of the tibia during knee extension from data collected during the landing task at the same knee flexion. Gender comparisons between all clinical alignment measures, KT 1000 and kinematic data sets were conducted using ANOVA. Pearson product moment correlation coefficients were calculated to identify those parameters related to maximal ATT. Linear and forward stepwise multiple regression techniques were used to describe and identify the individual and multiple variable models that best predict maximal ATT during the landing.

RESULTS:
Significant differences were noted between genders with regards to pelvic angle, hip anteverision and Q-angle (all p ≤ 0.01). No gender differences were observed in KT 1000, genu recurvatum, tibial torsion, navicular drop, rear foot angle (all ≥ 0.09). There were no differences between genders in any of knee joint rotation variables (all p ≥ 14). There were no differences between genders in the initial, maximal, minimal or range of ATT or Medial/Lateral tibial translation values (all p ≥ 0.2; Figure 2).

DISCUSSION:
Anterior knee laxity as measured by KT 1000 independently explained 79% of the variance in ATT measured during the drop landing across all subjects. This direct relationship has not been previously documented and suggests that anterior knee laxity taken during a passive examination can be predictive of ATT during a dynamic activity. Moreover, this relationship was observed in otherwise healthy individuals whose KT 1000 measures were (for both males and females) within normal limits as provided by previous reports [5]. These observations serve to support previous retrospective studies which have noted increased risk ACL injury with increased anterior knee laxity.

CONCLUSIONS:
Peak ATT is positively correlated with KT 1000 in both healthy males and female adult knees when performing a stiff drop landing motion. These findings are in agreement and generally support previous work which has shown that anterior knee laxity is associated with an increased risk of ACL injury; and, is a parameter that is easily obtained and should be considered in future, prospective studies concerning the non-contact ACL injury.

REFERENCES:

ACKNOWLEDGEMENT:
Supported by Steadman Philippon Research Institute and NIH AR39683 (PI: Savio L-Y. Woo). Medis Specials is acknowledged for providing MBRSA software.