CROSS-PROFESSIONAL DIFFERENCES IN REAL-TIME ASSESSMENT OF ACL INJURY RISK

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Simple visual inspection of movement is a potentially low cost method for anterior cruciate ligament (ACL) injury screening and prevention. Although many professionals, athletes, and coaches utilize some form of visual inspection of movement/injury risk, there is currently no substantial data on group skill differences. Sports medicine professionals, exercise science students/academics, and strength and conditioning coaches exhibited consistently superior ACL injury risk estimation skill compared to sport coaches, parents of athletes and the general public (about 2 standard deviations). In addition, many individuals' visual risk assessment accuracy was similar to or exceeded clinical instrument-based biomechanical assessment methods (i.e., ACL nomogram). Perceptual-cognitive mechanisms are discussed.

KEYWORDS: movement analysis, injury prevention, observational screening, visual inspection, knee biomechanics

INTRODUCTION: Sport related non-contact Anterior Cruciate Ligament (ACL) injuries are a significant economic and global health problem, which disproportionately affect young female athletes (Kim *et al.,* 2011). Athletes sustaining an ACL injury lose substantial time out of sport/school, and are at greater risk for re-injury and osteoarthritis (Lohmander *et al.,* 2007; Wright *et al.,* 2007; Ardern *et al.,* 2011). Prevention techniques such as physical or neuromuscular training has been shown to be effective for reducing ACL injuries (Myer *et al.,* 2012). However, the time and resources involved in administering large-scale prevention programs is non-trivial (Hägglund *et al.,* 2013; Frank *et al.,* 2014).
One potential solution to reduce prevention time and increase effectiveness would be to ensure that practitioners have the ability to accurately and reliably assess ACL injury risk via real-time observation. First, skilled "injury risk assessors" would significantly reduce screening time and cost over current biomechanical instrument based methods (Hewett *et al.,* 2005; Myer *et al.,* 2010). Second, successful injury prevention programs emphasize biomechanical technique correction or feedback (Hewett *et al.,* 2006), thus the observer must have the ability to detect movement patterns that would place an individual at risk for injury.
Limited research using a small number of physiotherapists has begun to answer questions related to an individuals' ability to accurately assess ACL injury risk via simple observation. (Ekegren *et al.,* 2009; Stensrud *et al.,* 2010; Whatman *et al.,* 2013; Nilstad *et al.,* 2014) In addition to the limitations associated with criterion choice and judgment task instructions, three of the aforementioned studies used a limited number of raters limiting the assessment of individual differences in risk estimation ability. Moreover, all of these studies utilized physio- or physical therapists; accordingly, results cannot be generalized to other individuals who would benefit from assessing ACL injury risk including physicians, athletic trainers, sport coaches, strength & conditioning coaches, parents of athletes, and athletes themselves.
The purpose of this study was to assess differences in observational ACL injury risk estimation ability across various groups likely to use observational movement analysis for ACL injury risk. Subgroups were also compared the optimized clinically available instrument-based screening method (i.e., ACL Nomogram). Perceptual-cognitive mechanisms were explored to provide

insight into specific areas for targeted risk estimation training.

METHODS: Data from this study were obtained from 428 individuals with various occupational backgrounds (see Table 1 for specific demographic and occupational characteristics). Participants were recruited via email, through personal networks, list-serv/blog/social media posts, and from a paid web panel. Institutional Review Board approval was obtained through both Cincinnati Children's Hospital and Michigan Technological University.

Table 1
Participant demographic characteristics

Group	N	Age (SD)	Gender (% within group)	
			F	M
ExSci Student	27	24 (3.32)	52	48
ExSci Academic	21	38.05 (9.56)	33	67
S&C Coach	34	30.09 (6.7)	24	77
Athletic Trainer	50	31.52 (7.96)	50	50
Physical Therapist	46	35.26 (9.09)	35	65
Physician[a]	36	45.83 (12.3)	17	83
Sport Coach	32	31.19 (9.47)	63	38
Parent of Athlete	26	44.92 (9.31)	77	23
Female Athlete[b]	11	20.82 (1.4)	100	0
General Public	145	36.49 (12.87)	53	47

ExSci = Exercise Science; S&C = Strength and Conditioning; [a]81% of Physicians Specialized in Orthopedics/Sports Medicine and 19% in Family Medicine; [b]≤ 25 years old.

Procedures: The participants completed the web-based, five-item ACL-IQ (see www.ACL-IQ.org, and (Petushek *et al.,* 2014) for development, reliability and validation). The ACL-IQ is composed of five video clips of female athletes performing a drop vertical jump where individuals are asked to rate the risk for future ACL injury on a 1-10 scale. No other instructions or training (e.g., what to focus on) was used. The athletes featured in the videos participated in landing and cutting sports and served as the participants for the development and validation of the clinical ACL nomogram (Myer *et al.,* 2011) (*M* ± *SD;* age: 15.9 ± 1.3 years; height: 163.6 ± 9.9 cm; body mass: 57 ± 12.1 kg). Participants' risk rating responses were compared to athletes' concurrent 3D biomechanical analysis of knee abduction moment. After completing the ACL-IQ, participants reported their assessment strategies with a brief survey where they rated the importance of 11 visual cues (e.g., knee motion, hip motion, trunk motion, landing stiffness, height, weight, etc.) for making their risk assessment decision. Participants also answered 11 questions related to the ACL location, function, and risk factors for ACL injury to capture ACL specific knowledge.

Statistical Analyses: Univariate one-way analysis of variance was used to compare ACL-IQ, ACL knowledge, and cue utility ratings across the 10 groups (exercise science students, exercise science academics, physical therapists, athletic trainers, physicians, female athletes, sport coaches, parents, and general public). Post hoc, pairwise comparisons, using Tukey HSD, were used to follow up significant main effects. Independent one-sample t-tests were conducted to compare ACL-IQ scores of each subgroup with the ACL nomogram score. All statistical analyses were conducted with SPSS Version 21 (IBM, SPSS Statistics, New York). The *a priori* alpha level was set at $P < 0.05$.

RESULTS: Risk estimation performance: Specific occupation ACL-IQ scores are depicted in Figure 1. Parents and general public performed lower than all other groups ($P < 0.05$). Female athletes performed lower than exercise science students ($P < 0.05$).[1] Sport coaches displayed lower ACL-IQ scores than exercise science students and academics, physicians, strength and conditioning coaches, athletic trainers, and physical therapists ($P < 0.05$). There was no statistically significant difference in ACL-IQ between exercise science students and academics, physicians, strength and conditioning coaches, athletic trainers, or physical therapists ($P < 0.05$).

[1] Only 11 non-exercise science/sports medicine female athletes were included in the sample thus mean estimates are imprecise.

When scores were compared to ACL nomogram performance, the ACL nomogram performed better than all groups except exercise science students (*t* (26) = -1.01, *P* = 0.32; see Figure 1 top panel with Nomogram line). However, a substantial number of individuals performed similar to or better than the ACL nomogram.

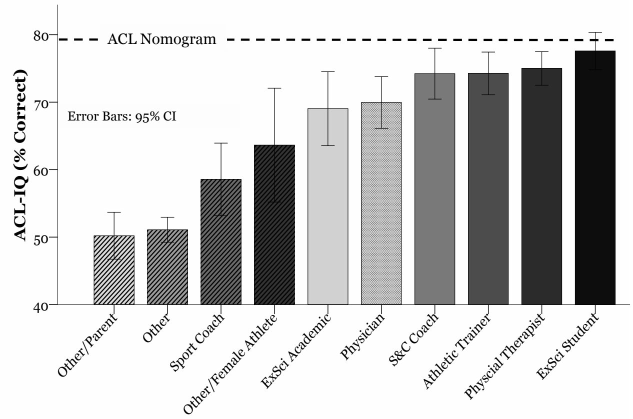

Figure 1: Cross-professional differences in ACL risk estimation skill

ACL knowledge: Sport coaches, parents, female athletes, and general public groups displayed lower ACL knowledge compared to exercise science students and academics as well as strength and conditioning coaches, athletic trainers, physical therapists, and physicians (*P* < 0.05). There were no significant differences in ACL knowledge between exercise science students and academics, physicians, strength and conditioning coaches, athletic trainers, or physical therapists (*P* > 0.05).

Cue utilization: Various differences in cue utility ratings were exhibited across groups. Overall, the superior performers (exercise science students and academics, physicians, strength and conditioning coaches, athletic trainers, and physical therapists) rated knee/thigh and trunk motion as more important for assessing injury risk compared to the less skilled (general public group, parents, female athletes, or sport coaches) (*P* < 0.05). In addition, less skilled groups rated weight and jump height as more important for assessing injury risk compared to higher skilled groups.

DISCUSSION: This investigation revealed considerable cross-professional differences in ACL injury risk estimation ability. Specifically, parents, sport coaches, and individuals not in the sport medicine/exercise science fields (general public), on average, performed poorly. Exercise science students and other sports medicine/exercise science professionals) performed at levels that were roughly equivalent to that of the clinical instrument-based ACL injury risk assessment method (i.e., ACL nomogram). Although skilled performance was relatively high, the majority of the sample studied did not reach the performance level of the ACL nomogram, and thus may benefit from training or decision support when utilizing visual inspection only.

The conclusions from this cross-sectional analysis parallel the recent perceptual-cognitive modeling results (Petushek *et al.,*). That is, parents, sport coaches and general public have lower ACL-IQ likely due to their lower ACL knowledge, rating the importance of knee/thigh motion lower, and weight and jump height higher. The slightly higher ACL-IQ of sport coaches over the general public group is likely due to the slightly higher ACL knowledge and higher rating of knee/thigh motion. These four factors (i.e., ACL knowledge and cue utility ratings for knee/thigh motion, jump height and weight) were the dominant factors influencing ACL-IQ performance even when considering ACL injury risk assessment experience, educational level, personality, and domain general perceptual-cognitive abilities (Petushek *et al.,* 2014). Theoretically, modifying any of these factors should improve performance. However, the most efficient and effective method for training visual assessment skill has not been investigated. Future research may benefit from utilizing higher fidelity cognitive process tracing methods (e.g., eye-tracking, verbal reports, etc.) to develop training or decision support systems.

CONCLUSION: Overall, the findings from this study identified the groups who need the most improvement in their ACL injury risk assessment ability. Sport coaches and parents may benefit from training in visual assessment and even sports medicine practitioners would benefit from improvement in order to reach the level of clinical based biomechanical assessment systems. The ACL-IQ is an assessment technology and feedback system for ACL injury risk prediction ability. Individuals can assess their ACL injury risk prediction ability with a short, free, and online (www.ACL-IQ.org) tool. Future research will focus on developing efficient and effective methods to improve observational risk prediction performance as well as establishing predictive evidence that individuals with high ACL-IQ can reduce ACL injuries.

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