Association of Concussion History With Lower Extremity Biomechanics

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Background & Purpose

- Athletes with a history of sport-related concussion are at up to a 2 times greater risk of lower extremity (LE) injury up to a year after return to play.[1,2,3,4]
- Disrupted cortical pathways post-concussion are proposed to explain increased lower extremity injury rates following concussion.[2]
- Although the mechanism between concussion and LE injury is unknown, it is postulated that LE biomechanics play a role, as it is known that biomechanics contribute to LE injury risk.[5]
- The Eriksen Flanker test is used to assess perceptual-motor coupling and reaction time. Slower reaction time and decreased accuracy have been documented following a mild traumatic brain injury or concussion.[6]
- It is possible that perceptual-motor coupling may partially explain the mechanics between concussion and subsequent LE injury.

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Purpose & Hypothesis

- The purpose of this study was to determine the extent to which concussion history is associated with LE biomechanics and the level to which this relationship is mediated by perceptual-motor function.
- We hypothesized that there would be an association of concussion history with altered single-leg squat biomechanics, defined as increased knee valgus, contralateral hip drop, and ipsilateral trunk lean, and this relationship would be mediated by decreased perceptual-motor reactivity.

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Methods

- Each participant completed an Overall Wellness Index (OWI) survey, a phone Flanker test, and a series of 3 single leg squats on both legs.
  - OWI is a 10-category questionnaire consisting of a list of 82 symptoms derived from known post-concussion syndrome symptoms, which produces a score of 0-100 based on the frequency and recency of those symptoms.[7]
  - Flanker test is a measure of perceptual-motor reaction time through the use of a custom phone application. Participants tilt the phone to the left or right corresponding to the direction of the middle arrow in a congruent (<<<<< or >>>>>) or incongruent (<<><< or >><>>) sequence.[7,8]
  - Single leg squats were filmed in the frontal plane. Trunk (ipsilateral lean), pelvis (contralateral pelvic drop), and knee (valgus/abduction) angles at peak knee flexion were measured offline with ImageJ software and used for analysis.[9]

Descriptive statistics for participants

	Males (n = 34)	Females (n = 53)
Age, y	23.53 ± 5.08	21.91 ± 2.55
Height, m	1.83 ± 0.06	1.65 ± 0.07
Weight, kg	84.38 ± 15.44	64.36 ± 13.5
Concussion history	9	12
Months since last concussion	69.14 ± 77.62	53.19 ± 59.21

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Methods - Statistical Analysis

- Multiple regression (stratified by sex) was used to generate models that quantified the level to which concussion history and OWI associated with biomechanics and the extent to which this relationship was mediated by perceptual-motor function (PMF).
  - **Independent variables:**
    - Concussion history (yes/no)
    - OWI symptom score (higher score = fewer symptoms)
  - **Mediators: (lower scores indicate superior PMF)**
    - Conflict index (incongruent reaction time [RT] minus congruent RT)
    - Efficiency index (RT divided by response accuracy)
  - **Dependent variables:**
    - Trunk - ipsilateral lean angle
    - Pelvis - contralateral drop angle
    - Knee - abduction/valgus angle

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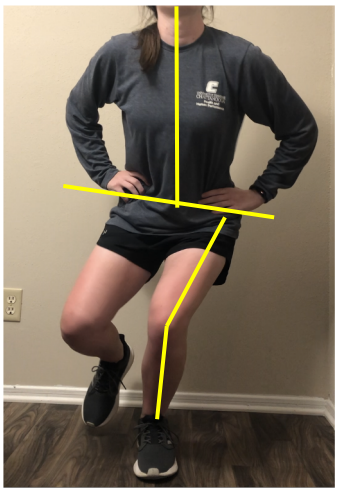
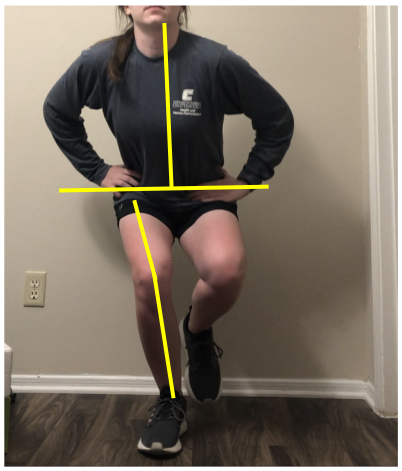


Left Side Single-leg Squat



Right Side Single-leg Squat

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Female Results (Table 1)
N=53

Part Correlations

			P value		Control variables		Mediator variables	
Dependent variable	Step	L/R	R^2	R^2 change	Con HX	OWI Symp.	FKR EFF	FKR CI
Trunk Ipsilateral lean	1	R	.03 (.45)		.09	-.17		
	2		.03 (.79)	.003 (.93)	.09	-.17	-.05	.03
	1	L	.05 (.29)		.13	-.21		
	2		.09 (.34)	.04 (.36)	.10	-.19	-.18	.01
Pelvis Contralateral drop	1	R	.03 (.50)		-.12	.15		
	2		.29 (.002)	.26 (<.001)	-.18	.14	.02	-.46
	1	L	.02 (.65)		-.08	-.07		
	2		.12 (.18)	.10 (.07)	-.13	-.05	-.16	-.17
Knee Abduction	1	R	.04 (.41)		-.19	.05		
	2		.05 (.63)	.02 (.66)	-.20	.04	.03	-.13
	1	L	.07 (.15)		-.26	-.004		
	2		.08 (.39)	.006 (.85)	-.24	.001	-.03	.08

R/L= Right limb/Left limb; R^2 (p-value), R^2 Change (p-value), Con HX= Concussion History; OWI Symp. = Overall Wellness Index Symptom number; FKR EFF= Flanker Efficiency; FKR CI= Flanker Conflict Index

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Male Results (Table 2)
N=34

Part correlations

			P value		Control variables		Mediator Variables	
Dependent variable	Step	R/L	R^2	R^2 change	Con HX	OWI Symp.	FKR EFF	FKR CI
Trunk Ipsilateral lean	1	R	.03 (.66)		-.16	.04		
	2		.10 (.55)	.07 (.34)	-.19	.06	.19	-.02
	1	L	.02 (.73)		.14	.01		
	2		.04 (.90)	.02 (.80)	.15	.003	-.12	.08
Pelvis Contralateral drop	1	R	.03 (.65)		-.16	-.02		
	2		.15 (.32)	.12 (.15)	-.12	-.05	-.32	.15
	1	L	.01 (.93)		-.05	.06		
	2		.06 (.76)	.05 (.44)	-.05	.05	.11	-.22
Knee Abduction	1	R	.05 (.49)		-.16	-.11		
	2		.10 (.53)	.06 (.42)	-.17	-.11	-.10	.22
	1	L	.03 (.66)		.12	-.13		
	2		.08 (.66)	.05 (.46)	.13	-.14	-.19	.22

R/L= Right limb/Left limb; R^2 (p-value), R^2 Change (p-value), Con HX= Concussion History; OWI Symp. = Overall Wellness Index Symptom number; FKR EFF= Flanker Efficiency; FKR CI= Flanker Conflict Index

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Results - Females

- Concussion history and increased OWI symptoms explained 3% (right side) and 2% (left side) of greater contralateral drop of the pelvis.
- The addition of superior perceptual-motor function explained an additional 26.1% (R^2 change=0.261, p change=0.002) of variance on the right side of the pelvis and 10.3% (R^2 change=0.103, p change=0.071) on the left side of the pelvis.

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Results - Males

- Concussion history and increased OWI symptoms explained 3% variance of greater right contralateral drop of the pelvis and 5% variance of right knee abduction.
- The addition of superior perceptual-motor function explained an additional explained variance of 11.9% (R^2 change= 0.119; p change=0.152) on the right side of the pelvis and an increase of 5.5% (R^2 change= 0.0.55; p change=0.420) in abduction of the right knee.

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Discussion

- Our results partially supported our hypothesis.
  - We expected there to be some association between PMF and altered LE biomechanics, but we did not find an association between concussion history and altered biomechanics.
- While there was little association found between concussion history, OWI symptom score, and altered biomechanics, our results suggest there may be a link between altered perceptual-motor function and biomechanics.

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Clinical Applications

- A reported history of concussion may not be directly associated with alterations in lower extremity biomechanics, leading to increased risk of injury.
  - It is possible that time from last concussion may have a greater impact on an individual's subsequent risk of injury, as studies have indicated that increased lower extremity injury risk is present up to a year following concussion.[1-3]
    - For the present study, the subjects who had a history of concussion were an average of five years out from their most recent concussion.
- Perceptual-motor function may matter more on single-leg tasks compared to double-leg tasks, which is driving our results related to contralateral pelvic tilt.
  - It may be more beneficial clinically to have the athlete complete a reaction time task to better gauge their abilities of utilizing perceptual-motor function during tasks rather than relying on self-reported symptoms of concussion.

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Acknowledgements

- Special thanks to the following individuals for completing data collection and product development of the Flanker phone application used:
  - Data Collection:
    - Ashley Williams, MS, ATC
    - Colt Jenkins, MS, ATC
    - Samantha Kendall, MS, ATC
  - Flanker App Development:
    - Alnour Alharin

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