The Effect of Vertical Jump Fatigue and Sprint Fatigue on Total-Body Biomechanics

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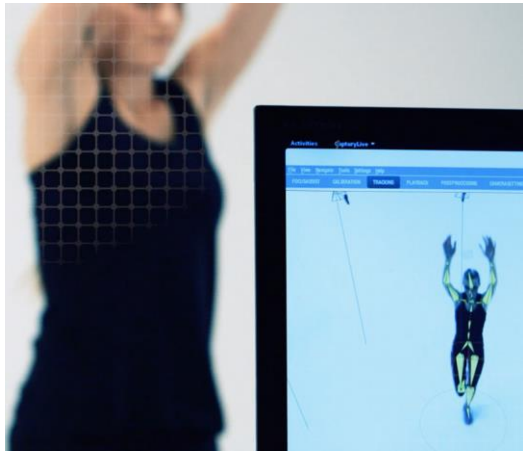
Motion Capture Systems

- Advancements in technology
  - Specifically motion capture systems
  - Markered & markerless MCS
  - Used to assess individual’s upper-and lower-body motions
  - Both explosive and functional motions in nature

- Provide detail kinetic and kinematic analyses of movements
  - Counter-movement vertical jumps
  - Vertical displacement COM
  - Other dynamic motions

- Markerless MCS
  - Quantify kinetic and kinematic movement of body segments and joints influencing forces generated and enhanced performance during CMVJ with AS



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Vertical Jumps

- Vertical Jumps
  - Preformed in variety of athletic events
  - Essential component of successful athletic performance
  - Relies of muscle groups to actively synchronize to raise COM
  - Predictor of changes in lower-body power and lifting performance

  - Testing Devices
    - Sargent’s jump test
    - Vertical jumping mat
    - Force plate
    - Video analysis
    - Motion capture system

Anaerobic Tests

- Variety of anaerobic tests that incorporate
  - Different modes of exercise
  - Movement patterns
  - All varying in durations

- Examples of anaerobic tests
  - Wingate anaerobic test
  - Kansas squat test
  - Bosco jump test
  - Non-motorized resisted sprint

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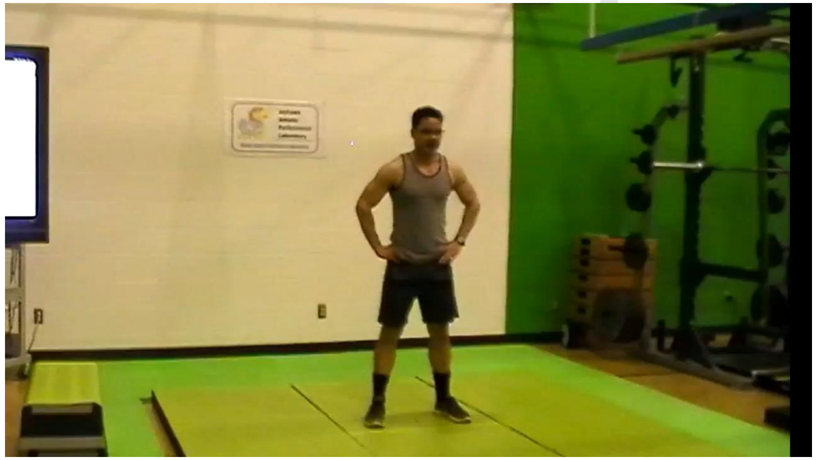
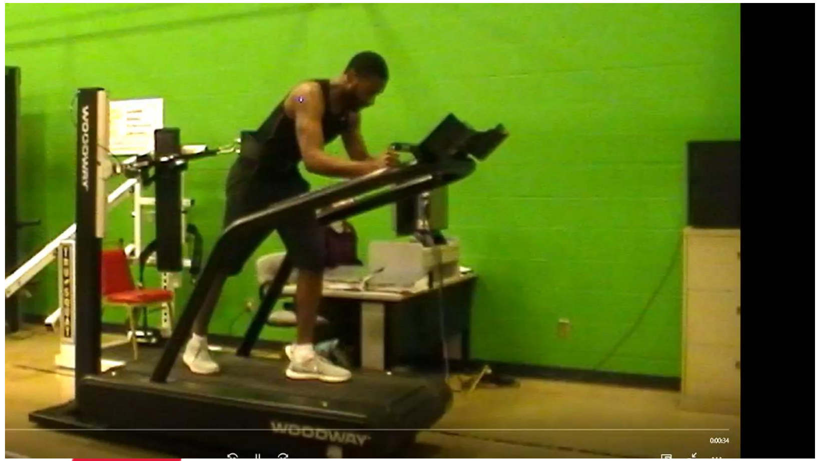
Anaerobic Tests

- Variety of anaerobic tests
  - Bosco test – Repeated-jump protocol
    - 60 seconds
    - Hands on hips
    - 90 deg. Knee flexion
  - Non-motorized resisted sprint
    - 25 second sprint
    - 18% BW resistance
- Repeated VJs and sprinting protocols
  - Measure anaerobic power and capacity





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Injury Mechanics

- ACL injuries are most common knee injuries in athletes
- According to NCAA injury surveillance system
  - The lower extremities are the most common injury sites (50.4%)
  - Knee is most common injury location overall (17.1%)
  - Acute non-contact is most common injury mechanism (24.1%)
  - 70% of all ACL tears are due to non-contact mechanisms
  - Re-injury accounts for 13% of all injuries
- Sports require high amount of energy to accelerate and decelerate
  - Muscle performance fatigue

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Fatigue Mechanics

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- Fatigue is extrinsic factor affecting the musculoskeletal and neurological systems

- System of fatigue seems to create environment
  - Increases the risk of non-contact ACL injury
    - By altering lower extremity landing strategies

- Fatigue has been reported
  - Decrease balance skill
  - Increase knee joint laxity and stabilization
  - Decrease balance skill
  - Decrease proprioception
  - Decrease capacity to absorb energy

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Injury Mechanics

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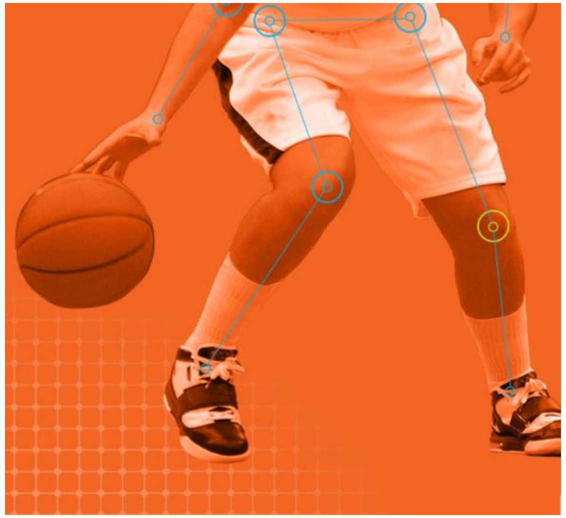
- Decreased capacity for controlling body movement after fatigue and can be considered as a contributor to injuries specifically non-contact ACL injuries

- Fatigue protocol of VJs and sprints cause individuals to land with increased proximal tibia peak anterior shear force and decreased knee flexion
  - Chappell et al. 2005



- If musculature surrounding the joints are not properly developed, maintained, or fatigue, it may lead to ligament susceptibility during shock experienced during movements

- Prevention and intervention have become focal points for researchers and clinicians

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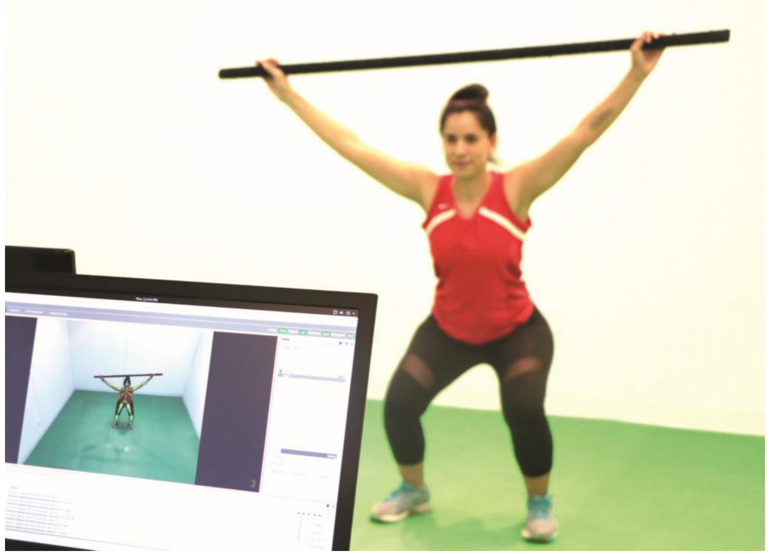
Problem Statement

- Further evaluation and understanding of biomechanical changes in performance will give future insight into how fatigue can be rated and prevent fatigue related injuries

- Notion that fatigue is a predisposing factor responsible for increase number of musculoskeletal injuries
  - Risk of non-contact injuries
  - Altering lower extremity takeoff and landing strategies

- Evaluation of acute biomechanical fatigue rates may determine when an athlete is able to return to sport following rehabilitation



Purposes

- Determine the acute biomechanical alterations on total-body following VJ fatiguing and sprint fatiguing tasks

- Understanding acute total-body biomechanical fatigue may further provide information for understanding when an athlete begins altering mechanics to sustain performance

Methods

- Experimental Approach to the Problem
  - To determine the acute biomechanical performance alterations of total-body following acute fatiguing protocols
  - Specifically, a markerless 3-D video motion capture system and force plate was used to compare the kinetic and kinematic changes in performance following variety of fatiguing protocols

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Methods

- Subjects

Table 1. Descriptives Characteristics

Mean ± SD	Subjects (#)	Age (yrs)	Height (cm)	Weight (kg)
Females	11	20.8 ± 1.1	172.2 ± 7.4	68.0 ± 7.2
Males	11	23.0 ± 2.6	180.3 ± 4.8	80.4 ± 7.3

- Recreationally Trained
  - Physically active for a minimum for 1 hour for three days per week
  - For preceding three months
  - No current neuromuscular diseases or musculoskeletal injuries
  - Functional ROM to hip, knee, ankle, and shoulder joints
  - Mechanical motion and performance during VJ and running
  - Approved by University's institutional review board for human subjects' research

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Methods

- Procedures
  - Four visits
  - 1 Familiarization, 1 Control, 2 Experimental Sessions
  - Experimental Sessions
    - Modified VJ test, 25-sec resisted sprint test

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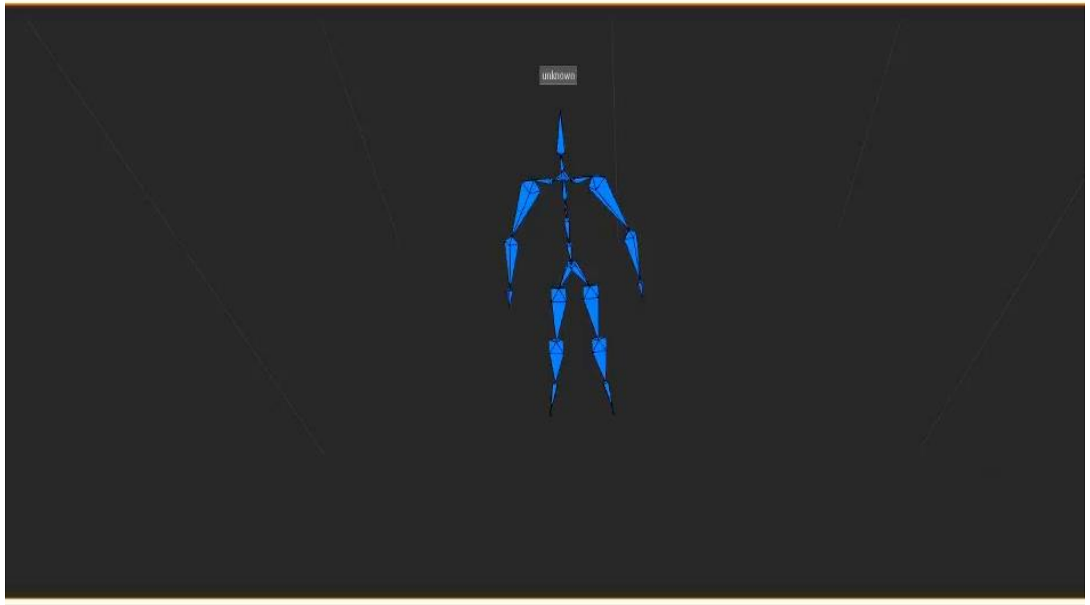
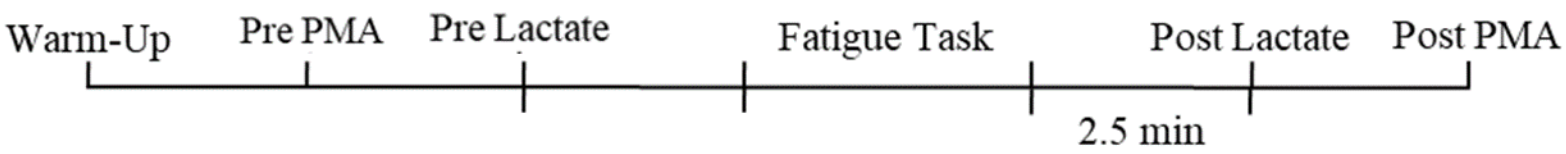
Methods

- Procedures
- 3-D markerless motion capture system
    - 8-camera motion capture system
    - DARI Motion Software (Scientific Analytics)
    - Performance Motion Analysis
        - PMA or FMA



Methods

- Procedures
  - Control & Experimental Sessions
    - 10-min standardized Warm-up
    - Pre- & Post-Test PMA
    - Accumulated blood lactate
      - Before & 2.5 min post fatigue test
    - Heart rate
      - Before & after fatigue test



  - Control Session
    - Sit comfortably for 15 mins

Dynamic Warm-Up
10 Quad Pull to RDL
10 Tin Shoulders
10 Figure 4
10 Walking Lunges with T-Spine Rotation
5 Inchworms
Forward Skip with Forward Arm Circles
Backward Skip with Backward Arm Circles
Forward Skip with Hip Internal Rotation
Backward Skip with Hip External Rotation
A-Skip
A-Skip to Squat
10 Body Weight Squats

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Acute Fatigue Protocols

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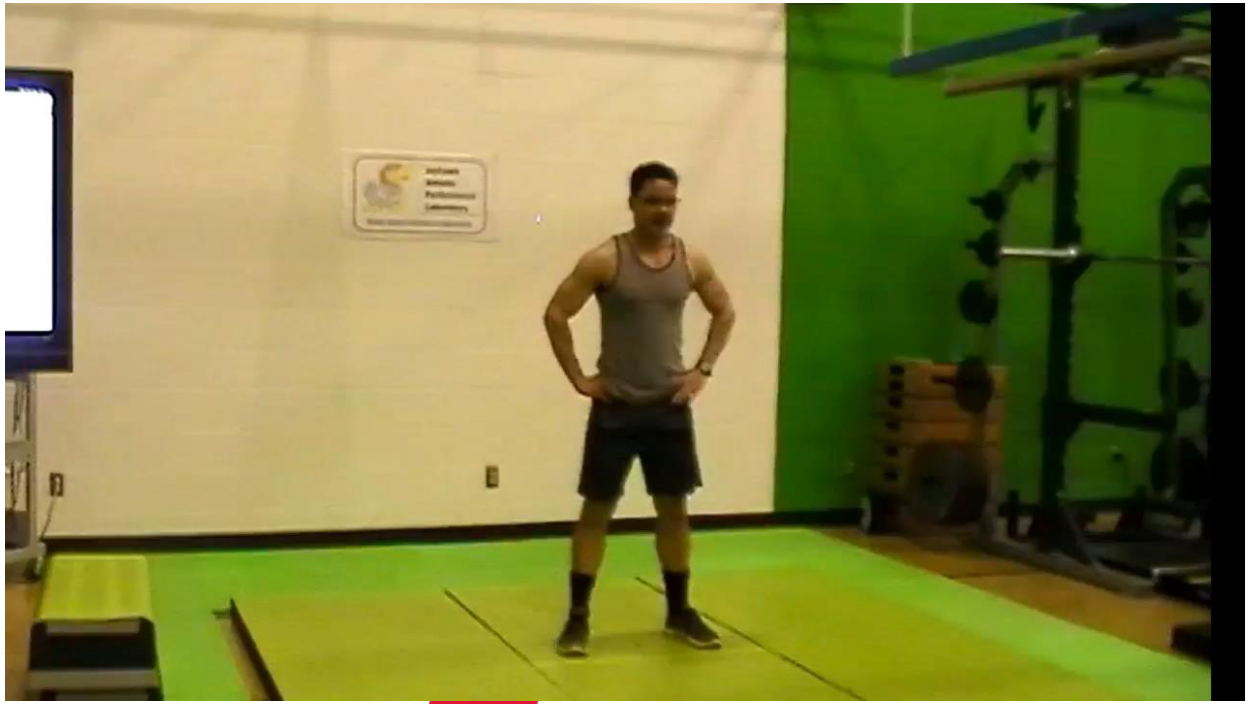
- Modified Vertical Jump Test
  - Force Plate - Rice Lake Weighing Systems
  - Data Acquisition System - Biopac MP150 System

  - Bend knee to 90 degrees and jump explosively
  - Repeat immediately on landing

  - 5 sets (~5 minutes)
    - Each set last 1 minute
    - 15 sec jumping
    - 15 sec rest
    - Repeat



Acute Fatigue Protocols

- 25-second Sprint Test
  - Resisted harness of a non-motorized treadmill
    - Woodway Force 3.0 treadmill

  - Resistance equal to 18% of subject's body weight
  - 25-second maximal sprint

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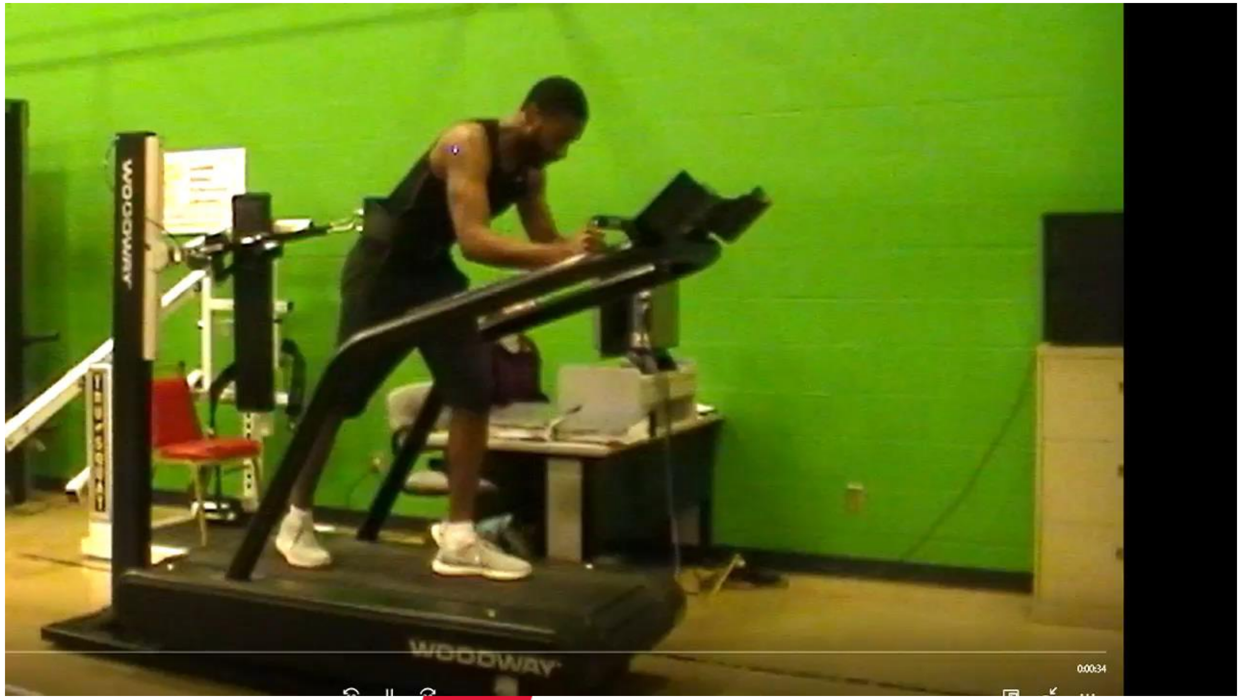

Performance Motion Analysis

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- Performance motion analysis (PMA)
  - Shoulder ROM
    - Shoulder abduction and adduction
    - Horizontal abduction and adduction
    - Internal and external rotation
    - Flexion and extension
  - Trunk rotation

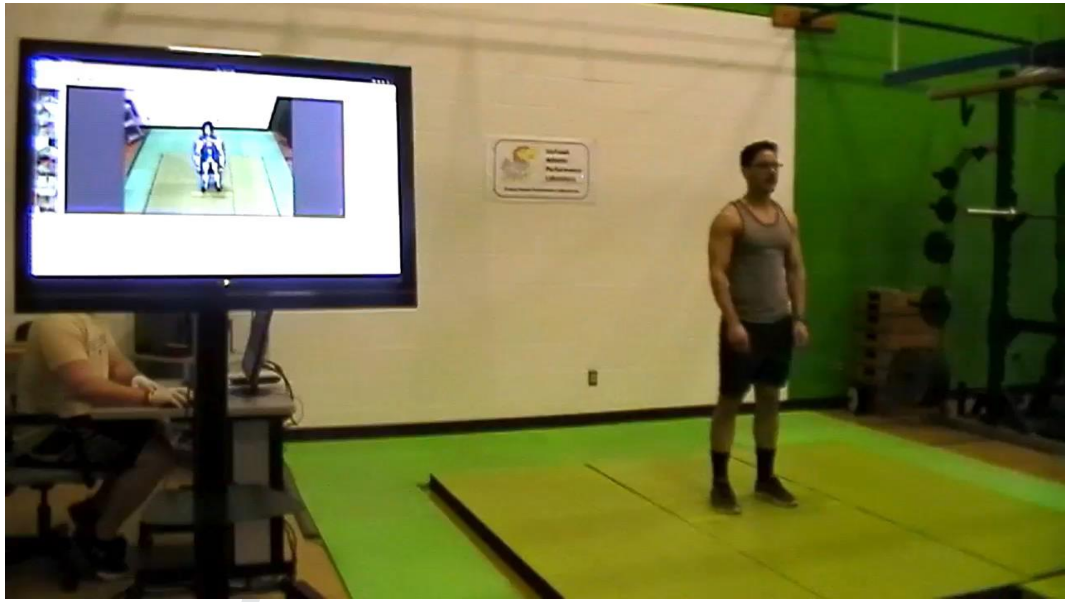
3

  - Bilateral overhead squat
  - Unilateral squats
  - Forward lunges
  - Single leg balance

2

  - Bilateral counter-movement vertical jump (CMVJs)
  - Unilateral CMVJs
  - Concentric-only VJ
  - Multiple unilateral CMVJs
  - Depth Jump

1



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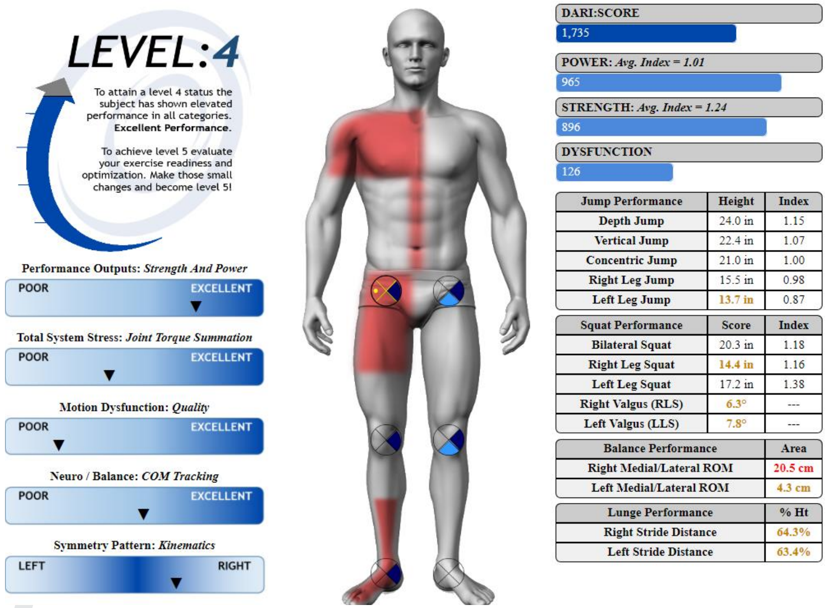
PMA Scores

- 19 PMA motions
- 192 Variables collected from kinetic and kinematic data
- Calculated into 6 performance scores

- PMA Scores
  - MCS Composite Score
  - Power Score
  - Strength Score
  - Dysfunction Score
  - Exercise Readiness Score
  - Vulnerability Score



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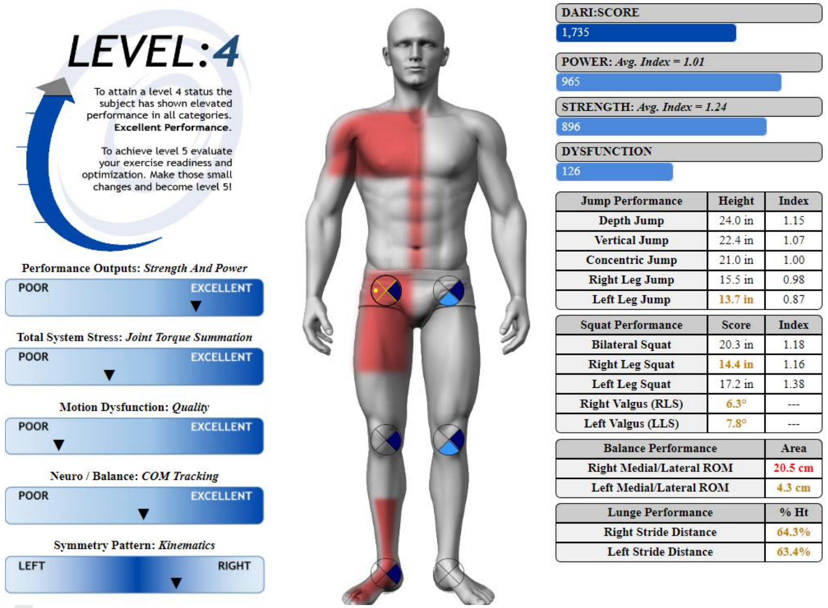
PMA Scores

- MCS Composite Score
  - Combination of strength, power, and dysfunction scores

- Power Score
  - Accumulation of jump motions
  - Vertical Jump height
  - Aggregate of all jump performance metrics

- Strength Score
  - Accumulation of squat motions
  - Squat depths
  - Aggregate of all squat performance metrics

- Dysfunction Score
  - Asymmetry, knee valgus, kinetic chaining, balance performances



Jump Performance	Height	Index
Depth Jump	24.0 in	1.15
Vertical Jump	22.4 in	1.07
Concentric Jump	21.0 in	1.00
Right Leg Jump	15.5 in	0.98
Left Leg Jump	13.7 in	0.87

Squat Performance	Score	Index
Bilateral Squat	20.3 in	1.18
Right Leg Squat	14.4 in	1.16
Left Leg Squat	17.2 in	1.38
Right Valgus (RLS)	6.3°	---
Left Valgus (LLS)	7.8°	---

Balance Performance	Area
Right Medial/Lateral ROM	20.5 cm
Left Medial/Lateral ROM	4.3 cm

Lunge Performance	% Ht
Right Stride Distance	64.3%
Left Stride Distance	63.4%

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PMA Scores

- Exercise Readiness Score
  - Rebalance
    - Remove compensations and find symmetry between right and left upper and lower extremities consisting of unilateral forces, joint flexions, and joint torques
    - Individual is in the structuring phase and focus on basic mechanics
  - Development
    - Individual is on the right path and needs to continue the development
    - Individual displays kinetic and kinematic symmetry and is in the developmental phase
  - Optimize
    - Individual needs to maintain
    - Individual is displaying peak performance mechanics

PMA Scores

- Vulnerability Score
  - Scale 0-100%

  - Aggregate of overall performances

  - Joint stresses
    Consisting of unilateral high forces, joint flexions, & joint torques

  - Compensation patterns
    - Overuse of dominate side or limited usage due to history of an injury

  - High risk for injury
    - Vulnerability score >60%
    - Composite score <1800 points
    - Strength & power score difference ≥350 points
    - Joint torque differences greater than 30% bilateral joints

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Statistical Analyses

- Pearson Correlation Matrix
  - Relationship between each PMA Scores during familiarization session

- 2-way ANOVAs
  - Condition (VJ, Sprint, Control) x Time (Pre-test, Post-test)
    - Differences in HR
    - Accumulated blood lactate

- Paired Samples *t*-tests
  - Differences in flight time & positive impulses
  - 2nd jump of set 1 & last jump of set 10

Statistical Analyses

- Repeated Measures MANOVA
  - Performance Scores x Condition x Time x Sex
    - Performance Scores
      - Composite, Power, Strength, Dysfunction, Exercise Readiness Score, Vulnerability Scores
    - Condition
      - VJ, Sprint, Control
    - Time
      - Pre-test & Post-test
    - Sex
      - Male & Female
- Post hoc comparisons were conducted when needed using the Bonferroni correction. The level of significance was set to $P \leq 0.05$

Results

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Table 3. Pearson correlation matrix among the reported scores during the familiarization session

	MCS Composite Score	Power Score	Strength Score	Dysfunction Score	Vulnerability Score	Exercise Readiness Score
MCS Composite Score	----	0.90*	0.78*	-0.41	-0.26	0.92*
Power Score	----	----	0.47*	-0.12	-0.18	0.89*
Strength Score	----	----	----	-0.39	-0.42	0.64*
Dysfunction Score	----	----	----	----	0.64*	-0.33
Vulnerability Score	----	----	----	----	----	-0.47*
Exercise Readiness Score	----	----	----	----	----	----

n=22; *correlation indicates significance $p < 0.05$

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Results

Table 2. Reported MCS Composite, power, strength, dysfunction, vulnerability, and exercise readiness scores durin (FAM), and pre and post test during the vertical jump (VJ), sprint, and control (CON) experimental sessions.

Condition	Sex	MCS Composite Score	Power Score	Strength Score	Dysfunction Score	Vulnerability Score	Exercise Readiness Score
FAM	F	1363.0 ± 200.8	663.6 ± 114.3	840.6 ± 94.3	141.5 ± 72.4	44.3 ± 14.7	15.7 ± 2.7
	M	1859.3 ± 152.3	1009.5 ± 141.3	974.1 ± 94.9	124.2 ± 36.5	40.1 ± 9.6	21.7 ± 2.0
Pre VJ	F	1387.2 ± 184.6	665.6 ± 86.0	830.6 ± 97.4	108.8 ± 48.8	40.9 ± 10.1	16.0 ± 2.3
	M	1839.2 ± 159.4†	1015.3 ± 132.0†	949.7 ± 83.1	126.0 ± 32.3	37.0 ± 8.0	21.7 ± 2.3
Post VJ	F	1217.9 ± 166.9*	585.5 ± 45.1*	779.2 ± 113.0*	146..7 ± 60.8	46.7 ± 11.0*	13.8 ± 1.6*†
	M	1518.1 ± 264.1*	789.2 ± 173.6*	883.6 ± 101.8*	163.7 ± 73.5	42.6 ± 13.4	18.2 ± 3.6*
Pre Sprint	F	1414.8 ± 212.1	691.1 ± 95.4	840.5 ± 101.5	116.7 ± 37.1	39.9 ± 7.1	16.4 ± 2.2
	M	1804.0 ± 143.0	999.0 ± 126.1	928.3 ± 107.4	123.2 ± 56.6	37.6 ± 9.1	21.0 ± 2.3
Post Sprint	F	1365.9 ± 170.1	633.8 ± 82.2	838.6 ± 85.4	164.5 ± 203.2	41.6 ± 7.3	15.4 ± 1.9
	M	1662.8 ± 221.9*	889.9 ± 155.2	907.4 ± 114.8	131.6 ± 48.0	37.8 ± 10.9	20.2 ± 2.8
PRE CON	F	1387.3 ± 210.1	655.3 ± 106.3	834.6 ± 85.4	102.6 ± 44.5	40.6 ± 9.0	15.7 ± 2.6
	M	1799.7 ± 145.6	965.1 ± 138.2	948.7 ± 100.4	114.2 ± 51.9	37.4 ± 10.2	21.3 ± 2.2
Post CON	F	1354.7 ± 210.1	643.5 ± 121.1	823.9 ± 100.4	112.5 ± 46.7	41.1 ± 8.7	15.3 ± 2.9
	M	1676.4 ± 276.9	918.0 ± 160.2	806.1 ± 307.5	126.5 ± 51.3	39.0 ± 14.3	20.1 ± 3.5

Mean ± SD for reported scores for females (F) and males (M). * indicates significant differences between pre to post. MANOVA significant differences between score x condition x time (p=0.14). † indicates further the MANOVA significant differences (*p* <0.05).

Results

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Table 4. Heart rate and change in accumulated lactate during multiple time points throughout the vertical jump (VJ), sprint, and control (CON) sessions

		Heart Rate (bpm)		Accumulated Lactate (mmol/L)	
Condition	Sex	Pre	Post	Pre	Post
VJ	F	80.9 ± 15.5	183.9 ± 12.8*†	2.6 ± 1.7	11.2 ± 2.4*†
	M	69.9 ± 10.5	171.2 ± 23.9*†	2.1 ± 1.2	13.6 ± 1.8*†
Sprint	F	79.3 ± 18.9	168.5 ± 30.8*†	2.5 ± 1.6	10.7 ± 2.0*†
	M	75.1 ± 10.0	176.6 ± 8.8*†	3.3 ± 3.0	14.8 ± 3.0*†
CON	F	75.4 ± 18.9	74.7 ± 6.4	1.7 ± 0.5	3.1 ± 2.9
	M	81.6 ± 17.0	86.7 ± 11.9	3.2 ± 2.5	2.3 ± 2.2

Heart rate and change in accumulated lactate for females (F) and males (M). * indicates significant differences between pre to post, † indicates significant differences from the control ($p<0.05$).

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Table 5. Vertical jump performances $\bar{X} \pm SD$ for females (F) and males (M) during the modifed vertical jump test during the first and last set

	Set 1			Set 10				
		Jump 2 of Set 1			Last Jump of Set 10		Change in Flight	Change in Positive
Sex	# of Jumps	Flight Time (sec)	Positive Impulse (N·sec)	# of Jumps	Flight Time (sec)	Positive Impulse (N·sec)	Time (%)	Impulse (%)
F	13.0 ± 1.0	0.4 ± 0.1	250.0 ± 48.5	13.0 ± 1.0	0.3 ± 0.0*	161.5 ± 52.8*	-33.7 ± 12.7	-33.8 ± 20.4
M	14.0 ± 1.0	0.5 ± 0.0	381.4 ± 46.5	13.0 ± 1.0	0.3 ± 0.1*	204.1 ± 80.5*	-41.8 ± 9.7	-46.2 ± 20.6

Females (F), Males (M). * indicates significant differences between set 1 and set 10, ($p<0.05$), Change in flight time and positive impulse during the selected vertical jump

Results

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Table 6. Sprint performance $\overline{X} \pm$ SD of females (F) and males (M) during the 25 sec non-motorized resisted sprint test

Sex	Distance (m)	Mean Sum Force (N)	Mean Power (W)	Peak Power (W)	Change in Power (%)	Mean Velocity (m/s)	Peak Velocity (m/s)	Change in Velocity (%)
F	70.15 ± 7.46	155.43 ± 15.92	400.44 ± 76.24	1577.05 ± 316.41	-47.36 ± 12.15	2.80 ± 0.30	3.54 ± 0.47	-24.32 ± 6.77
M	94.68 ± 7.96	190.19 ± 17.13	716.34 ± 114.73	2825.17 ± 439.93	-66.24 ± 11.04	3.78 ± 0.32	5.05 ± 0.64	-33.86 ± 10.80

Mean sum force is the sum of horizontal and vertical forces; mean power and mean velocity is the average across the 25 sec sprint; peak power and peak velocity is the maximum value across the 25 sec sprint; change in power and change in velocity is the difference between the maximum peak to the last peak represented as a percent

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Table 7. Reported the fatigue rates $\bar{X}$ ± SD percent for the composite, power, strength, dysfunction, vulnerability, and exercise readiness scores during the vertical jump (VJ), sprint, and control (CON) experimental session

Condition	Sex	MCS Composite Score	Power Score	Strength Score	Dysfunction Score	Vulnerability Score	Exercise Readiness Score
VJ	F	-11.88 ± 8.08	-11.40 ± 9.22	-6.18 ± 8.27	57.87 ± 96.71	17.24 ± 23.43	-12.64 ± 8.85
	M	-17.69 ± 10.09	-22.68 ± 11.11	-7.03 ± 5.64	46.03 ± 94.37	21.39 ± 47.41	-16.19 ± 11.77
Sprint	F	-3.02 ± 5.24	-7.96 ± 7.20	-0.13 ± 6.78	48.72 ± 170.35	5.28 ± 18.28	-6.00 ± 6.29
	M	-7.74 ± 10.94	-10.56 ± 13.50	-1.93 ± 9.57	20.71 ± 52.02	2.70 ± 23.90	-3.62 ± 12.55
Control	F	- 2.25 ± 9.96	-1.00 ± 17.69	-1.34 ± 5.47	26.75 ± 80.48	3.99 ± 23.40	-2.08 ± 13.54
	M	-7.09 ± 11.32	-5.20 ± 3.88	-15.07 ± 31.63	25.44 ± 62.65	3.61 ± 15.47	-6.1 ± 9.99

Fatigue rate is the difference between the pre score and post score as a percent of mean change across subjects

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Discussion

- Determined mMCS was capable of detecting acute total-body biomechanical changes due to acute fatigue tests
- PMA scores indicated alterations of performance following the modified VJ test
    - Composite Score, Power Score, ERS
- Decrease in Power Score can account for the reduction in Composite Score
    - Decrease in the Power Score can be explained by a reduction in power and velocity
- No changes in strengths scores
    - Explained by aggregate of all squat performances
    - Not affected by the acute fatigue

Condition	Sex	DARI Score	Power Score	Strength Score
FAM	F	1363.0 ± 200.8	663.6 ± 114.3	840.6 ± 94.3
	M	1859.3 ± 152.3	1009.5 ± 141.3	974.1 ± 94.9
Pre VJ	F	1387.2 ± 184.6	665.6 ± 86.0	830.6 ± 97.4
	M	1839.2 ± 159.4†	1015.3 ± 132.0†	949.7 ± 83.1
Post VJ	F	1217.9 ± 166.9*	585.5 ± 45.1*	779.2 ± 113.0*
	M	1518.1 ± 264.1*	1518.1 ± 264.1*	883.6 ± 101.8*
Pre Sprint	F	1414.8 ± 212.1	691.1 ± 95.4	840.5 ± 101.5
	M	1804.0 ± 143.0	999.0 ± 126.1	928.3 ± 107.4
Post Sprint	F	1365.9 ± 170.1	633.8 ± 82.2	838.6 ± 85.4
	M	1662.8 ± 221.9*	889.9 ± 155.2	907.4 ± 114.8
PRE CON	F	1387.3 ± 210.1	655.3 ± 106.3	834.6 ± 85.4
	M	1799.7 ± 145.6	965.1 ± 138.2	948.7 ± 100.4
Post CON	F	1354.7 ± 210.1	643.5 ± 121.1	823.9 ± 100.4
	M	1676.4 ± 276.9	918.0 ± 160.2	806.1 ± 307.5

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Discussion

- Differences in Power Scores
  - Indicate high power and velocity movements are first to falter
  - Most susceptible to fatigue

- Fry et al. 1994
  - Strength is maintained unless the fatigue stimulus is extended for a longer duration

- Decreases in ERS following modified VJ Test
  - Indicate changes in one of the 3 variables
    - Rebalance, Development, Optimize
  - Speculated the decease is due to the optimize score
    - Acute decrease in performance

Condition	Sex	DARI Score	Power Score	Strength Score	Exercise Readiness Score
FAM	F	1363.0 ± 200.8	663.6 ± 114.3	840.6 ± 94.3	15.7 ± 2.7
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Post VJ	F	1217.9 ± 166.9*	585.5 ± 45.1*	779.2 ± 113.0*	13.8 ± 1.6*†
	M	1518.1 ± 264.1*	1518.1 ± 264.1*	883.6 ± 101.8*	18.2 ± 3.6*
Pre Sprint	F	1414.8 ± 212.1	691.1 ± 95.4	840.5 ± 101.5	16.4 ± 2.2
	M	1804.0 ± 143.0	999.0 ± 126.1	928.3 ± 107.4	21.0 ± 2.3
Post Sprint	F	1365.9 ± 170.1	633.8 ± 82.2	838.6 ± 85.4	15.4 ± 1.9
	M	1662.8 ± 221.9*	889.9 ± 155.2	907.4 ± 114.8	20.2 ± 2.8
PRE CON	F	1387.3 ± 210.1	655.3 ± 106.3	834.6 ± 85.4	15.7 ± 2.6
	M	1799.7 ± 145.6	965.1 ± 138.2	948.7 ± 100.4	21.3 ± 2.2
Post CON	F	1354.7 ± 210.1	643.5 ± 121.1	823.9 ± 100.4	15.3 ± 2.9
	M	1676.4 ± 276.9	918.0 ± 160.2	806.1 ± 307.5	20.1 ± 3.5

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Discussion

- No changes in Vulnerability and Dysfunction Scores
  - Indicating as stable scores

  - Score variables unaffected
    - Asymmetry
    - Kinetic chaining
    - Compensation
    - Balance performances

Condition	Sex	Dysfunction Score	Vulnerability Score
FAM	F	141.5 ± 72.4	44.3 ± 14.7
	M	124.2 ± 36.5	40.1 ± 9.6
Pre VJ	F	108.8 ± 48.8	40.9 ± 10.1
	M	126.0 ± 32.3	37.0 ± 8.0
Post VJ	F	146..7 ± 60.8	46.7 ± 11.0*
	M	163.7 ± 73.5	42.6 ± 13.4
Pre Sprint	F	116.7 ± 37.1	39.9 ± 7.1
	M	123.2 ± 56.6	37.6 ± 9.1
Post Sprint	F	164.5 ± 203.2	41.6 ± 7.3
	M	131.6 ± 48.0	37.8 ± 10.9
PRE CON	F	102.6 ± 44.5	40.6 ± 9.0
	M	114.2 ± 51.9	37.4 ± 10.2
Post CON	F	112.5 ± 46.7	41.1 ± 8.7
	M	126.5 ± 51.3	39.0 ± 14.3

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Discussion

- Increases in HR and accumulated lactate
  - Indicate the modified VJ & resisted sprint tests
  - Glycolytic fatigue
  - Difference from Control

- Bosco et al. 1983
  - Indicated accumulated lactate
  - Wingate test - 15.4 mm·L
  - Bosco 60 jump test - 8.1 mm·L

- McLain et al. 2015
  - 25 sec resisted sprint - 15.8 mm·L

- Time of collection of accumulated lactate
- Prevent excessive recovery from acute fatigue
- Indicate significant fatigue responses

		Accumulated Lactate (mmol/L)	
Condition	Sex	Pre	Post
VJ	F	2.6 ± 1.7	11.2 ± 2.4*†
	M	2.1 ± 1.2	13.6 ± 1.8*†
Sprint	F	2.5 ± 1.6	10.7 ± 2.0*†
	M	3.3 ± 3.0	14.8 ± 3.0*†
CON	F	1.7 ± 0.5	3.1 ± 2.9
	M	3.2 ± 2.5	2.3 ± 2.2

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Discussion

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- During modified VJ Test
  - Decreases in flight times & positive impulses
  - 2nd VJ of set 1 vs. last VJ of set 10

	Jump 2 of Set 1		Last Jump of Set 10	
Sex	Flight Time (sec)	Positive Impulse (N·sec)	Flight Time (sec)	Positive Impulse (N·sec)
F	0.4 ± 0.1	250.0 ± 48.5	0.3 ± 0.0*	161.5 ± 52.8*
M	0.5 ± 0.0	381.4 ± 46.5	0.3 ± 0.1*	204.1 ± 80.5*

  - Individuals spent more time on the ground than time in the air

- During 25-sec resisted sprint test
  - McLain et al. 2015
  - Reported similar decrease change in velocity and power

Sex	Change in Power (%)	Change in Velocity (%)
F	-47.36 ± 12.15	-24.32 ± 6.77
M	-66.24 ± 11.04	-33.86 ± 10.80

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Conclusion

- Assessed individuals' upper- and lower-body mechanics

- Differences in PMA Scores and performance following acute fatigue tests
  - Indicate biomechanical alterations on total-extremities
  - Specifically lower-extremities
  - During modified VJ test

  - Affected by the deceases in power production and during high velocity movements

- Future research
  - Different populations
    - Different training history
  - Other fatiguing methods
    - Acute & chronic
  - Impact performance

Questions

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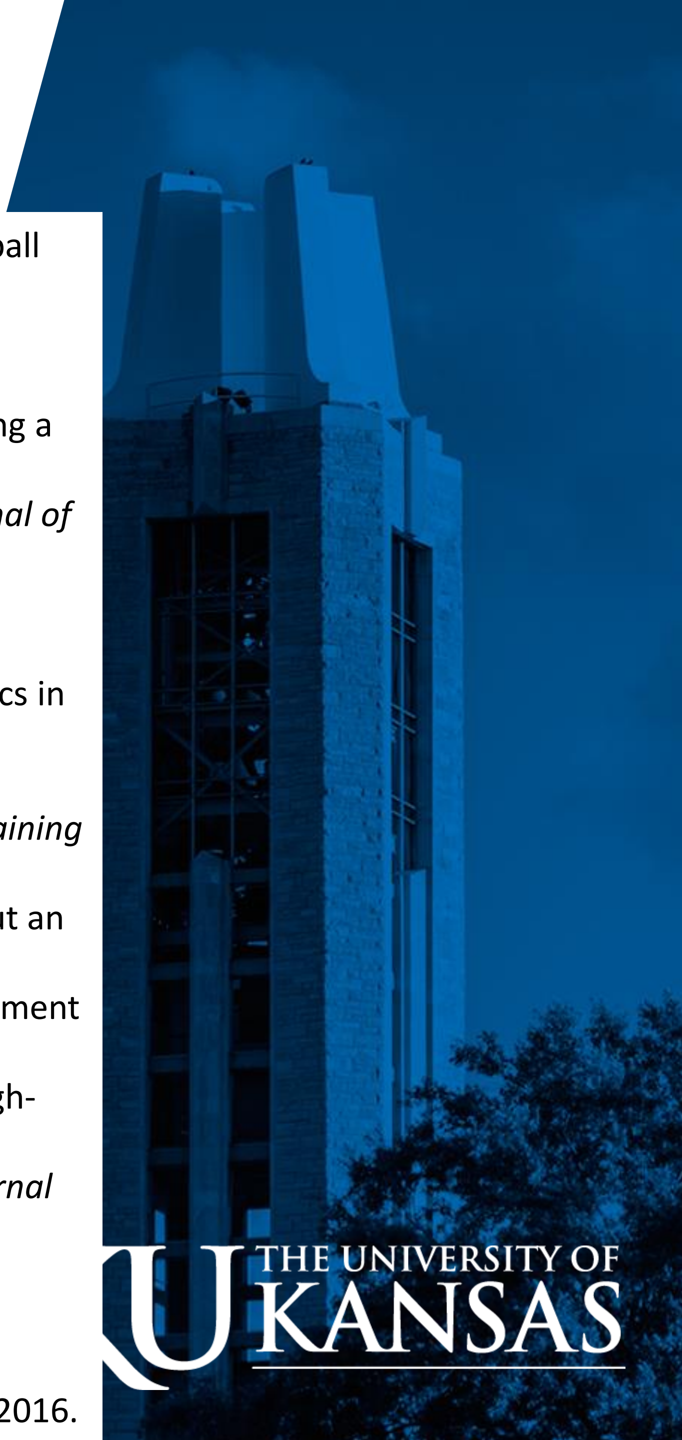

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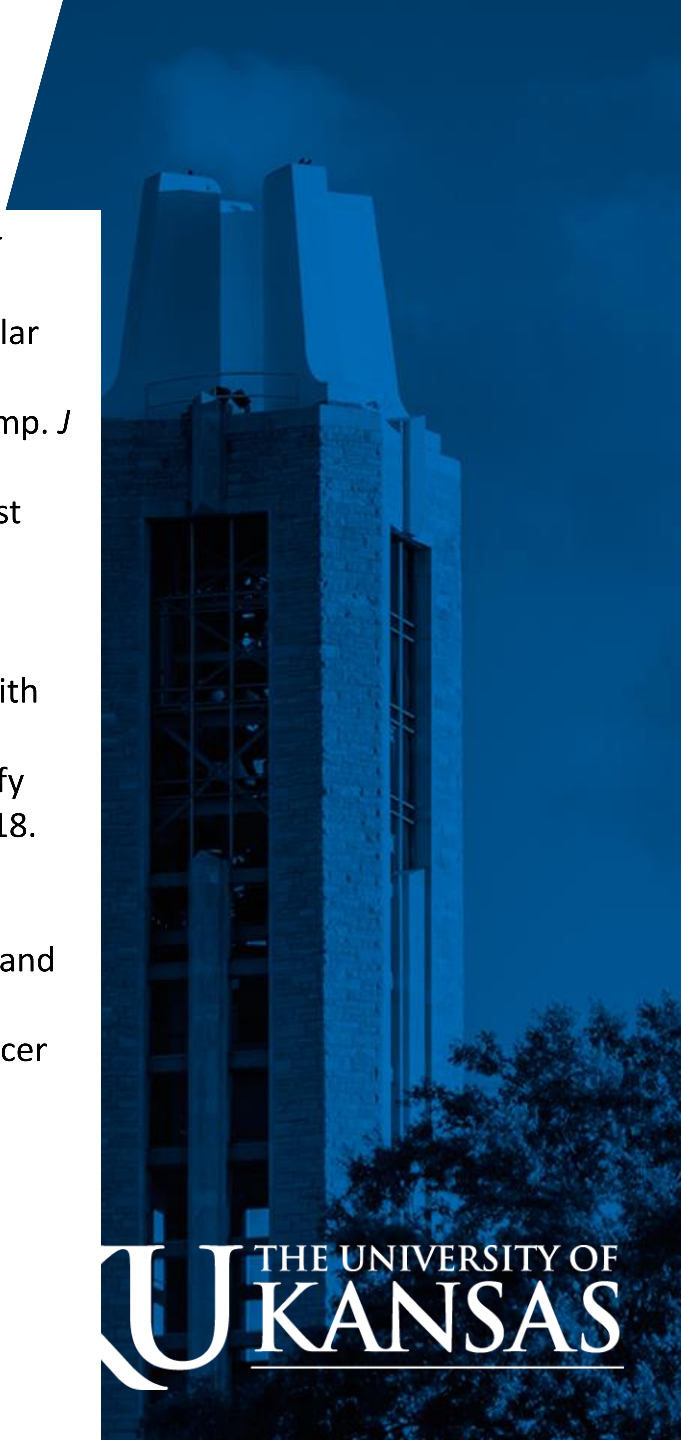

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