

# Association of Landing Error Scoring System with Self-Reported Fitness And Wellness Among ROTC Cadets

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## Background

- Lower extremity (LE) injuries are common among ROTC cadets<sup>1</sup>
- Prevention depends on identification of modifiable risk factors
- Landing Error Scoring System (LESS) can predict LE injury<sup>2</sup>
- ROTC programs often lack routine access to an Athletic Trainer (AT)<sup>3</sup>
- Survey responses can quantify function- and health-related problems
- Baseline survey administration may identify individuals with injury risk

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## Purpose

To assess the potential for using function- and health-related survey responses to identify ROTC cadets with poor jump landing kinematics

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## Participants: 34 ROTC Cadets

### ☐ Male n=24

- ☐ Age:  $20.5 \pm 2.4$  (Range: 18-27)
- ☐ Height:  $177.7 \pm 8.4$  cm (Range: 152.4 - 190.5)
- ☐ Mass:  $77.2 \pm 11.6$  kg (Range: 49.5 - 96.8)

IRB #16-122

### ☐ Female n=10

- ☐ Age:  $20.0 \pm 1.4$  (Range: 18-22)
- ☐ Height:  $164.8 \pm 7.1$  cm (Range: 154.9 - 175.3)
- ☐ Mass:  $63.8 \pm 12.2$  kg (Range: 51.8 - 87.8)

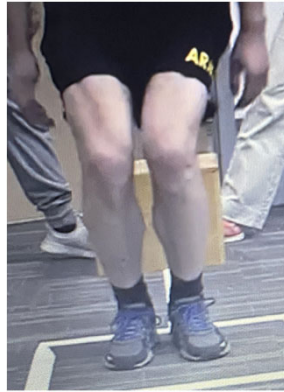
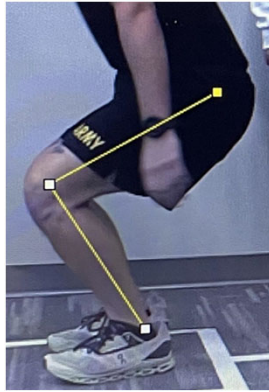
### ☐ Exclusionary Criterion

- ☐ Current injury (precluding drop-landing from 30cm box)

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# Methods

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- Cross-sectional cohort study
- State Variable: Suboptimal landing<sup>2</sup>
  - LESS score  $\geq 5$
- Predictor Variables:
  - Sport Fitness & Wellness Index (SFWI)
    - Sport Fitness Index (SFI)
    - Overall Wellness Index (OWI)

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## Sport Fitness Index

1. Over the past several years, how often have moderate-to-severe muscle and/or joint injuries limited your ability to participate fully in sports-related activities?
 

Never	Rare	Infrequent	Occasional	Frequent	Persistent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Over the past several years, how often has PAIN in any body part limited your OVERALL sport performance capabilities?
 

Never	Rare	Infrequent	Occasional	Frequent	Persistent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. To what extent do you feel that previous muscle and/or joint injuries currently limit your speed, power output, and/or endurance?
 

Not at all	Insignificant	Marginal	Moderate	Substantial	Severe
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. To what extent is your OVERALL ability to perform weightlifting exercises and/or activities that require explosive force output (such as maximum-effort jumping) currently limited by PAIN?
 

Not at all	Insignificant	Marginal	Moderate	Substantial	Severe
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. To what extent is your ability to perform any SPORT-SPECIFIC SKILL (such as throwing, swinging, or kicking accuracy) currently limited by PAIN?
 

Not at all	Insignificant	Marginal	Moderate	Substantial	Severe
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. To what extent are you bothered by muscle spasms, stiffness, and/or aching discomfort during routine activities of daily living (such as sleeping, walking, climbing/descending stairs, etc.)?
 

Not at all	Insignificant	Marginal	Moderate	Substantial	Severe
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. How often do you experience sensations of joint instability, giving-way, and/or sudden pain that create apprehension during rapid and forceful movements (such as pivoting and cutting)?
 

Never	Rare	Infrequent	Occasional	Frequent	Persistent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. As a result of participating in sport-related activities, how often do you experience joint aching, limited motion, stiffness, and/or swelling?
 

Never	Rare	Infrequent	Occasional	Frequent	Persistent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. To what extent are you bothered by chronic joint symptoms like joint locking, catching, grinding, or persistent aching?
 

Not at all	Insignificant	Marginal	Moderate	Substantial	Severe
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Over the past 12 months, to what extent have personal life events created emotional responses (such as sadness, depression, and/or anxiety) that have interfered with your enjoyment of life, ability to concentrate, and/or fulfillment of routine daily responsibilities?
 

Never	Rare	Infrequent	Occasional	Frequent	Persistent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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# Overall Wellness Index

**Overall Wellness Index - Question 1 of 10** **1. Physical Problems (11)**

Check each of the physical problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Headaches
- Pressure in head
- Neck pain
- Muscle aches
- Nausea/vomiting
- Light sensitivity
- Noise sensitivity
- Joint aches
- Urinary incontinence
- Bowel incontinence
- General discomfort
- None

**Overall Wellness Index - Question 2 of 10** **2. Sleep/Stamina Problems (6)**

Check each of the sleep/stamina problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Sleeping less
- Sleeping more
- Trouble falling asleep
- Fatigue/lethargy
- Drowsiness
- Feeling slowed down
- None

**Overall Wellness Index - Question 3 of 10** **3. Muscle Control Problems (10)**

Check each of the muscle control problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Muscle weakness
- Involuntary movements
- Muscle twitching
- Muscle jerking
- Difficulty walking
- Tremor (oscillating motions)
- Changed handwriting
- Trouble using tools
- Difficulty using hands or feet
- Trouble swallowing
- None

**Overall Wellness Index - Question 4 of 10** **4. Balance/Perception Problems (10)**

Check each of the balance/perception problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Postural sway/tilting/falling
- Spinning sensations
- Dizziness
- Lost in familiar environment
- Trouble seeing things properly
- Difficulty recognizing faces
- Impaired perception of objects
- None

**Overall Wellness Index - Question 5 of 10** **5. Abnormal Sensations (5)**

Check each of the altered sensations listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Vision changes
- Tingling
- Numbness
- Body pains
- Other changed sensations
- None

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# Overall Wellness Index

**Overall Wellness Index - Question 6 of 10** **6. Mood Problems (6)**

Check each of the emotional problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Suppression of emotions
- Emotional instability
- Depression/sadness
- Anxiety
- Nervousness
- Irritability
- None

**Overall Wellness Index - Question 7 of 10** **7. Behavior Regulation Problems (13)**

Check each of the behavior problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Apathy/lack of motivation
- Loss of inhibitions
- Hyper-religiosity
- Delusions
- Personality changes
- Agitation/aggression
- Violent outbursts
- Obsession/compulsion
- Repetitive behaviors
- Criminal behavior
- Impaired hygiene
- Altered eating habits
- Hallucinations
- None

**Overall Wellness Index - Question 8 of 10** **8. Memory-Related Problems (4)**

Check each of the memory-related problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Misplaced objects
- Asking questions repetitively
- Missed appointments
- Difficulty remembering past events
- None

**Overall Wellness Index - Question 9 of 10** **9. Thinking-Related Problems (9)**

Check each of the thinking-related problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Planning/organizing difficulty
- Multi-tasking difficulty
- Problem-solving difficulty
- Mental rigidity (inflexibility)
- Impulsive responses
- Mental fog/iness
- Difficulty concentrating
- Bad decisions
- Confusion
- None

**Overall Wellness Index - Question 10 of 10** **10. Language-Related Problems (11)**

Check each of the language-related problems listed below that have ever interfered with your ability to function in a normal manner during normal day-to-day activities. Select all that apply. If none apply, select "none".

\* must provide value

- Impaired writing
- Impaired spelling
- Impaired reading
- Trouble choosing words
- Slurred speech, difficulty articulating words
- Stuttering
- Incorrect word use/mispronunciation
- Increased speech output
- Impaired language comprehension
- Decreased speech output
- Impaired word comprehension
- None

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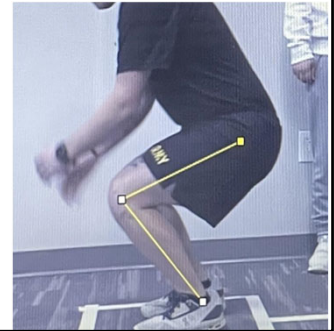
# Landing Error Scoring System

## Participant instructions<sup>2</sup>

- Jump forward without vertical motion
- Leave box with simultaneous motion of both feet
- Land with both feet within target area with immediate counter-movement jump

## Target Landing Area

- Center located at  $\frac{1}{2}$  height distance from box



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Landing Error Scoring System Item	Operational Definition of Error	Scoring
Knee flexion: initial contact	The knee is flexed less than 30° at initial contact.	0 = Absent 1 = Present
Hip flexion: initial contact	The thigh is in line with the trunk at initial contact.	0 = Absent 1 = Present
Trunk flexion: initial contact	The trunk is vertical or extended on the hips at initial contact.	0 = Absent 1 = Present
Ankle plantar flexion: initial contact	The foot lands heel to toe or with a flat foot at initial contact.	0 = Absent 1 = Present
Medial knee position: initial contact	The center of the patella is medial to the midfoot at initial contact.	0 = Absent 1 = Present
Lateral trunk flexion: initial contact	The midline of the trunk is flexed to the left or the right side of the body at initial contact.	0 = Absent 1 = Present
Stance width: wide	The feet are positioned greater than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Stance width: narrow	The feet are positioned less than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Foot position: external rotation	The foot is externally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Foot position: internal rotation	The foot is internally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Symmetric initial foot contact: initial contact	One foot lands before the other foot or 1 foot lands heel to toe and the other foot lands toe to heel.	0 = Absent 1 = Present
Knee-flexion displacement	The knee flexes less than 45° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Hip-flexion displacement	The thigh does not flex more on the trunk between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Trunk-flexion displacement	The trunk does not flex more between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Medial-knee displacement	At the point of maximum medial knee position, the center of the patella is medial to the midfoot.	0 = Absent 1 = Present
Joint displacement	Soft: the participant demonstrates a large amount of trunk, hip, and knee displacement. Average: the participant has some, but not a large amount of, trunk, hip, and knee displacement.	0 = Soft 1 = Average
Overall impression	Stiff: the participant goes through very little, if any, trunk, hip, and knee displacement. Excellent: the participant displays a soft landing with no frontal-plane or transverse-plane motion. Average: all other landings. Poor: the participant displays large frontal-plane or transverse-plane motion, or the participant displays a stiff landing with some frontal-plane or transverse-plane motion.	2 = Stiff 0 = Excellent 1 = Average 2 = Poor

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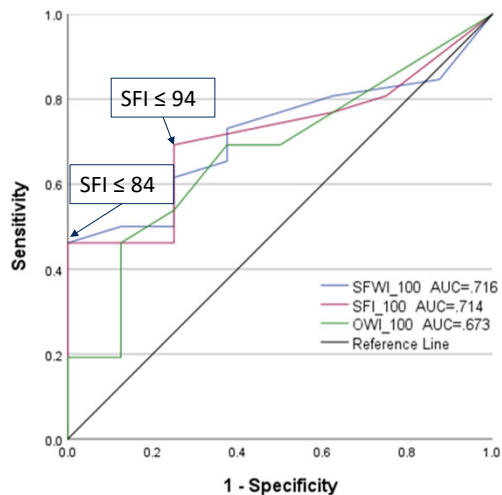
## Statistical Analysis

- Receiver operating characteristic analyses and cross-tabulation analyses used to determine which overall survey scores and individual item responses were most strongly associated with LESS score  $\geq 5$ 
  - Area Under Curve
  - Sensitivity
  - Specificity
  - Odds Ratio

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## Results: SFI, OWI, and SFWI (SFI + OWI Combined) Scores

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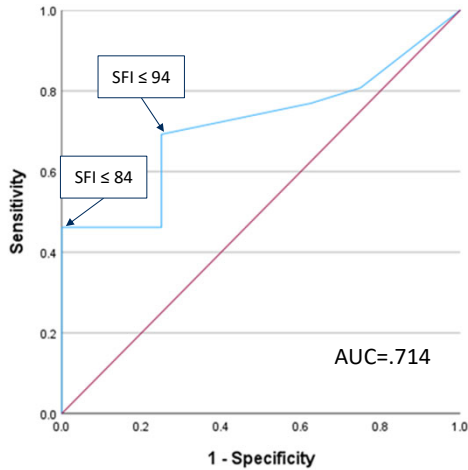


Survey Score	AUC (95%CI)	Cut Point	Odds Ratio (95% CI)
<b>SFI (0-100)</b>	<b>.714 (.538, .890)</b>	<b><math>\leq 94</math></b>	<b>6.75 (1.11, 41.00)</b>
OWI (0-100)	.673 (.472, .874)	$\leq 94$	3.75 (0.72, 19.64)
SFWI (0-100)	.716 (.544, .889)	$\leq 92$	4.80 (0.81, 28.60)

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## Results: SFI Scores

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		LESS ≥ 5		Incidence
		Yes	No	
SFI Score	≤ 94	18	2	90%
	> 94	8	6	57%
Total		26	8	

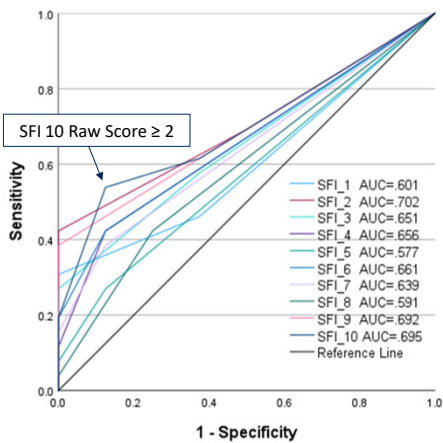
Sensitivity 69%    Specificity 75%

$\chi^2(1)=4.94$     **OR=6.75**  
 1-Sided P=.035    95% CI: 1.11, 41.00

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## SFI Item 10: Negative Impact of Personal Life Events

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10. Over the past 12 months, to what extent have personal life events created emotional responses (such as sadness, depression, and/or anxiety) that have interfered with your enjoyment of life, ability to concentrate, and/or fulfillment of routine daily responsibilities?

Never    Rare    Infrequent    Occasional    Frequent    Persistent

		LESS ≥ 5		Incidence
		Yes	No	
SFI Score on Item 10	≥ 2	14	1	93%
	< 2	12	7	63%
Total		26	8	

Sensitivity 54%    Specificity 88%

$\chi^2(1)=4.24$     **OR=8.17**  
 1-Sided P=.046    95% CI: 0.88, 76.15

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## Discussion

- ❑ Poor LESS score ( $\geq 5$ ) more common among current ROTC cadets than previously reported for this population<sup>4</sup>
- ❑ Strong association identified between self-reported factors affecting musculoskeletal function and overall well-being with high LESS score
- ❑ Among survey items, strongest association apparent for impact of negative life events on daily activities
- ❑ Both neuromuscular and psychosocial factors may adversely affect performance capabilities of military personnel

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## Clinical Relevance

- ❑ Baseline survey administration may be a valuable screening procedure for identification of individuals who are likely to demonstrate a high LESS score
- ❑ LESS test confirmation of suboptimal landing mechanics would justify intervention for injury risk reduction
  - ❑ Improvement of jump landing biomechanics: FIFA 11+, SportsMetrics, etc.<sup>5</sup>
  - ❑ Address self-reported psychosocial factors that contribute to injury risk



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## References

1. Eckard TG, Marshall SW, Kucera KL, et al. Trends in movement quality in US Military Academy cadets 2005-17: A JUMP-ACL study. *Phys Ther Sport*. 2021;48:109-115.
2. Padua DA, Marshall SW, Boling MC, Thigpen CA, Garrett WE Jr, Beutler AI. The Landing Error Scoring System (LESS) Is a valid and reliable clinical assessment tool of jump-landing biomechanics: The JUMP-ACL study. *Am J Sports Med*. 2009;37(10):1996-2002.
3. Radzak KN, Sefton JM, Timmons MK, Lopp R, Stickley CD, Lam KC. (2020). Musculoskeletal Injury in Reserve Officers' Training Corps: A report from the Athletic Training Practice-Based Research Network. *Orthop J Sports Med*. 8(9), 2325967120948951. <https://doi.org/10.1177/2325967120948951>
4. Ericksen HM, Reckelberg R, Earl-Boehm J. The injury risk profile of an Army Reserve Officers' Training Corps population: A preliminary descriptive study. *Phys Ther Sport*. 2021;51:65-70.
5. Sadigursky D, Braid JA, De Lira DN, Machado BA, Carneiro RJ, Colavolpe PO. (2017). The FIFA 11+ injury prevention program for soccer players: a systematic review. *BMC Sports Sci Med Rehabil*. 9, 18. <https://doi.org/10.1186/s13102-017-0083-z>