Managing Musculoskeletal Injuries: Lessons Learned from the Air Force's Special Warfare Human Performance Support Group

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Presenter

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Lt Col Cody Butler is the Research Flight Commander for Special Warfare Human Performance Squadron in the Special Warfare Training Wing at Lackland Air Force Base, Texas. His responsibilities include directing data management and conducting operational research for the Special Warfare Training Wing. He leads a team of seven staff and supervises human performance and clinical investigation related to the pipeline.

Lt Col Butler commissioned into the United States Air Force in 2012. He has 12 years of active-duty service and has served as a physical therapist at two Air Force medical treatment facilities. Additionally, he provided care during a humanitarian mission as part of Operation Pacific Angel in Vietnam. Prior to his current assignment, he served as an Air Force Institute of Technology (AFIT) Ph.D. student at the University of Connecticut.

Disclosures

- Lt Col Cody Butler has no relevant financial or non-financial relationships to disclose relating to the content of this activity.
- The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the Department of Defense, nor the U.S. Government.
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- Commercial support was not received for this activity.

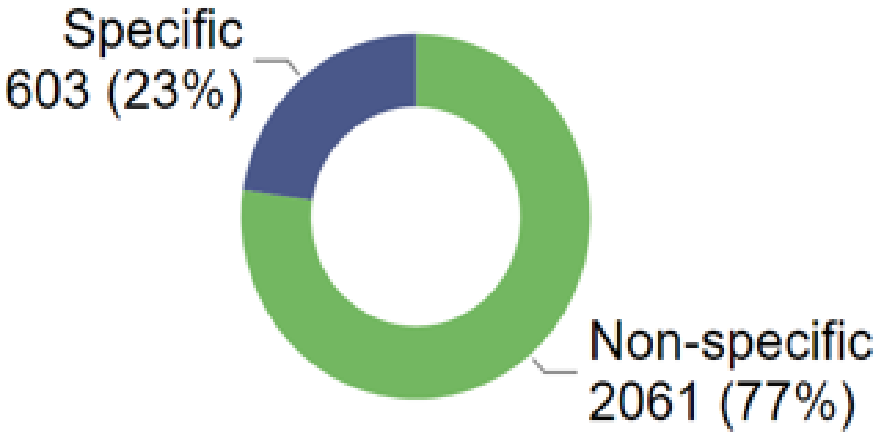
Learning Objectives

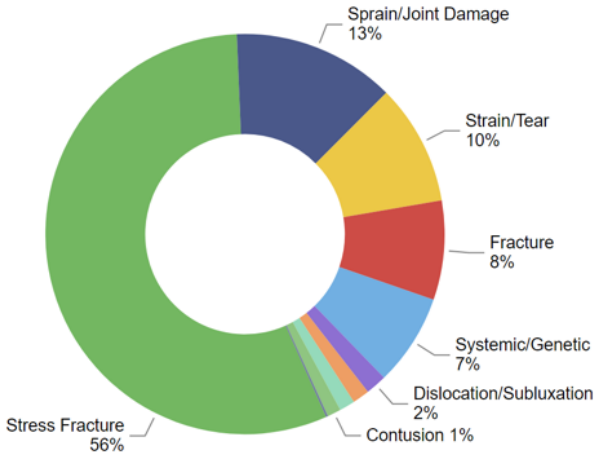
At the conclusion of this activity, participants will be able to:

1. Identify the role of wearable technology in the recognition of musculoskeletal injuries (MSKi).
2. Discuss the current state of motion capture and force plate technology in the prevention and recognition of musculoskeletal injuries.
3. Summarize the benefits and challenges of a holistic model in the prevention and management of musculoskeletal injuries.

Special Warfare Training Wing Injuries

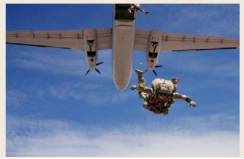
- Between Fiscal Year (FY) 19-22, **59% of candidates** had AT LEAST 1 outpatient medical encounter for a musculoskeletal (MSK) injury diagnosis.





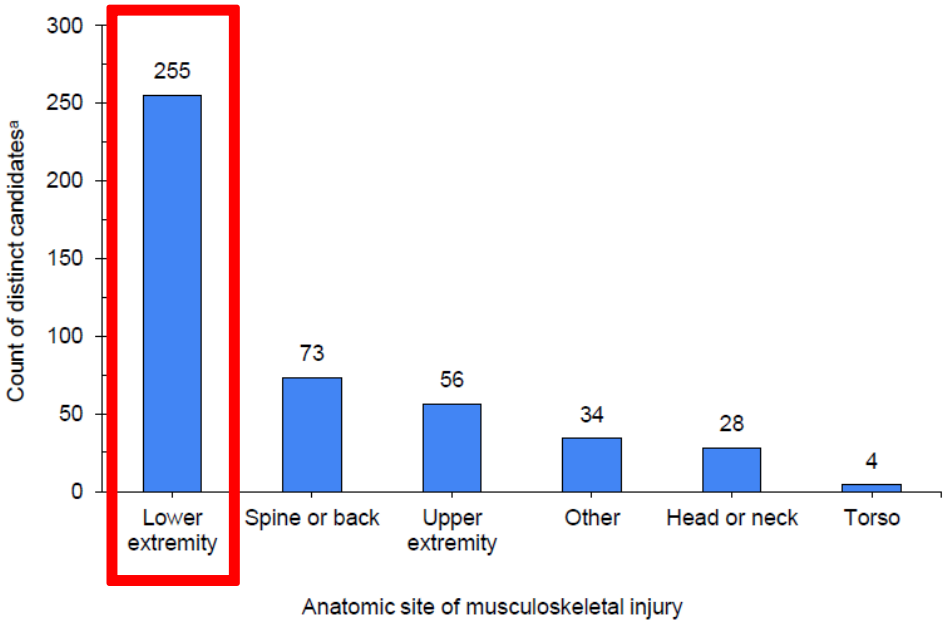
Assessment & Selection Injuries

MEDICAL SURVEILLANCE MONTHLY REPORT August 2022 | Vol. 29 | No. 8



IN THIS ISSUE:

FIGURE 4. Frequency of musculoskeletal injury by anatomic site, fiscal years 2019–2021



Tactical Air Control Party (TACP) Apprentice injuries

Original research

Musculoskeletal injuries in US Air Force Tactical Air Control Party trainees: an 11-year longitudinal retrospective cohort study and presentation of a musculoskeletal injury classification matrix

Ben R Hando ,[1] J Bryant ,[2] V Pav,[1] L Haydu,[3] K Hogan,[4] J Mata,[3] C Butler[4]

Table 3 Frequency counts and incidence proportions of TACP-AC trainees incurring MSKIs during and 1 year post training,* broken down by MSKI matrix categories

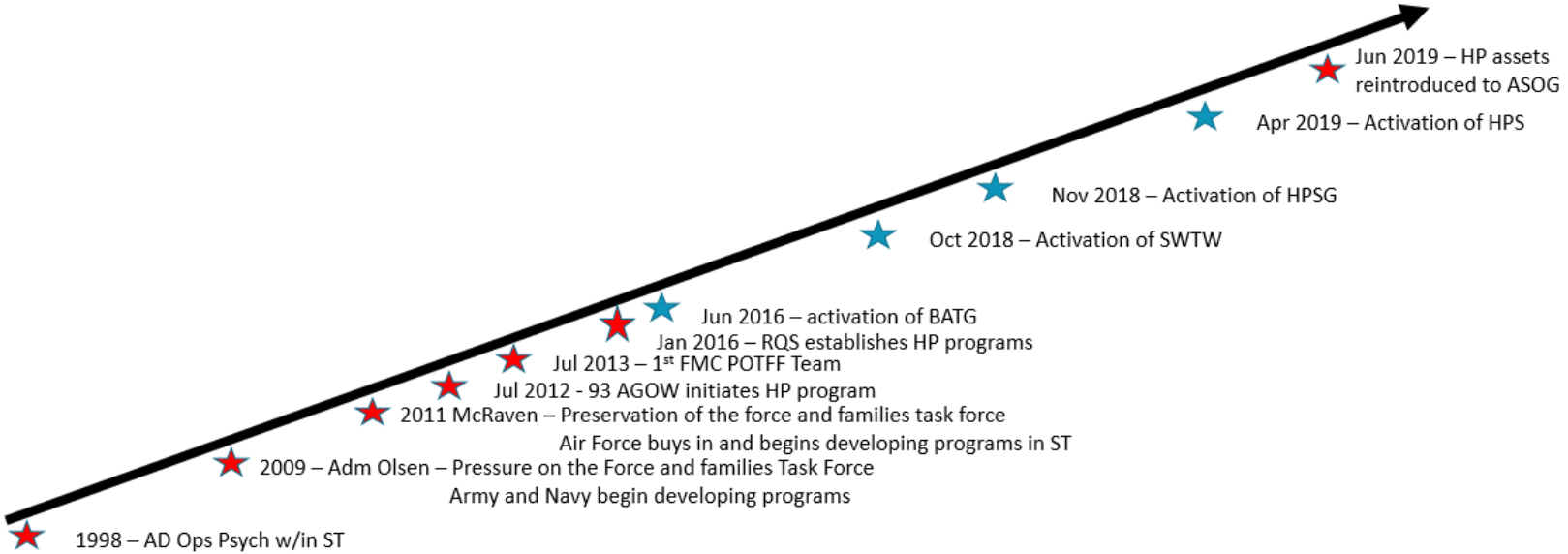
MSKI matrix categories	During TACP-AC N=3242 (all trainees)	0–1 year post TACP-AC n=1950 (graduated course and joined career)
Body region 1 (all categories)		
Lower extremity	1133 (35.0)	368 (18.9)
Spine and back	403 (12.4)	212 (10.9)
Other	360 (11.1)	147 (7.5)
Upper extremity	289 (8.9)	205 (10.5)
Head and neck	82 (2.5)	97 (5.0)
Torso	25 (0.8)	46 (2.4)

Department of Defense (DoD) Investment in HP Optimization

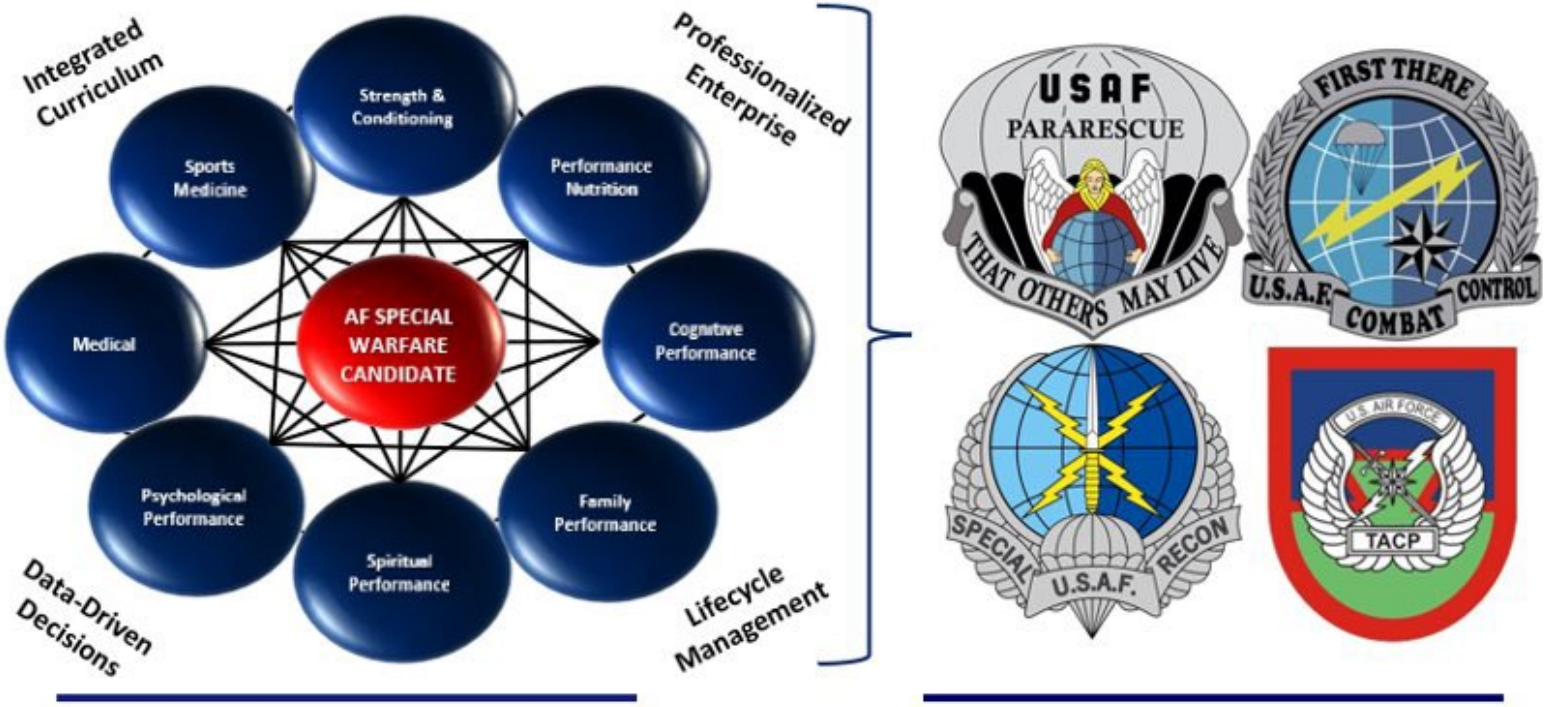
- Since 2006, multiple human performance (HP) optimization initiatives all aimed at improving force readiness
- Injury Prevention has been a large components for each program

(DoD, n.d.)

Background


Jun 2019 – HP assets reintroduced to ASOG
Apr 2019 – Activation of HPS
Nov 2018 – Activation of HPSG
Oct 2018 – Activation of SWTW
Jun 2016 – activation of BATG
Jan 2016 – RQS establishes HP programs
Jul 2013 – 1st FMC POTFF Team
Jul 2012 - 93 AGOW initiates HP program
2011 McRaven – Preservation of the force and families task force
Air Force buys in and begins developing programs in ST
2009 – Adm Olsen – Pressure on the Force and families Task Force
Army and Navy begin developing programs
1998 – AD Ops Psych w/in ST

Special Warfare Human Performance Support Group (SWHPSG)

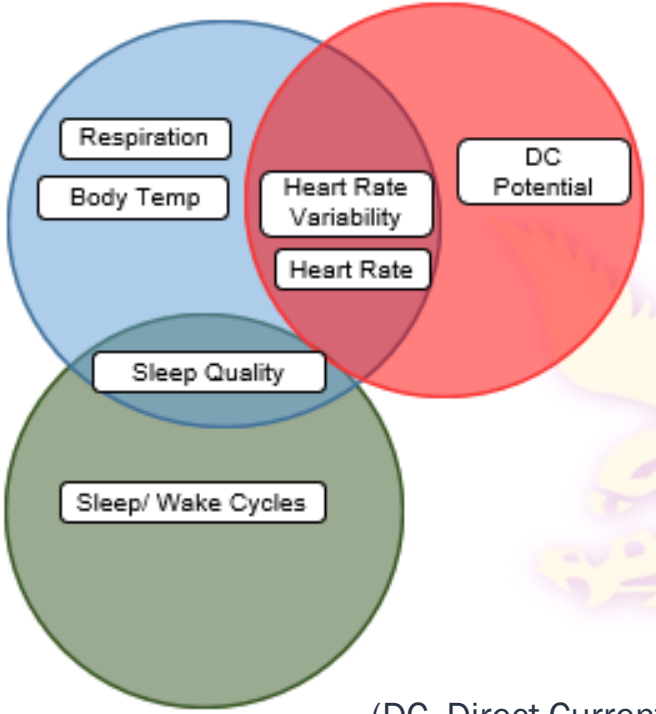


Human Performance Technology (2019-2021)

- Wearable technology
  - Rest and recovery
  - Training load

- Functional movement technology
  - Biomechanical analysis
  - Force plate systems

Wearable Technology (rest and recovery)



(DC- Direct Current)

Oura Ring
(ouraring.com)

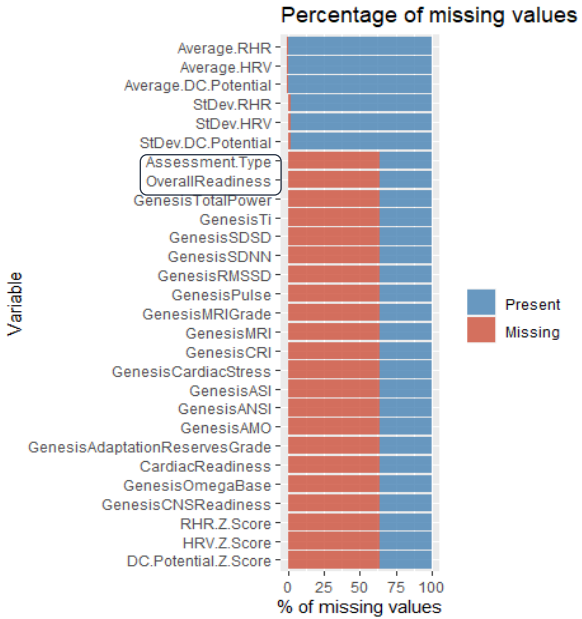
Omegawave System
(Omegawave.com)

Readiband
(fatiguescience.com/readiband)

Omegawave Data Exploration

- Overall Readiness and Assessment Type (AM or PM) were used for analysis.

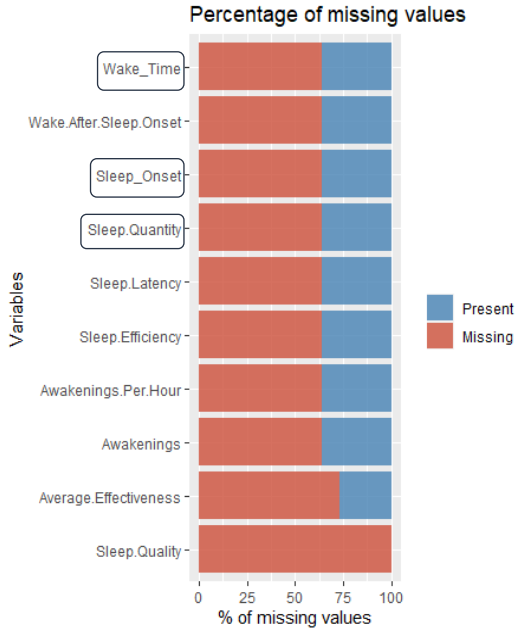
- Course 1 and Course 2 *(displayed to the right)* had 10% and 64% missing values, respectively.



Fatigue Science (Readiband) Data Exploration

- Wake Time, Sleep Onset, and Sleep Quantity were used for analysis.

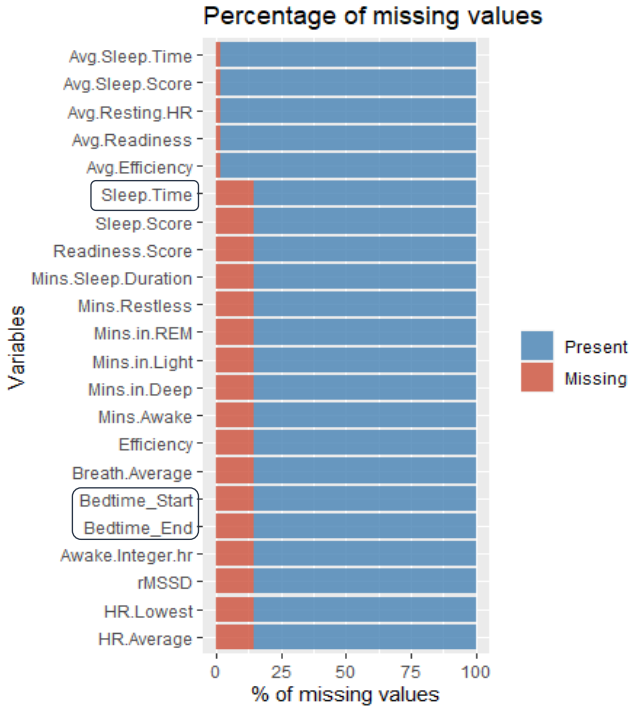
- Course 1 and Course 2 *(displayed to the right)* had 34% and 64% missing values, respectively.



Oura Data Exploration

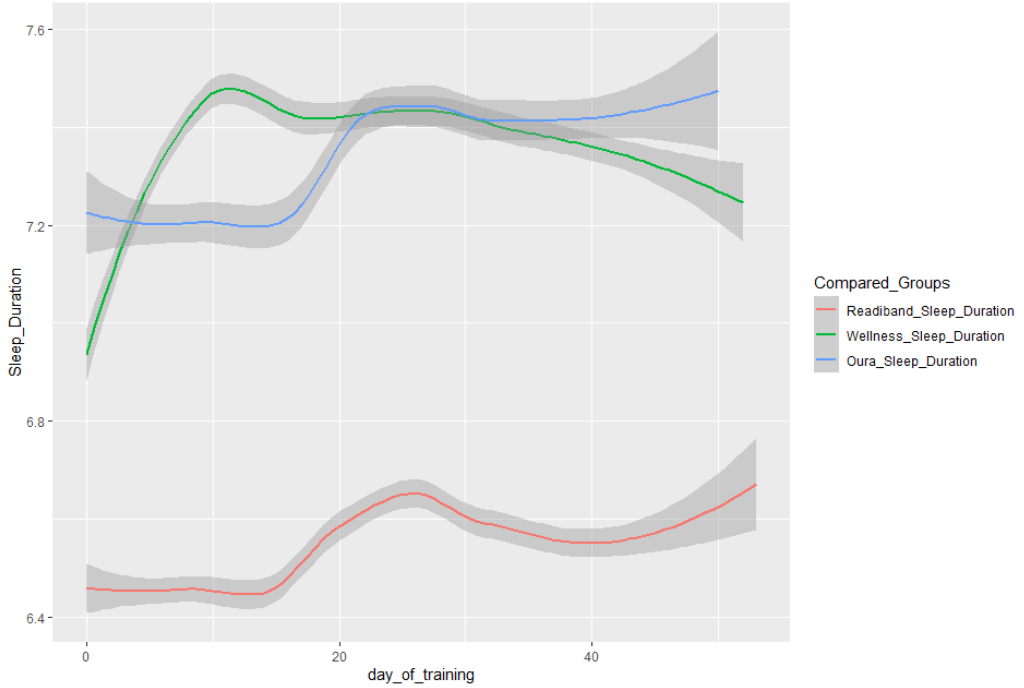
- Oura had fewer missing data than Readiband and Omegawave.

- The variables Sleep Time, Bedtime Start and Bedtime End were used for analyses - each have 15% missing values.



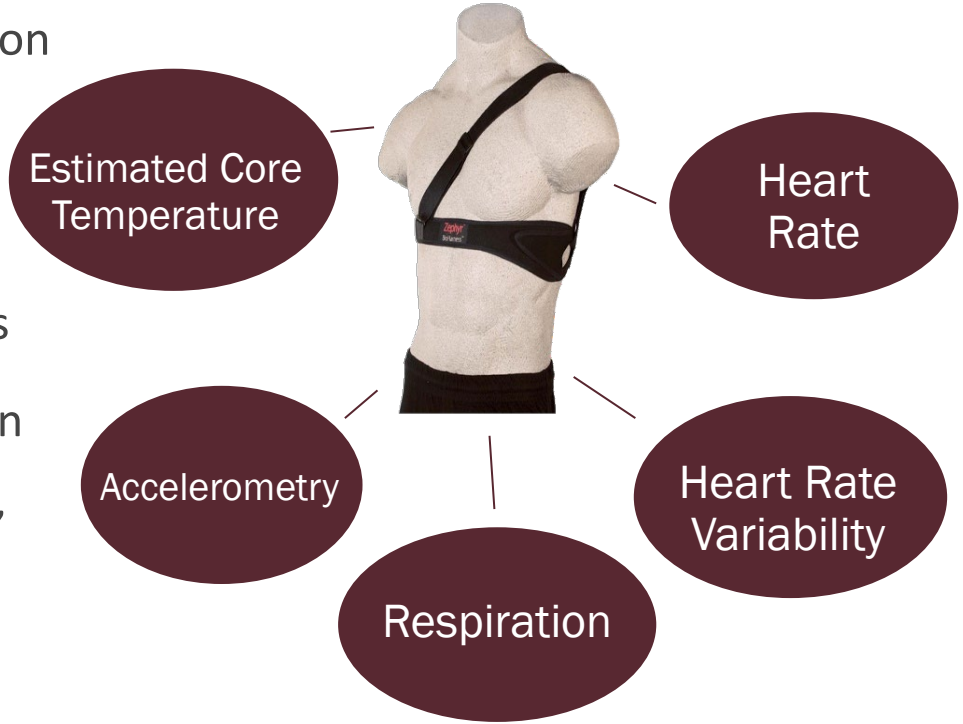
Sleep Analysis (smooth plot)

- Smoothing plot comparing Readiband, Oura, and Wellness Questionnaire Sleep Duration.



Zephyr Bioharness (training load)

- Cardiac monitoring has strong correlation with electrocardiogram (ECG) gold standard that is **mildly** diminished with heat and movement speed & type
- Speeds of movement, movement patterns, and environmental conditions commonly encountered within SWTW **reduce reliability** of device transmission
- Requires well-controlled environments, low speed of movement, and thermoneutral environments for maximum accuracy and reliability.

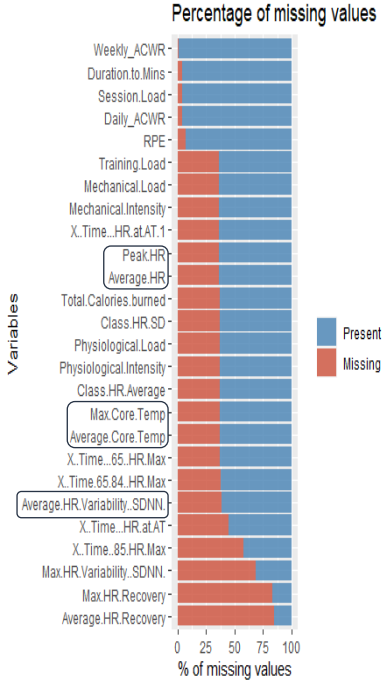


(zephyranywhere.com)

Zephyr Bioharness Data Exploration

The variables Average/Peak Heart Rate (HR), Average/Max Core Temp, and Average HR Variability were used for analysis.

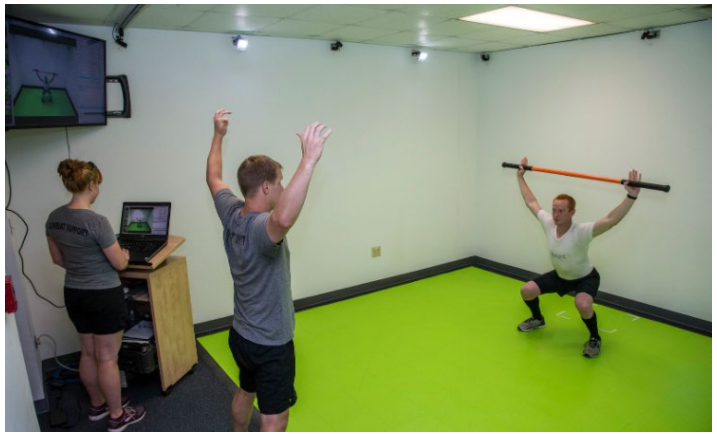
- Average/Peak HR have **36%** missing data
- Average/Max Core Temp have **37%** missing data
- Average HR Variability has **38%** missing data



Wearable Technology Re-cap

- Be extremely **deliberate** in what human performance-related variables you want to measure
- Ensure the tools you want to use those metrics are **valid** and **reliable**
- Periodically perform a **quality-control check** to ensure data is appropriately being collected and stored
- Have a plan of **what you are going to do** with the findings

Motion Capture



› Orthop J Sports Med. 2021 Oct 29;9(10):23259671211041656. doi: 10.1177/23259671211041656. eCollection 2021 Oct.

Association Between Markerless Motion Capture Screenings and Musculoskeletal Injury Risk for Military Trainees: A Large Cohort and Reliability Study

Ben R Hando [1], W Casan Scott [1], Jacob F Bryant [1], Juste N Tchandja [1], Ryan M Scott [2], Siddharrtha S Angadi [3]

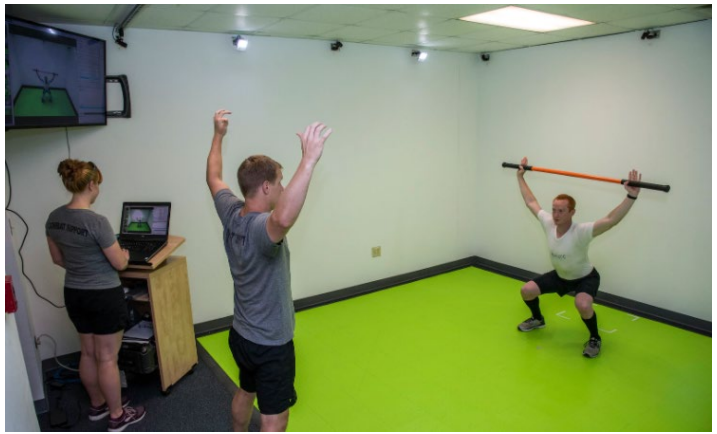
Affiliations + expand

PMID: 34734097 PMCID: PMC8558809 DOI: 10.1177/23259671211041656

FINDINGS (n=1570 SWTW trainees)

- **Poor to moderate** test-retest reliability
- Did **NOT** demonstrate ability to discriminate likelihood of sustaining injury
- **No** operational utility found with DARI

Motion Capture (continued)



Front Bioeng Biotechnol. 2023 Dec 6:11:1293923. doi: 10.3389/fbioe.2023.1293923. eCollection 2023.

Identifying special operative trainees at-risk for musculoskeletal injury using full body kinematics

Lance Frazer [1], Tylan Templin [1], Travis David Eliason [1], Cody Butler [2], Ben Hando [2 3], Daniel Nicolella [1]

Affiliations + expand

PMID: 38125303 PMCID: PMC10731296 DOI: 10.3389/fbioe.2023.1293923

FINDINGS

- Trainees identified within high versus low-risk clusters
- Trainees in high-risk cluster **5 times greater risk** of MSK injury as compared to trainees in low-risk cluster

Force Plate Technology (1 of 6)

- Force plates are highly prevalent in U.S. Active-Duty Units.
- 2021 National Defense Authorization Act (NDAA) mandated a report be provided to the Armed Services Committee regarding the potential of Force Plate Technology and Machine Learning to improve medical readiness
- No data was provided in report on effectiveness of Force Plate Technology or "Force Plate Machine Learning" – FPML™

REPORT TO THE CONGRESSIONAL ARMED SERVICES COMMITTEES

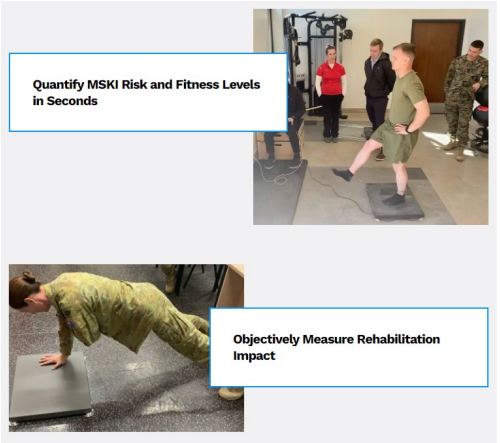
Report on Force Plate Technology Utilizing Machine Learning for Improving Combat Readiness

House Report 116-442, Pages 153-154, Accompanying H.R. 6395, the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021

March 2022

Force Plate Technology (2 of 6)

- Sparta Science™ (Menlo Park, CA) purportedly predicts MSK injuries and assesses overall fitness levels through repeated CMJs.
- Data from repeated Counter Movement Jumps (CMJs) are captured by the Sparta Science™ force plates and converted into proprietary scores that, per the company's instructions, may be used to inform strength and conditioning programs and quantify an individual's risk of suffering an MSK injury.
- Sparta Science™ claims, "rather than the current annual physical fitness tests, service members can be scanned weekly or monthly, giving leaders the ability to hold individuals accountable for progress and a clearer, up-to-date appraisal of overall fitness levels"



(spartascience.com)

Force Plate Technology (3 of 6)

- Load: average rate of force development, measured during the downward phase of the jump.
- Explode: average relative vertical concentric force measured during the transitional phase of the jump.
- Drive: average relative vertical concentric impulse measured during the upward phase of the jump.
- Sparta score is calculated by factoring in load, explode, drive, and the balance between the three.
- **MSK Health scores represent an individual's relative risk of injury with higher scores representing a lower risk of MSKI.**

MSK Health scores were the primary score of interest

Figure 1: Force-time curve for (1) Load: average eccentric rate of force development; (2) Explode: average relative vertical concentric force; (3) Drive: average relative vertical concentric impulse.

(spartascience.com)

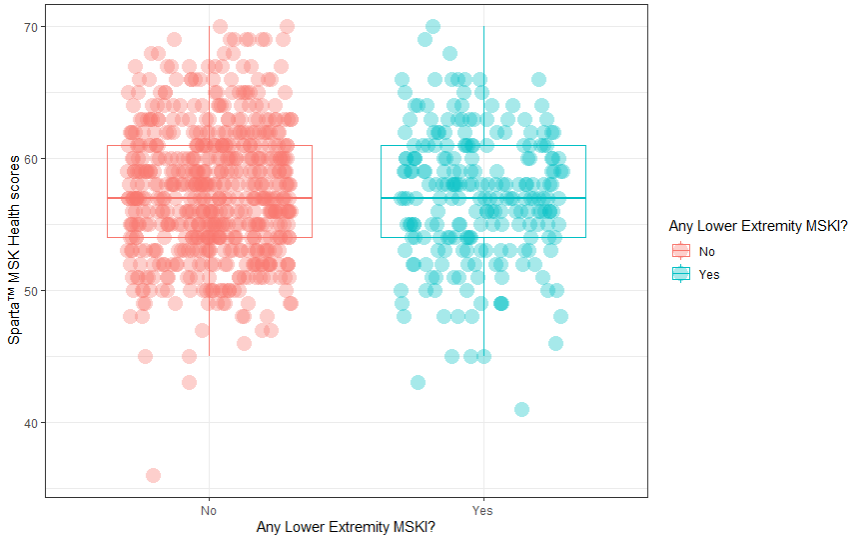
Force Plate Technology (4 of 6)

The Use of Force Plate Vertical Jump Scans to Identify Special Warfare Trainees at Risk for Musculoskeletal Injury: A Large Cohort Study

Ben R Hando [1], W Casan Scott [1], Jacob F Bryant [1], Juste N Tchandja [1], Siddhartha S Angadi [2]

Affiliations + expand

PMID: 35384740 DOI: 10.1177/03635465221083672

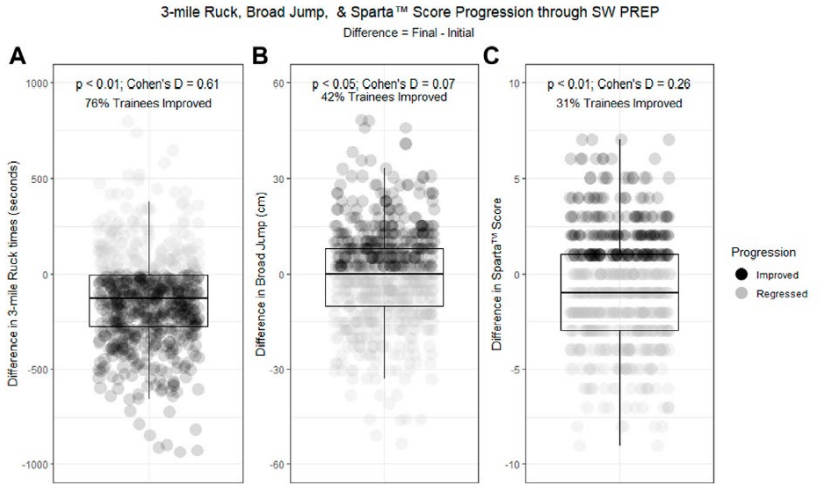


Force plate vertical jump scans are not a valid proxy for physical fitness in US special warfare trainees

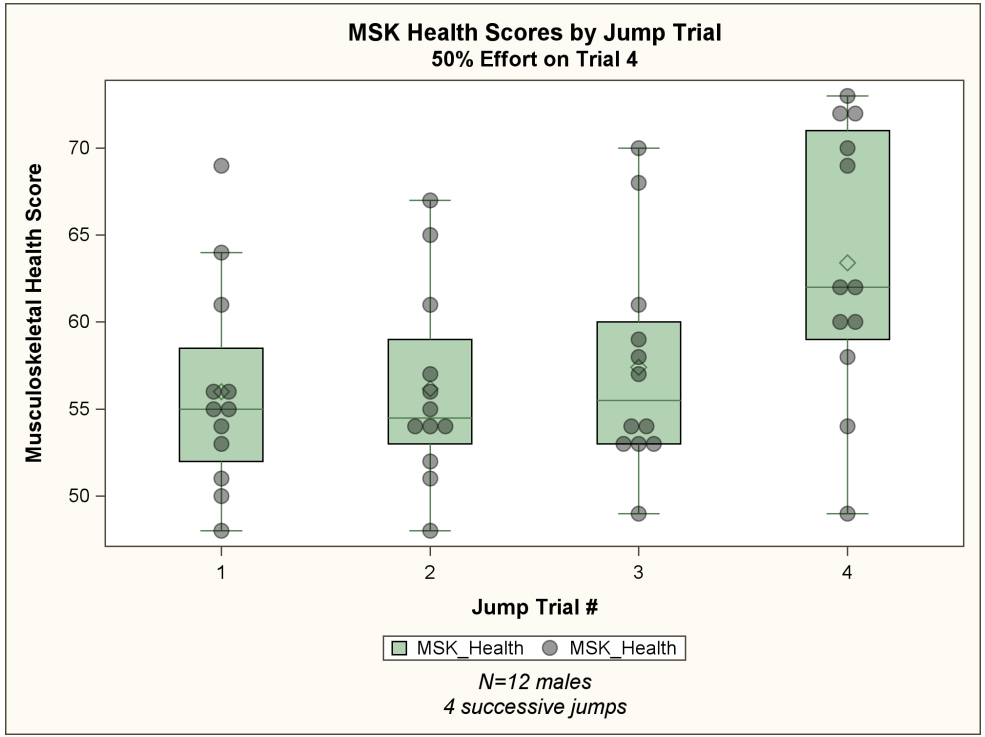
W Casan Scott [1 2], Ben R Hando [1 3], Cody R Butler [1], John D Mata [1], Jacob F Bryant [1], Siddhartha S Angadi [4]

Affiliations + expand

PMID: 36467678 PMCID: PMC9709481 DOI: 10.3389/fphys.2022.966970



Force Plate Technology (5 of 6)



An athlete with lower vertical jump scores, all other factors remaining constant, would be shown to have less vulnerability to injury. In other words, a person with an MSKi may not be appropriately flagged!

Force Plate Technolog 6)

Original Research

the Journal of Strength and Conditioning Research™

Countermovement Jump Force-Time Curve Analyses: Reliability and Comparability Across Force Plate Systems

Justin J. Merrigan,[1,2] Adam Strang,[1] Jason Eckerle,[1] Nick Mackowski,[1] Kaela Hierholzer,[1] Nicole T. Ray,[1,3] Roger Smith,[1] Joshua A. Hagen,[1,2] and Robert A. Briggs[1]

[1]STRONG Lab, Air Force Research Laboratory, Wright-Patterson Air Force Base (WPAFB), Ohio; [2]Human Performance Collaborative, Office of Research, The Ohio State University, Ohio; and [3]Infoscitex, Inc., WPAFB, Ohio

Motion Capture and Force Plate Re-cap

- Be cautious with tools with proprietary algorithms that give the user an “injury risk” score
- If your leadership is considering purchasing popular devices, feel free to contact me, and I’ll send you the full text of several peer-reviewed articles to help provide a more informed decision.

Military Injury Prevention Programs

› BMJ Mil Health. 2022 Jun 22:e002098. doi: 10.1136/bmjmilitary-2022-002098. Online ahead of print.

Effects of prevention programmes on injury risk in military personnel: a systematic review with meta-analysis

Priscila Dos Santos Bunn [1 2], R D S Sodré [2], M I Matos [2], G F Saliba [3], G D P Silva [2], R Caldas [2], J D S Esteves [4], E B Silva [2]

- 17 studies selected
- Neuromuscular training, stretching, agility training, combined exercise
- MSK injury risk reduction by 14%

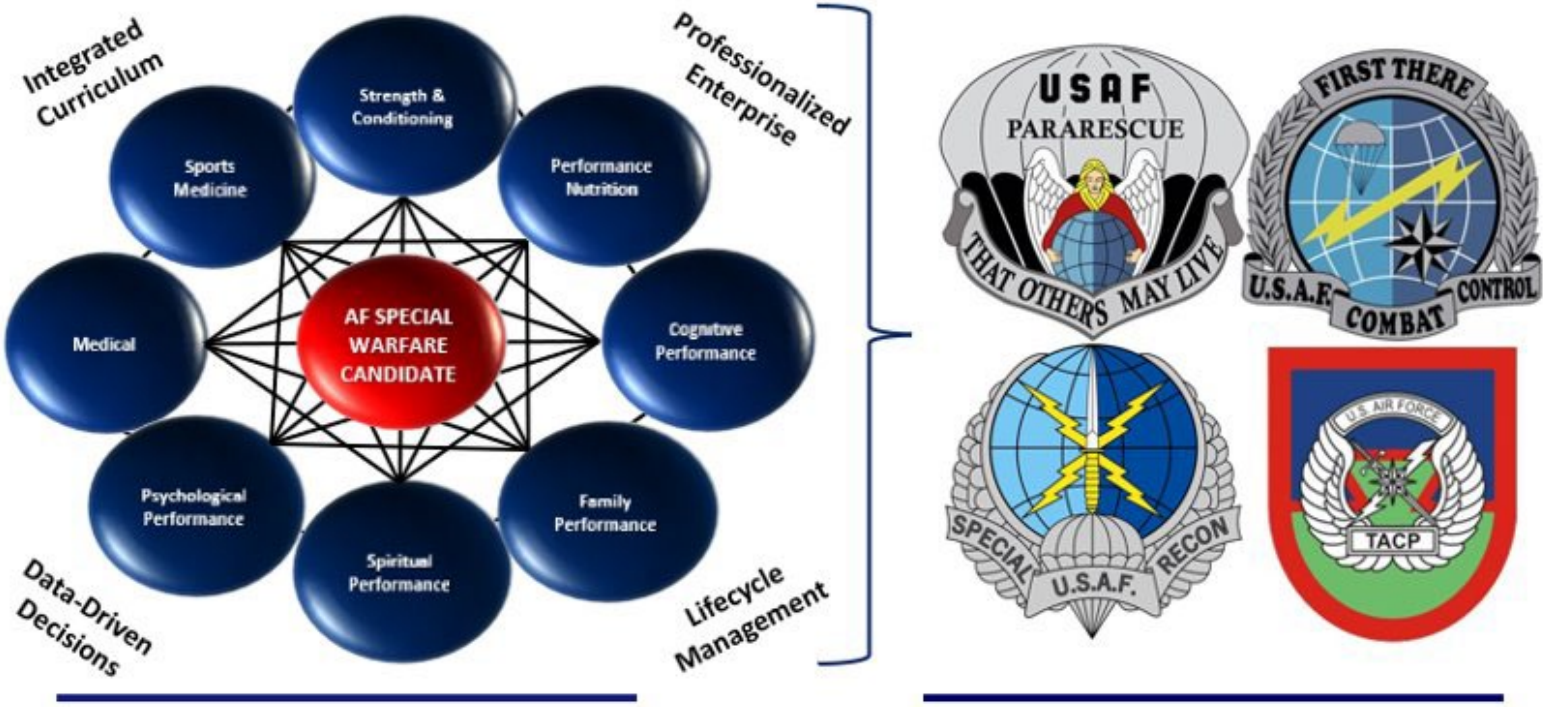
Meta-Analysis › Eur J Sport Sci. 2022 Jan;22(1):16-34. doi: 10.1080/17461391.2021.1931464. Epub 2021 Jun 18.

Much work remains to reach consensus on musculoskeletal injury risk in military service members: A systematic review with meta-analysis

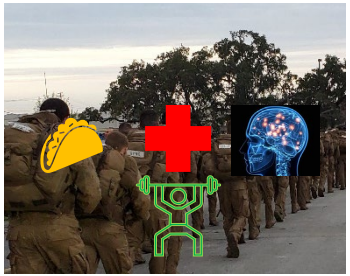
Daniel I Rhon [1 2], Joseph M Molloy [3], Andreas Monnier [4 5 6], Ben R Hando [7], Phillip M Newman [8]

- 74 studies selected
- 994 risk factors, 46 included in meta-analysis
- 7 predictors identified
  - Female sex, high Body Mass Index (BMI), functional movement screen (FMS) pain OR score <15, prior injury, slower run times, poor push-up performance

Special Warfare Human Performance Support Group



SWHPSG



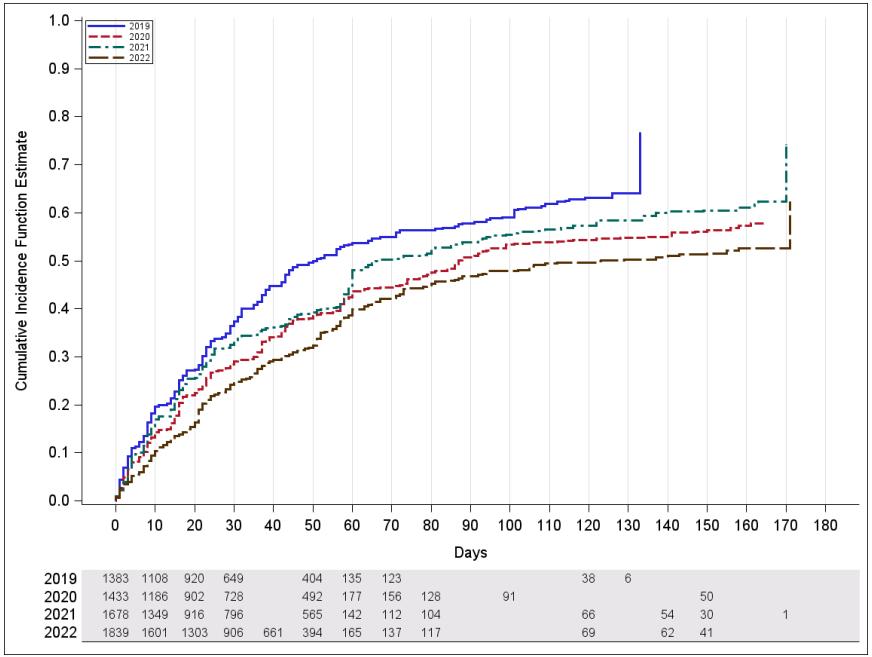

USAF
PARARESCUE
FIRST THERE
U.S.A.F.
COMBAT
SPECIAL
RECON
U.S.A.F.
U.S. AIR FORCE

SWHPSG Validation Project *(manuscript under review)*

Cumulative incidence of MSKi was significantly different when comparing fiscal years (P<0.001).

2022 had the lowest cumulative incidence of MSKi by 21 days of any course, 19%, compared with 28% in 2019, 23% in 2020, and 26% in 2021.

50 days to 50% 2019
86 “” 2020
66 “” 2021
122 days to 50% candidates with MSKi 2022

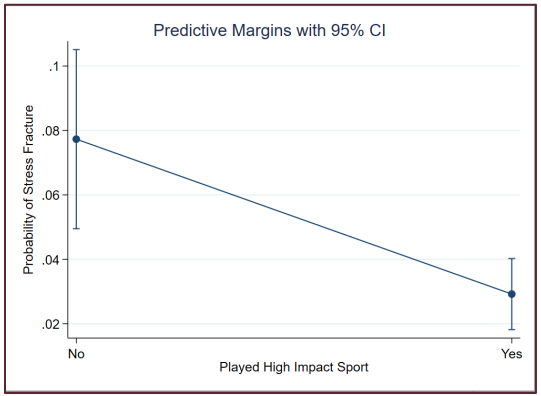


Current Challenges

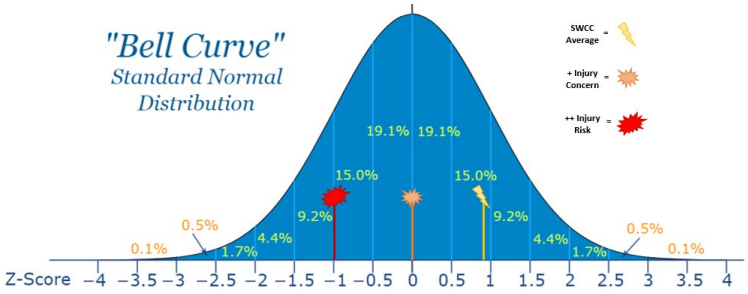
- Data tracking and flagging
  - Smartabase
  - Envision
  - Others (?)
- Appropriate baselining
- Most appropriate use of wearable technology

SWHPSG Baseline Testing

- Orthopedic Screener
  - History of a bone stress injury
  - History of an MSK injury
  - High school sports participation



(ge.com)



SWHPSG Wearable Tech in 2024

- Training aid ONLY (teaching tool)
- Garmin wristwatch and chest strap

(garmin,com)

USAF SPECIAL WARFARE HUMAN PERFORMANCE SQUADRON HEART RATE-GUIDED PHYSICAL TRAINING REFERENCE CHART			
Heart Rate Zone	*Desired Training Effect*	*Talk Test*	*Perceived Exertion (1-10)*
Zone 5 *90-100% MaxHR*	*Maximum Effort*	Cannot Talk; Out of Breath	9.5-10
Zone 4 *80-90% MaxHR*	*Anaerobic Threshold*	1-2 Words at a Time	8-9
Zone 3 *70-80% MaxHR*	*Aerobic Threshold*	1-2 Short Sentences	7-8
Zone 2 *60-70% MaxHR*	*Aerobic Capacity*	Conversational Pace	5-6
Zone 1 *50-60% MaxHR*	*Warm Up*	Normal Talking	4-5

(airforce.com)

Conclusion: The Population You Serve

(airforce.com)

Key Takeaways

- When it comes to wearable technology, **be cautious** of the bright and shiny. **Be deliberate** in what you purchase.
- Injury prediction tools still have a long way to go. As of 2024, a "**history of an injury**" is the **biggest predictor** of a future injury.
- Although a holistic approach to injury management intuitively makes sense, we need to do a better job at **tracking and reporting** on variables that aren't being documented (and therefore can't be extracted) in Genesis.

References (1 of 4)

Bird MB, Koltun KJ, Mi Q, Lovalekar M, Martin BJ, Doyle TLA, Nindl BC. (2023). Predictive utility of commercial grade technologies for assessing musculoskeletal injury risk in US Marine Corps Officer candidates. Front Physiol, 14, 1088813. https://doi.org/10.3389/fphys.2023.1088813

Bunn PDS, Sodré RDS, Matos MI, Saliba GF, Silva GDP, Caldas R, Esteves JDS, Silva EB. (2022). Effects of prevention programmes on injury risk in military personnel: a systematic review with meta-analysis. BMJ Mil Health.. https://doi.org/10.1136/bmjmilitary-2022-002098

Butler, C., Haydu, L., Bryant, J., Mata, J., Tchandja, J., Hogan, K., & Hando, B. (2022). Musculoskeletal Injuries During U.S. Air Force Special Warfare Training Assessment and Selection, Fiscal Years 2019-2021. MSMR, 29(8), 2–6.

Committee on Armed Services. (2022). Report on Force Plate Technology Utilizing Machine Learning for Improving Combat Readiness. https://health.mil/Reference-Center/Reports/2022/04/01/Report-on-Force-Plate-Technology-Utilizing-Machine-Learning-for-Improving-Combat-Readiness

References (2 of 4)

Frazer, L., Templin, T., Eliason, T. D., Butler, C., Hando, B., & Nicolella, D. (2023). Identifying special operative trainees at-risk for musculoskeletal injury using full body kinematics. Frontiers in bioengineering and biotechnology, 11, 1293923. https://doi.org/10.3389/fbioe.2023.1293923

Hando, B. R., Bryant, J., Pav, V., Haydu, L., Hogan, K., Mata, J., & Butler, C. (2023). Musculoskeletal injuries in US Air Force Tactical Air Control Party trainees: an 11-year longitudinal retrospective cohort study and presentation of a musculoskeletal injury classification matrix. BMJ military health, e002417. Advance online publication. https://doi.org/10.1136/military-2023-002417

Hando, B. R., Scott, W. C., Bryant, J. F., Tchandja, J. N., & Angadi, S. S. (2022). The Use of Force Plate Vertical Jump Scans to Identify Special Warfare Trainees at Risk for Musculoskeletal Injury: A Large Cohort Study. The American journal of sports medicine, 50(6), 1687–1694. https://doi.org/10.1177/03635465221083672

References (3 of 4)

Hando, B. R., Scott, W. C., Bryant, J. F., Tchandja, J. N., Scott, R. M., & Angadi, S. S. (2021). Association Between Markerless Motion Capture Screenings and Musculoskeletal Injury Risk for Military Trainees: A Large Cohort and Reliability Study. Orthopaedic journal of sports medicine, 9(10), 23259671211041656. https://doi.org/10.1177/23259671211041656

Johnson AS, Brismée JM, Hooper TL, Hintz CN, Hando BR. (2024). Incidence and Risk Factors for Bone Stress Injuries in United States Air Force Special Warfare Trainees. Mil Med. usae017. https://doi.org/10.1093/milmed/usae017

Merrigan, J. J., Strang, A., Eckerle, J., Mackowski, N., Hierholzer, K., Ray, N. T., Smith, R., Hagen, J. A., & Briggs, R. A. (2024). Countermovement Jump Force-Time Curve Analyses: Reliability and Comparability Across Force Plate Systems. Journal of strength and conditioning research, 38(1), 30–37. https://doi.org/10.1519/JSC.0000000000004586

Rhon, D. I., Molloy, J. M., Monnier, A., Hando, B. R., & Newman, P. M. (2022). Much work remains to reach consensus on musculoskeletal injury risk in military service members: A systematic review with meta-analysis. European journal of sport science, 22(1), 16–34. https://doi.org/10.1080/17461391.2021.1931464

References (4 of 4)

Scott, W. C., Hando, B. R., Butler, C. R., Mata, J. D., Bryant, J. F., & Angadi, S. S. (2022). Force plate vertical jump scans are not a valid proxy for physical fitness in US special warfare trainees. Frontiers in physiology, 13, 966970. https://doi.org/10.3389/fphys.2022.966970

Smith, C., Doma, K., Heilbronn, B., & Leicht, A. (2022). Reliability of Force Plate Metrics During Standard Jump, Balance, and Plank Assessments in Military Personnel. Military medicine, 188(7-8), e2058–e2066. Advance online publication. https://doi.org/10.1093/milmed/usac387

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