

NEEDS ANALYSIS → RELIABILITY → APPLICATION

International Journal of Environmental Research and Public Health 

Review

Monitoring Neuromuscular Performance in Military Personnel

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Abstract: A necessarily high standard for physical readiness in tactical environments is often accompanied by high incidences of injury due to overaccumulations of neuromuscular fatigue (NMF). To account for instances of overtraining stimulated by NMF, close monitoring of neuromuscular performance is warranted. Previously validated tests, such as the countermovement jump, are useful means for monitoring performance adaptations, resiliency to fatigue, and risk for injury. Performing such tests on force plates provides an understanding of the movement strategy used to obtain the resulting outcome (e.g., jump height). Further, force plates afford numerous objective tests that are valid and reliable for monitoring upper and lower extremity muscular strength and power (thus sensitive to NMF) with less fatiguing and safer methods than traditional one-repetition maximum assessments. Force plates provide numerous software and testing application options that can be applied to military's training but, to be effective, requires the practitioners to have sufficient knowledge of their functions. Therefore, this review aims to explain the functions of force plate testing as well as current best practices for utilizing force plates in military settings and disseminate protocols for valid and reliable testing to collect key variables that translate to physical performance capacities.

Keywords: military personnel; force plates; neuromuscular fatigue; countermovement jump; drop jump; isometric-mid-thigh pull; squat jump; tactical athletes; soldiers

1. Introduction

The physical and tactical training of the military is designed to maximize operational performance capacity. The purpose of training regimens prior to mission engagement is to adequately prepare military personnel for the physical and psychological demands of their mission [1,2]. To be effective, military personnel must possess enough muscular strength, power, and endurance capabilities to complete endurance marches across rugged terrain, swiftly maneuver under fire, and engage in close quarters combat, all of which may be sustained for long durations while carrying external loads [1–3] (Figure 1). Although tactical training strategies are designed to produce positive longitudinal adaptations, overtraining or chronic fatigue-driven decrements in operational performance can occur [4]. Deeper insights can be achieved by objectively measuring neuromuscular performance (NP) capabilities, which encompasses monitoring: (1) physical readiness, (2) neuromuscular fatigue (NMF), (3) injury risks, and (4) adaptations to training cycles.

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Article

Identifying Reliable and Relatable Force–Time Metrics in Athletes—Considerations for the Isometric Mid-Thigh Pull and Countermovement Jump

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Abstract: The purpose of this study was to evaluate intrasession reliability of countermovement jump (CMJ) and isometric mid-thigh pull (IMTP) force–time characteristics, as well as relationships between CMJ and IMTP metrics. Division I sport and club athletes ($n = 112$) completed two maximal effort CMJ and IMTP trials, in that order, on force plates. Relative and absolute reliability were assessed using intraclass correlation coefficients (ICCs) > 0.80 and coefficients of variation (CVs) < 10%. Intrasession reliability was acceptable for the majority of the CMJ force–time metrics except for concentric rate of force development (RFD), eccentric impulse and RFD, and lower limb stiffness. The IMTP's time to peak force, instantaneous force at 150 ms, instantaneous net force, and RFD measures were not reliable. Statistically significant weak to moderate relationships ($r = 0.20$ – 0.46) existed between allometrically scaled CMJ and IMTP metrics, with the exception of CMJ eccentric mean power not being related with IMTP performances. A majority of CMJ and IMTP metrics met acceptable reliability standards, except RFD measures which should be used with caution. Provided CMJs and IMTPs are indicative of distinct physical fitness capabilities, it is suggested to monitor athlete performance in both tests via changes in those variables that demonstrate the greatest degree of reliability.



Keywords: force plate; neuromuscular performance; strength; power; coefficient of variation; collegiate athletes

1. Introduction

An athlete's ability to repeatedly generate large amounts of force over short amounts of time (e.g., relative to their competition) positively influences their performance in an overwhelming majority of sports [1]. Sport scientists and/or practitioners routinely assess athletes' maximal force production (e.g., peak force) and their ability to generate force rapidly (e.g., rate of force development, RFD) as a means of assessing training adaptations and neuromuscular fatigue. Neuromuscular fatigue is commonly defined as a decrement in voluntary force generating capabilities [2]. Increased training loads and intensities, of sport training or competitions, may result in accumulated neuromuscular fatigue. These training loads and their implications must be adequately compensated for to prevent maladaptive responses to training, such as decreased power production and increased risk for musculoskeletal injury [3,4]. Given the unequivocal importance of greater force production by athletes, identifying the most effective strategies to reliably and objectively assess performance adaptations (i.e., acute and chronic changes in strength and power) is of interest in sport.

Although traditional one-repetition maximal (1-RM) testing is capable of determining maximal strength in athletes, there are concerns with its application in neuromuscular

Sports 2021, 9, 4. <https://doi.org/10.3390/sports9010004> <https://www.mdpi.com/journal/sports>


 

Review

Applying Force Plate Technology to Inform Human Performance Programming in Tactical Populations

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Abstract: Force plate assessments, such as countermovement jumps and isometric mid-thigh pulls, examine performances (e.g., jump height, force, power) and movement strategies (e.g., asymmetries, durations), and are best suited to characterize and monitor physical capabilities, not predict injuries. To begin applying force plate technologies, users must first: (1) develop a data management plan to visualize and capture data over time; (2) select appropriate force plates for their scenario; (3) design appropriate testing protocols to ensure valid and reliable data. Force plate assessments may be added to existing testing, serve as separate testing batteries for annual profile testing to compare individuals and understand initial physical capabilities, or for more frequent testing (i.e., monthly or weekly) to monitor training-related adaptations or neuromuscular fatigue. Although these assessments inform evidence-based program designs, human performance practitioners must understand the considerations for conducting appropriate force plate testing, as well as proper visualizations and management of force plate data. Thus, the aim of this review is to provide evidence-based practices for utilizing force plates in tactical populations (e.g., military, firefighters, police). This includes best practices to implement testing for performance profiling, training adaptations, and monitoring neuromuscular fatigue and force asymmetries. Of note, due to the large amount of force-time metrics to choose from, this article provides general examples of important metrics to monitor and training recommendations based on changes to these force-time metrics, followed by specific examples in three case studies.

Keywords: countermovement jump; isometric-mid-thigh pull; military; ground reaction force; force-time profiling; police; firefighter

1. Introduction

Although the physical demands and occupational requirements vary across and within tactical populations, muscular strength and power capabilities remain fundamentally vital to most tactical environments [1,2]. Rates of musculoskeletal injuries are high for many tactical populations, with lower extremities, back, and shoulders being the most common injury locations [3–12]. As a result, musculoskeletal injuries increase missed duty time and require rehabilitation, thereby inhibiting skill maintenance and acquisition, restricting operational capacities, and increasing compensatory workforce strain [2]. This series of events costs significant government funding and resources [9,13]. One resounding characteristic contributing to musculoskeletal injury rates is unwarranted accumulations of neuromuscular fatigue from monotonous high-volume training periods at initial entry points purported to prepare individuals for their career [2,7,14,15]. For example, in Navy recruits, greater run mileage increased incidences of injury without any further improvement in aerobic

Appl. Sci. 2021, 11, 6538. <https://doi.org/10.3390/app11146538> <https://www.mdpi.com/journal/applsci>

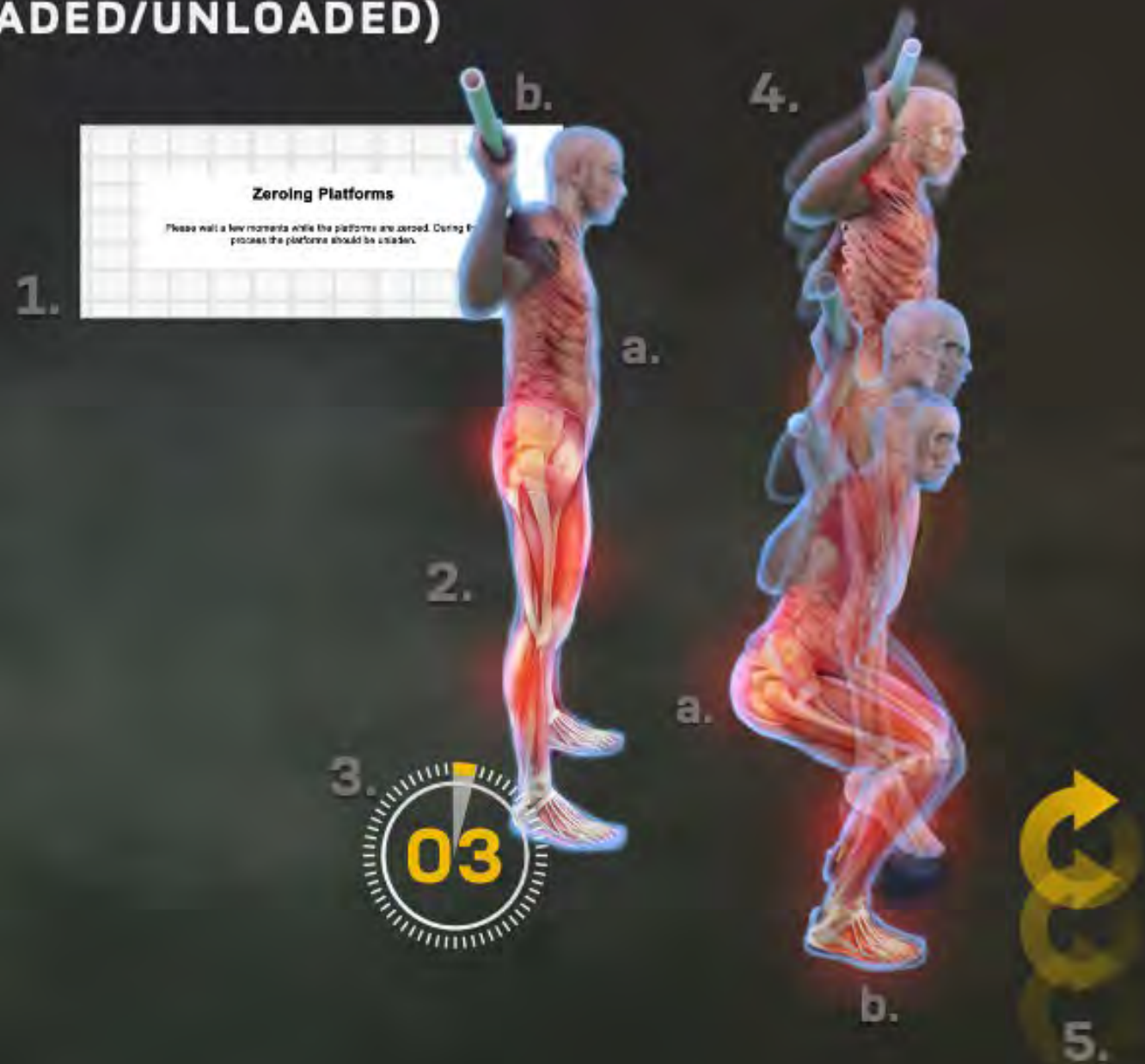


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 Evolution through Evaluation

2022 NSCA TACTICAL ANNUAL TRAINING

HOW TO EXECUTE: CMJ (LOADED/UNLOADED)

1. Zero the force plates
2. Assume the starting position
 - ☐ a. Standing upright and facing forward
 - ☐ b. Hands on PVC pipe or hips (unweighted)
 - ☐ c. Hands on barbell or weight vest (weighted)
3. Weigh individual for at least 1-3 seconds
 - ☐ a. They must be standing completely still
 - ☐ b. Include the external load if weighted
 - ☐ i. Mark the trial as weighted
4. Instruct the individual to "jump as high and explosively as possible"
 - ☐ a. Squat down and jump up, explosively, then
 - ☐ b. Land softly and remain in the starting position
5. Perform the jump 2-3 times before saving



DATA WORKFLOWS



API

DIRECT ENTRY

EXCEL UPLOADS

Application Programming Interface

- Automatic data flow from technology source to AMS
- Requires authentication and linking
- Simple and automated, but requires maintenance and upkeep

Group Entry

- Directly type into Web much like Excel
- Automatically saves to AMS when complete

Single Entry - Kiosk

- What was training like day/week before?

Single Entry - Smartphone

- For repeated measures, whether measuring same tactical athletes over time, or comparing groups – KEEP IT CONSISTENT

Spreadsheet

- Likely most familiar to staff
- Requires formats to be set and continuously followed
- Care must be taken with matching up with profiles in AMS
- Time formatting can be big issue!

LOGISTICS, LOGISTICS, LOGISTICS

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DATA CLEANING



LABELING

Profiling vs. Monitoring

- Profiling: Periodic assessments (potentially macrocycle)
- Monitoring: More frequent (weekly, daily)

Course / Timepoint

- Class or Course Number per test / tactical athlete. Allows for group analysis of class/course
- Baseline vs. Post-Testing (and anything in between) for progression over time

DISTRIBUTIONS

First Steps

- Run data distributions to visually inspect data
- Identify any labeling issues, data flow issues

General Understanding

- First visual look at distribution type

OUTLIERS

High / Low Results

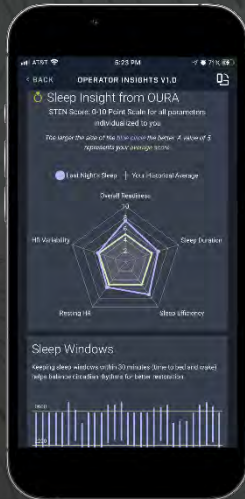
- Look at distributions to identify any potential outliers, likely due to mistakes in data entry or processes
- Some may be fixable, some may need to be excluded
- I.E. Initial weighing phase of force plate off by 100lbs will dramatically affect bodyweight normalized metrics

ACCURATE TOOLS, GOOD PROCEDURES....BUT POOR LABELING/CLEANING
MAY LEAD TO FALSE FINDINGS

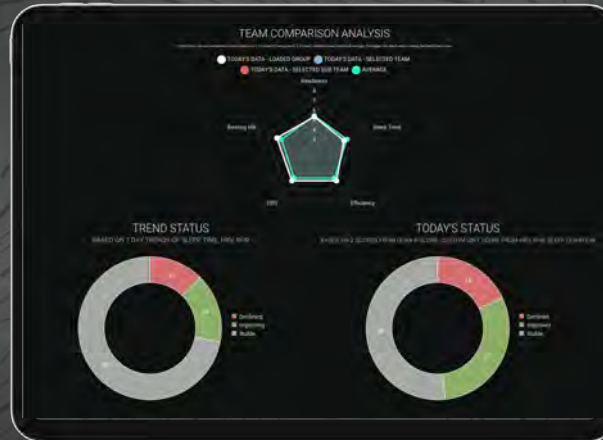
DATA VISUALIZATION



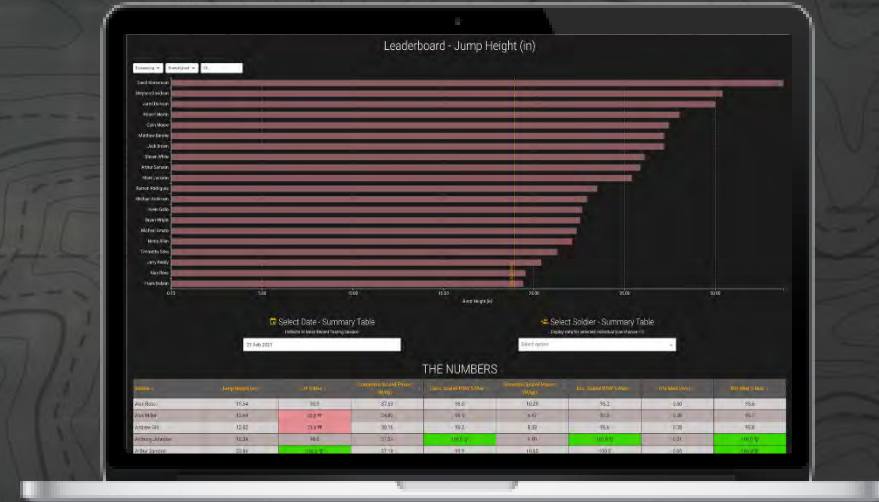
TACTICAL ATHLETE



PRACTITIONER



COMMAND



VISUALS MUST ALIGN WITH NEEDS OF EACH GROUP

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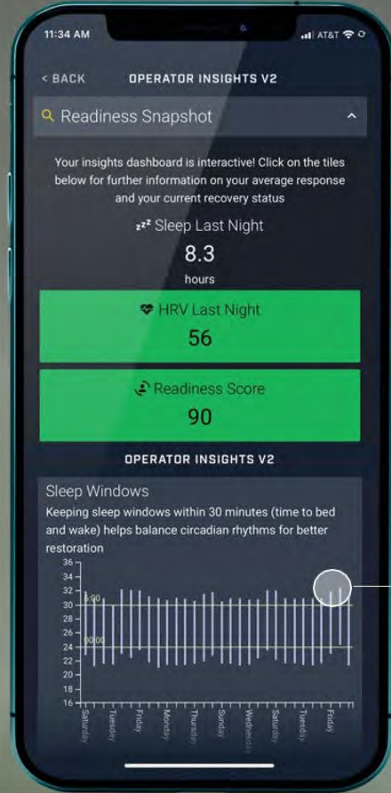
SMARTABASE MOBILE APP

- Aggregated data across multiple sources
- Personalized Analytics



Personalized insights on sleep physiology data compared only to their personal norms

Infographic Resource images to educate the soldier on health, wellness, and performance



Circadian Rhythm analysis for optimized sleep timing

POLAR WATCH AND MOBILE APP



Daily summary metrics on smartphone app including total distance, calories burned, activity goals etc.



Real time insights directly on the watch face, including session summaries and nutritional recommendations post training

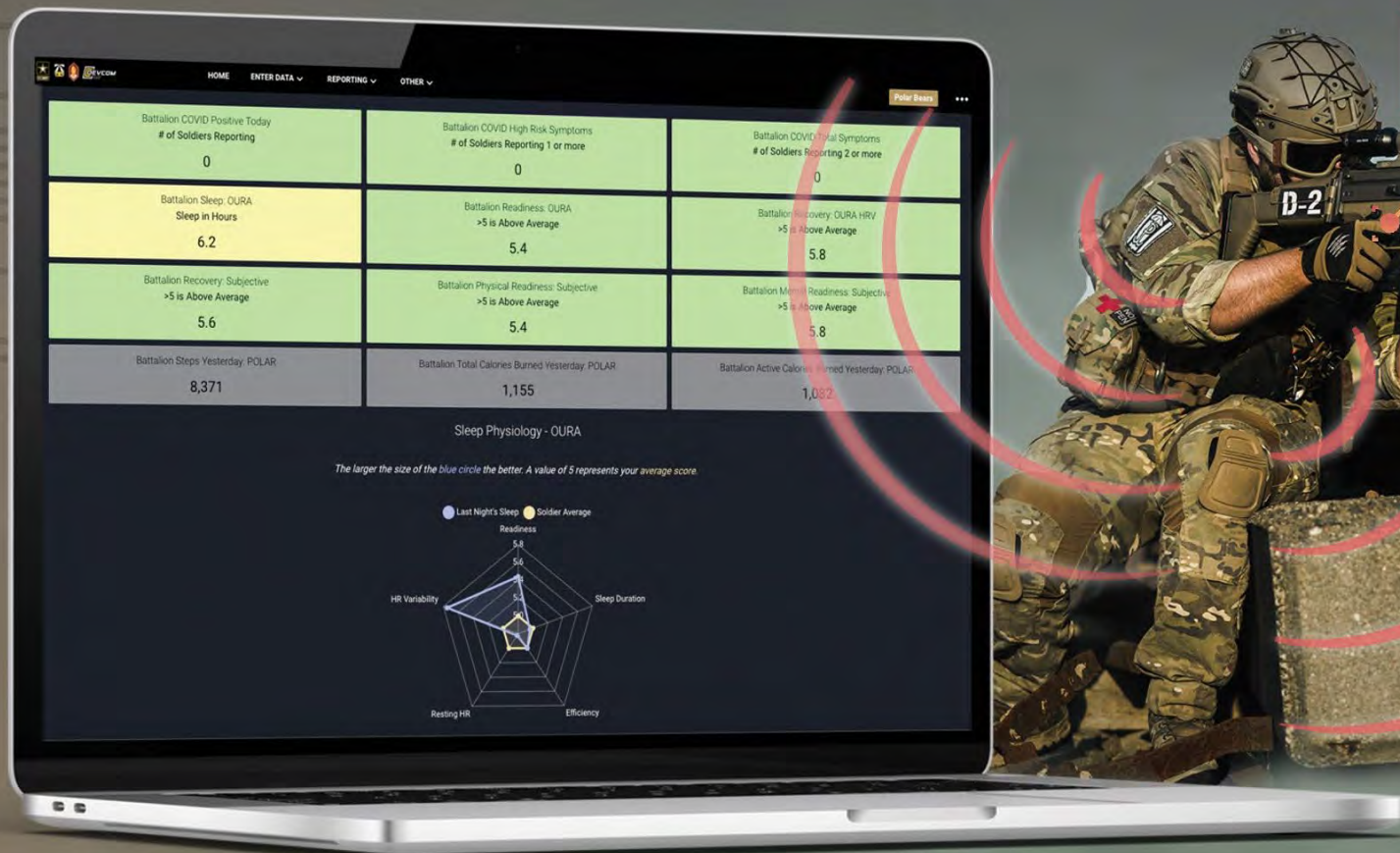


Historical heart rate tracing from training sessions and all day activities

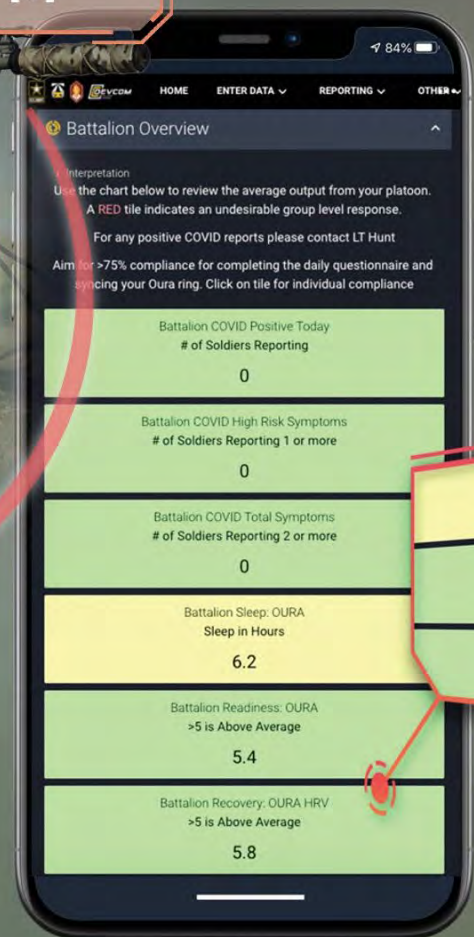
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156
BPM



Battalion Sleep: OURA
Sleep in Hours
6.2

Battalion Readiness: OURA
>5 is Above Average
5.4

Battalion Recovery: OURA HRV
>5 is Above Average
5.8

DATA INSIGHTS

Leadership dashboard for performance based insights from the group and individual level. Data includes sleep, recovery, and training load information from all wearables and subjective input.

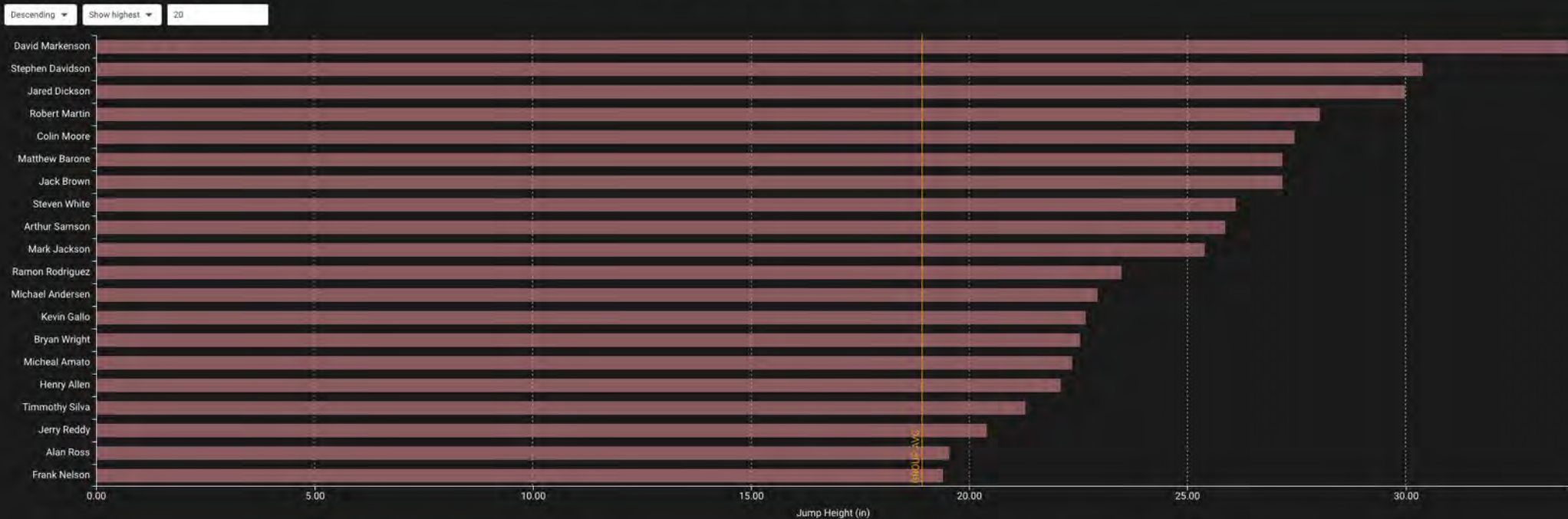
Information available via NIPR web access and Smartphone App, with permissions controlling all data and group access.

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Leaderboard - Jump Height (in)



Select Date - Summary Table
Defaults to Most Recent Testing Session

21 Feb 2021

Select Soldier - Summary Table
Display data for selected individual (can choose >1)

Select option

THE NUMBERS

Soldier	Jump Height (in)	JH % Max	Concentric Scaled Power (W/kg)	Conc. Scaled POW % Max	Eccentric Scaled Power (W/kg)	Ecc. Scaled POW % Max	RSI-Mod (m/s)	RSI-Mod % Max
Alan Ross	19.54	90.9	37.59	96.0	10.29	95.2	0.50	95.6
Alex Miller	12.64	62.8	24.80	96.5	6.47	92.0	0.38	95.7
Andrew Gill	12.62	73.9	30.16	96.5	8.53	95.6	0.38	95.8
Anthony Johnson	18.39	98.8	31.59	100.0	9.10	100.0	0.51	100.0
Arthur Samson	25.86	100.0	37.18	99.9	10.62	100.0	0.65	100.0



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1. SELECT DATE / SOLDIER

Displays specific data for the date / soldier selected (defaults to most recent test date and entire group).

Select Date - Summary
Defaults to Most Recent Testing Session

21 Feb 2021

Soldier Selector - Summary
Looking for Someone Specific? Use this (can choose >1)

Alan Ross

Select option

Alan Ross

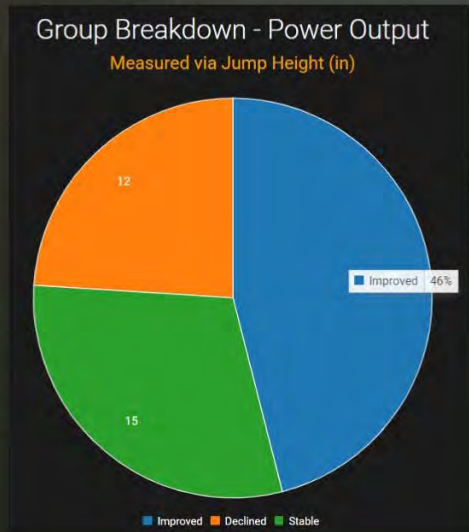
Alex Miller

Andrew Gill

Anthony Johnson

2. INTERACTIVE PIE CHART

Displays the number of individuals that experienced improved, maintained, or declined jump heights (hover over a piece of the pie to see the percent and click to see all individual's mean and max jump height, Z-score compared to historical average, and % of historical best).



3. INDIVIDUAL JUMP HEIGHTS

Achieved for selected date, all time average, and Z-score are in tables below the pie chart for those that increased, maintained, or decreased performances (can sort by any header).

DECREASED POWER Measured via Jump Height (in)				INCREASED POWER Measured via Jump Height (in)			
Soldier	Jump Height (in)	All Time AVG	Z-Score	Soldier	Jump Height (in)	All Time AVG	Z-Score
Michael Harris	18.73	23.25	-1.18	Jared Dickson	29.99	22.20	2.54
Manuel Garcia	7.00	10.66	-1.12	Kevin Gallo	22.66	15.35	2.49
Richard Jacobs	8.95	12.27	-1.13	Steven White	26.12	17.49	2.47

4. LEADERBOARD

Compares highest and lowest jump performances to group average (gold line) below the tables, can be sorted in ascending and descending order, displayed by highest or lowest jump performances, and limited to any number of individuals selected.

Leaderboard - Jump Height (in)

Descending Show highest 20

David Markenson

Stephen Davidson

Jared Dickson

5. THE "NUMBERS" TABLE

Displays jump heights, concentric power, eccentric power, and reactive strength indexes (RSI mod) for each person compared to their all time best. Green highlights and trophy icon indicate a personal best was achieved, while a red highlight and flag icon indicate a large reduction in performance. The entire group's overall status can be assessed with group total scores in the bottom rows.

Jump Height (in)	JH % Max
19.54	90.9
12.64	62.8
12.62	73.9
18.39	98.8
25.86	100.0
22.53	90.4

DATA ANALYSIS AND REPORTING



NORMS

Population Averages

- Tactical Athletes have very unique demands, and data must be acquired and analyzed specific to their population.
- Factors include MOS, gender, age, years of service etc.
- Establishing these norms allows for greater understanding of the population, and how each tactical athlete fits in

PROFILES

What is Normal?

- Does your battery of tests/data support your tactical athlete profile?
- If not, modify and re-assess

What is Optimal?

- How do you define a successful tactical athlete?
- Establish performance criteria
- Assess your profiles based off of performance

MODELING

Optimal Profile Model

- Multi-dimensional look at tactical athlete profiles to predict success
- Use this information to help train deficiencies

Outcome Models

- Potential to model other outcomes, i.e. Injury Risk, Career Longevity

ONLY WHEN ACCURATE, RELIABLE, AND CLEAN DATA IS COLLECTED CAN DATA ANALYSIS BE DONE



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ANNUAL TRAINING**

TRANSITION SLIDE

Thus Far We Have:

- Detailed setting the table with key data elements in play
- Discussed leveraging support to attack operational gaps
- Applied scientific best practices on the floor/in the field
- Digitized the entire human performance enterprise system
- Leveraged tools and technologies as a force multiplier

Now it's time to action the digital data infrastructure to learn from the past, understand + affect the present, and prepare for the future.

INFORMATION AGE DECISION MAKING

Requires a Data Driven Architecture

PROFILING

Movement Competency
Occupational Skills
Mindset

Power
Strength
Endurance



Aerobic Capacity
Anaerobic Capacity
Buffering

Training Age
Nutrition
Recovery

MONITORING

Baseline → Daily/Weekly → Post POI



PROGRAM EVALUATION

General Group Effects

- Subjective Wellness
- Compliance
- Fitness Scores
- MSKI

Specific Group Effects

- Improved Aerobic Capability
- Increased Self Use of Recovery Tools
- Decreased Limited/Light Duty Days

ANALYSIS & REPORTING → ACTIONING

Requires a Data Driven Architecture

PERFORMANCE RANKING

INITIAL PROFILING



RED
<16th



ORANGE
17th-50th

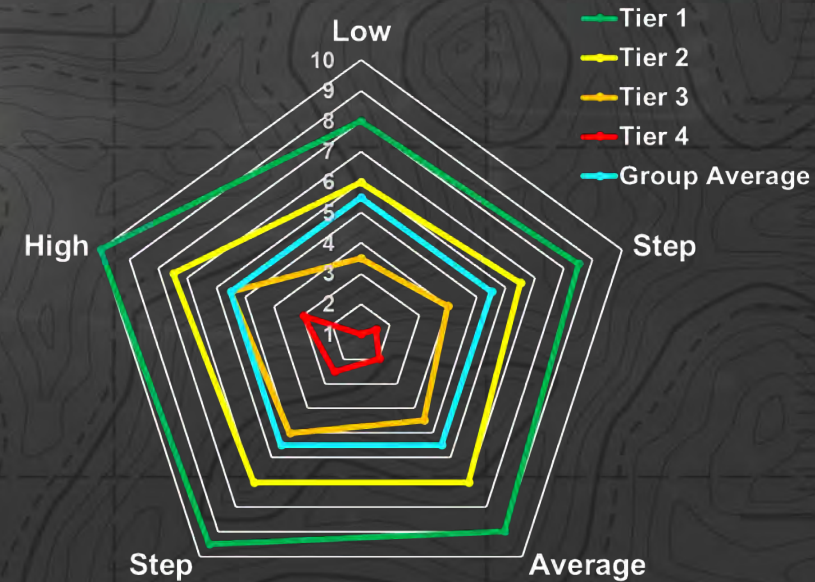
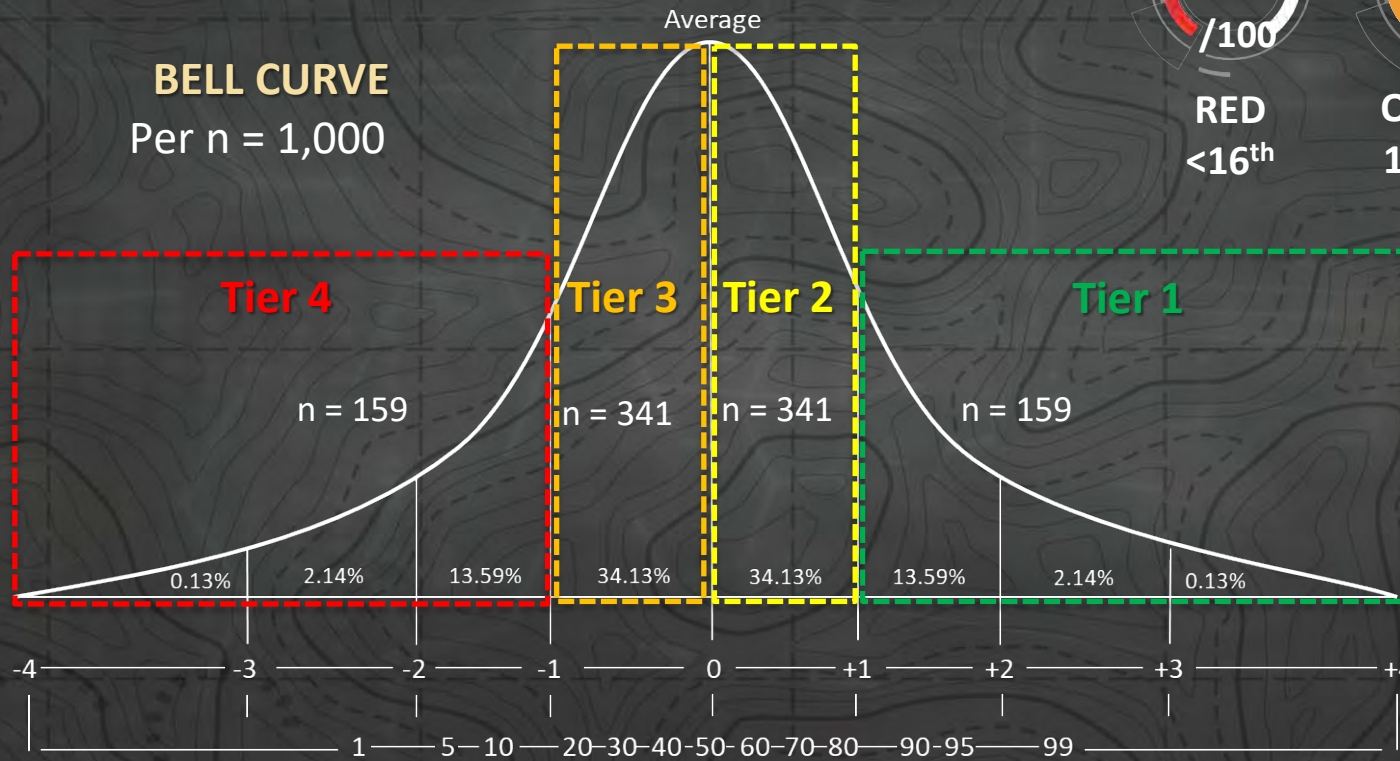


YELLOW
51st-83rd



GREEN
>84th

BELL CURVE
Per n = 1,000



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ANALYSIS & REPORTING → ACTIONING

Requires a Data Driven Architecture

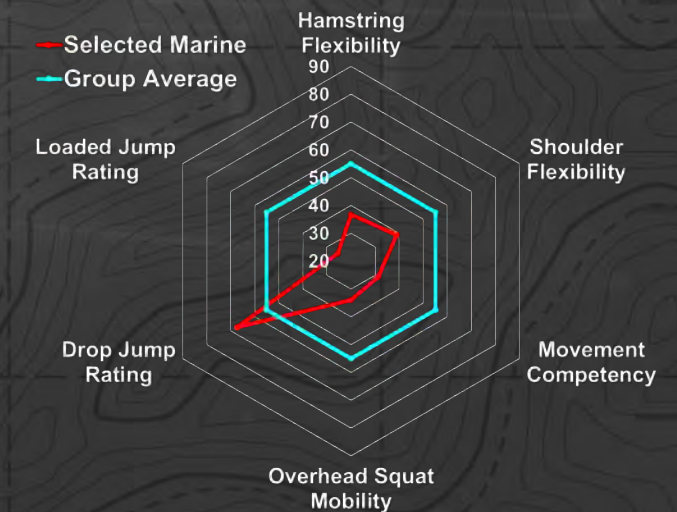
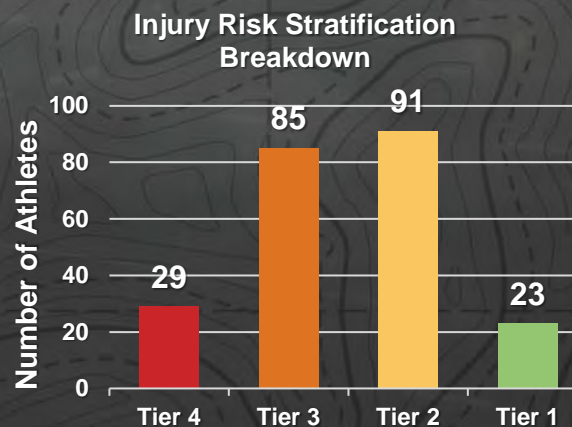
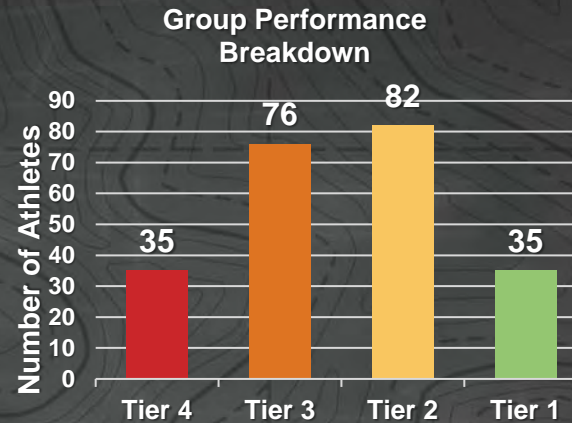
PROFILING

PERFORMANCE



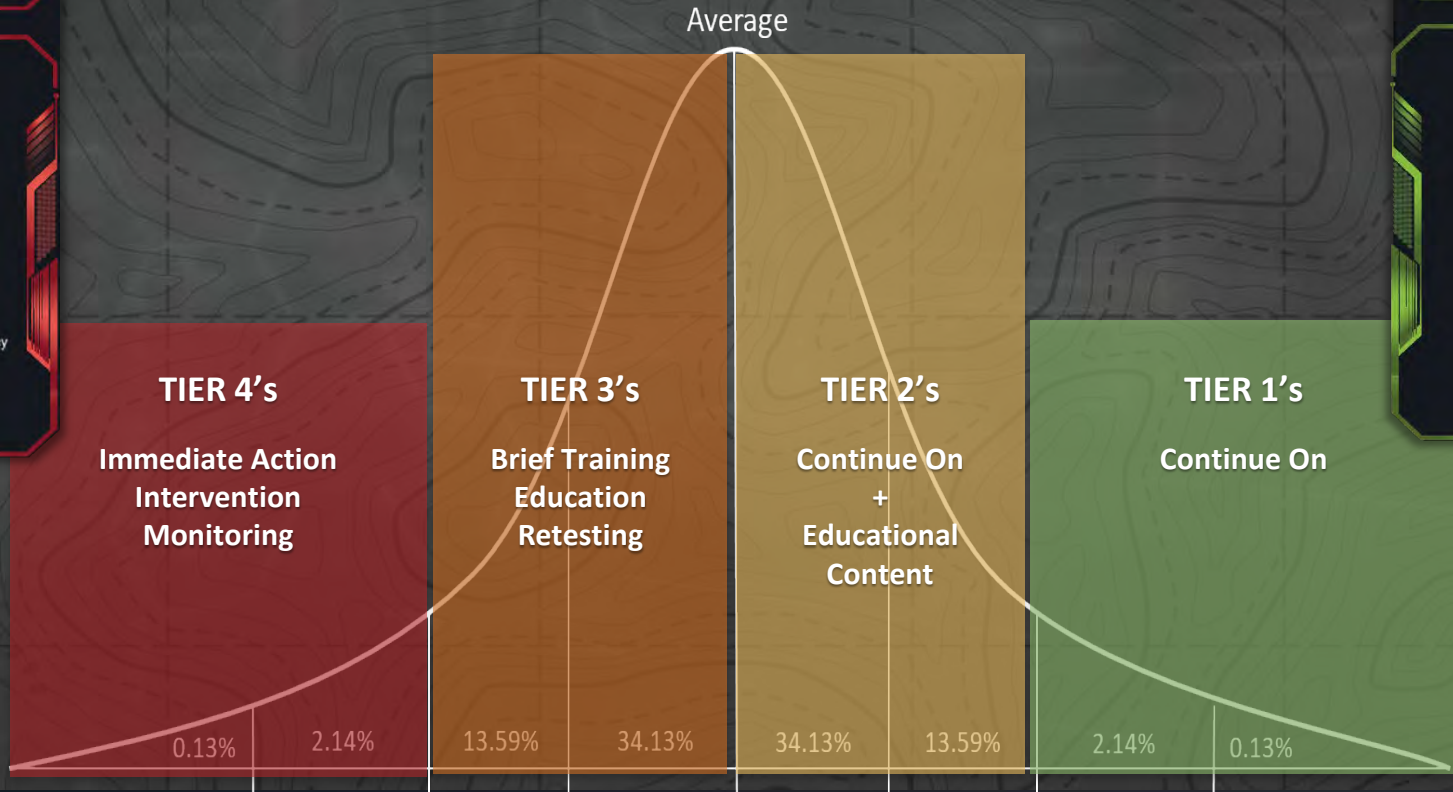
- Construct Ranking
- Main → Sub-Categories
- Percentile scores

INJURY RISK STRATIFICATION



4-TIERED APPROACH

Allocating Supporting Resources
 Determining Training Needs
 Binning PT Groups



RISKS

RISKS



PROGRAM EVALUATION

Across Groups / Timepoints

1 Variable @ 2 Levels (Pre vs Post; Condition 1 vs 2)

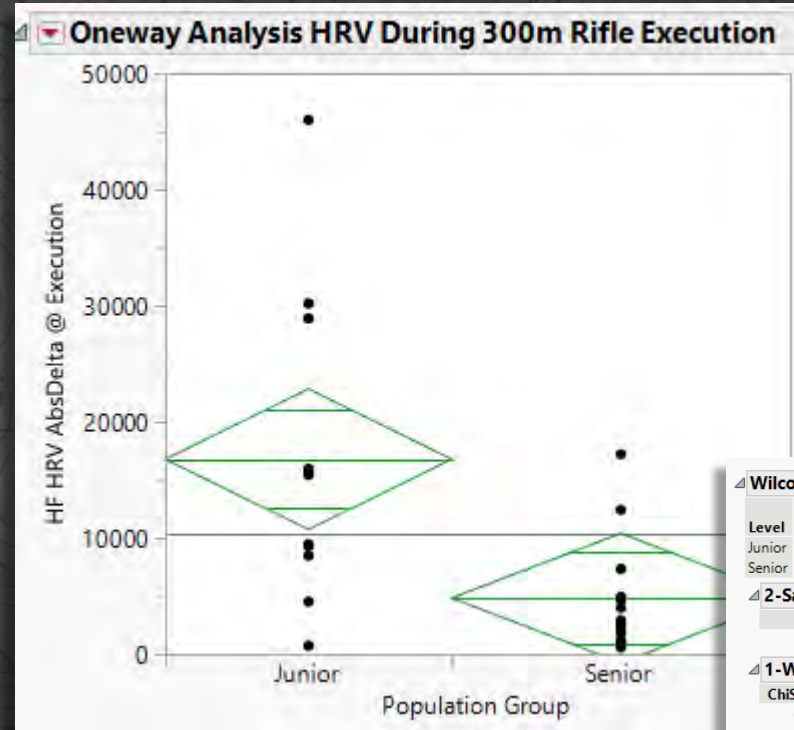
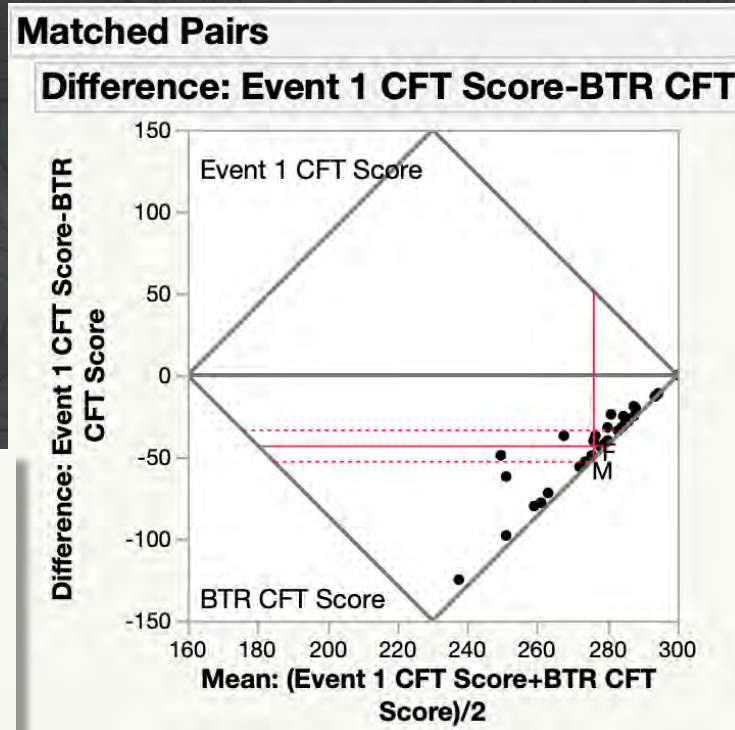
1 Variable @ 2 Labels (Matched Pairs; Population 1 vs 2)

Paired T Test

Are two sample means different than 0?

Event 1 CFT Score 254.355 t-Ratio -9.06175
 BTR CFT Score 297.161 DF 30
 Mean Difference -42.806 Prob > |t| <.0001*
 Std Error 4.72386 Prob > t 1.0000
 Upper 95% -33.159 Prob < t <.0001*
 Lower 95% -52.454
 N 31
 Correlation 0.24274

Across Groups			
	Count	Mean Difference	Mean Mean
F	15	-36.93	277.2
M	16	-48.31	274.41



Wilcoxon Singed Rank

Is a significant difference between population rank order / match-pairs?

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Junior	11	183.000	137.500	16.6364	2.607
Senior	13	117.000	162.500	9.0000	-2.607

2-Sample Test, Normal Approximation		
S	Z	Prob> Z
183	2.60714	0.0091*

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
6.9491	1	0.0084*

<http://www.sthda.com/english/wiki/comparing-means-in-r>

Analytical Scripts Can Automate Process to Save Time and Enhance Scalability

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LEARN FROM THE FIELD

REVIEW

META-ANALYSIS

POSITION STATEMENT(S)

- Summary of research on topic
- Survey of existing publications
- Narrative Review = easier to read, wider application spectrum
- Systematic Review = detailed, comprehensive with specific methods

- Critical analysis of multiple studies, combined for their theoretical relationships
- Increased power to answer specific questions = pooled significance
- Fundamental to evidence-based best practices

- Individual or group consensus statement regarding problem, process, or potential
- Usually supported by empirical investigations, reviews, and meta-analyses
- Often expresses direction of future relevant fields



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DATA DRIVEN DECISION MAKING



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DATA DRIVEN DECISION MAKING

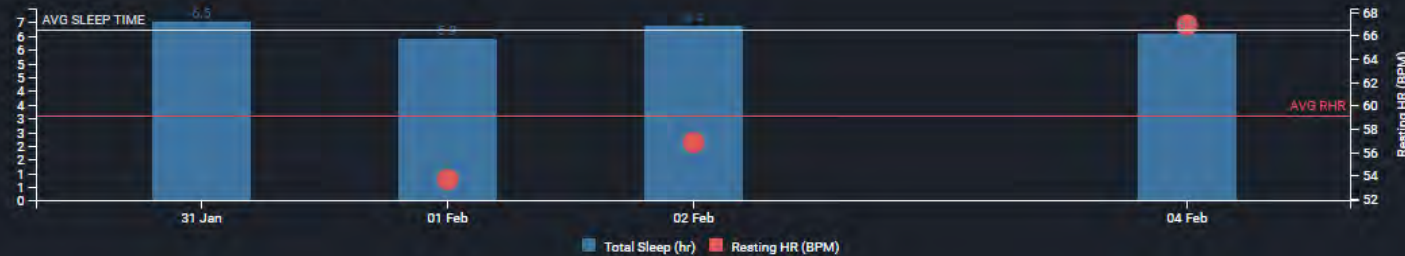


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Evolution through Evaluation

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DATA DRIVEN DECISION MAKING

Sleep Duration and RHR Timeseries



STATUS

Based on RESTING HR Deviations from Norm

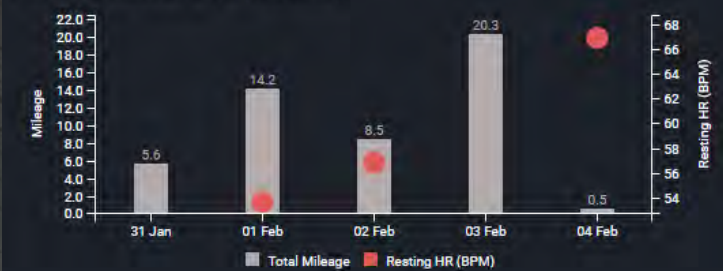


SLEEP DETAILS

MARINE	DATE	Sleep Duration	HRV	RHR
SOIE 1024	04 Feb	5.88 ↓		
SOIE 1009	04 Feb	5.57 →	51 ↓	71 ↑
SOIE 1010	04 Feb	5.02 ↓	131 ↓	53 ↑
SOIE 1037	04 Feb	5.72 ↑	52 ↓	70 ↑
SOIE 1036	04 Feb	5.83 ↑	23 ↓	83 ↑
SOIE 1002	04 Feb	4.72 ↓	79 ↓	56 ↑
SOIE 1013	04 Feb	6.54 ↓		
SOIE 1005	04 Feb	6.63 ↑	36 ↓	70 ↑
SOIE 1001	04 Feb	8.71 ↑	56 →	71 →

TOTAL MILEAGE AND RHR

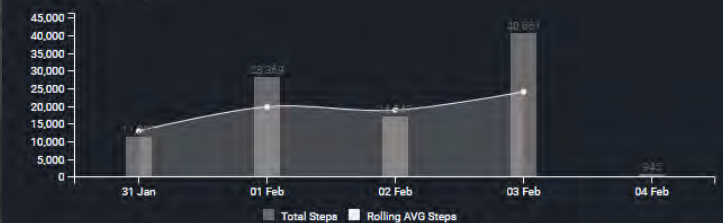
Calculated based on Steps (2000/mile)



Calories by Day

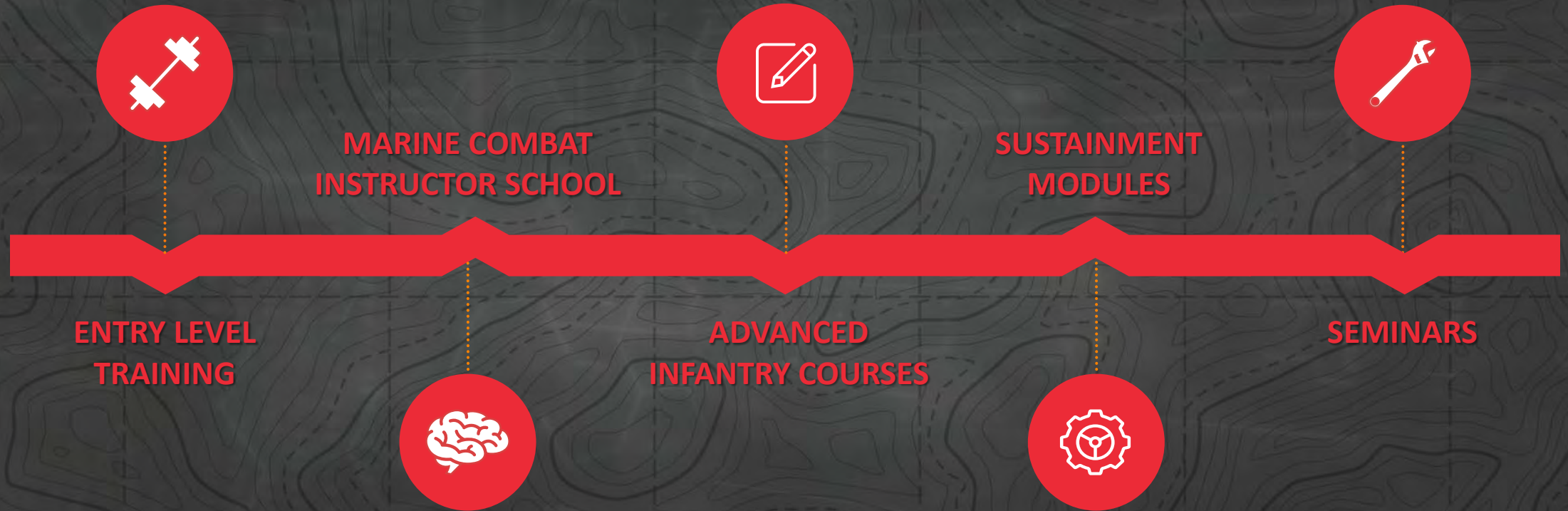


Steps by Day



TEACHING THEM TO FISH

Education on HP starts on Day 1 and continues throughout POI



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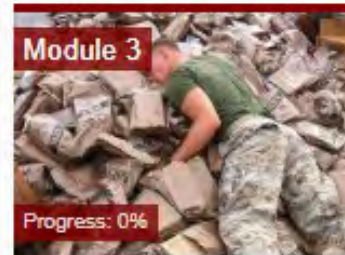
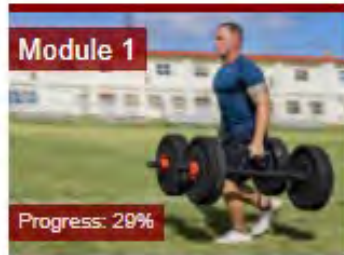
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TEACHING THEM TO FISH



Announcements

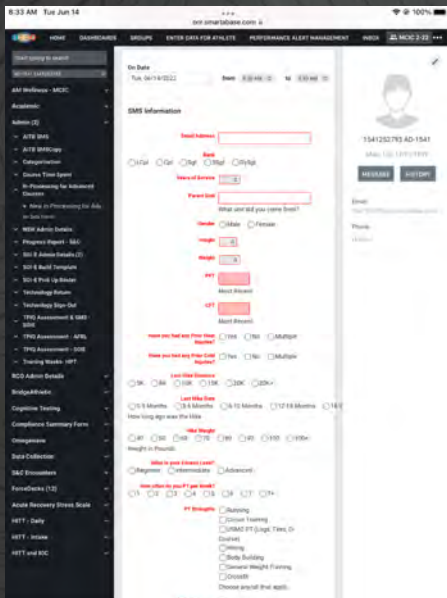


Module 1

LESSON ANS Awareness	LESSON Basics of Anatomy	LESSON Intro to Movement
LESSON Importance of Sleep	LESSON Energy Balance and Macronutrients	LESSON Movement Prep and Recovery
QUIZ Knowledge Check 1	PDF Glossary	SURVEY Assignment: End of Module Review
ASSIGNMENT Bridge Athletic	QUIZVENTURE quizventure	CUSTOM CERTIFICATE Module 1 Completion
FORUM Discussion Forum Topic 3: S&C in the Field	LESSON Topic 5: Micronutrients and Hydration (copy)	



ADVANCING BEST PRACTICE TECHNIQUES



O&M Requirements Inform S&T / R&D Efforts

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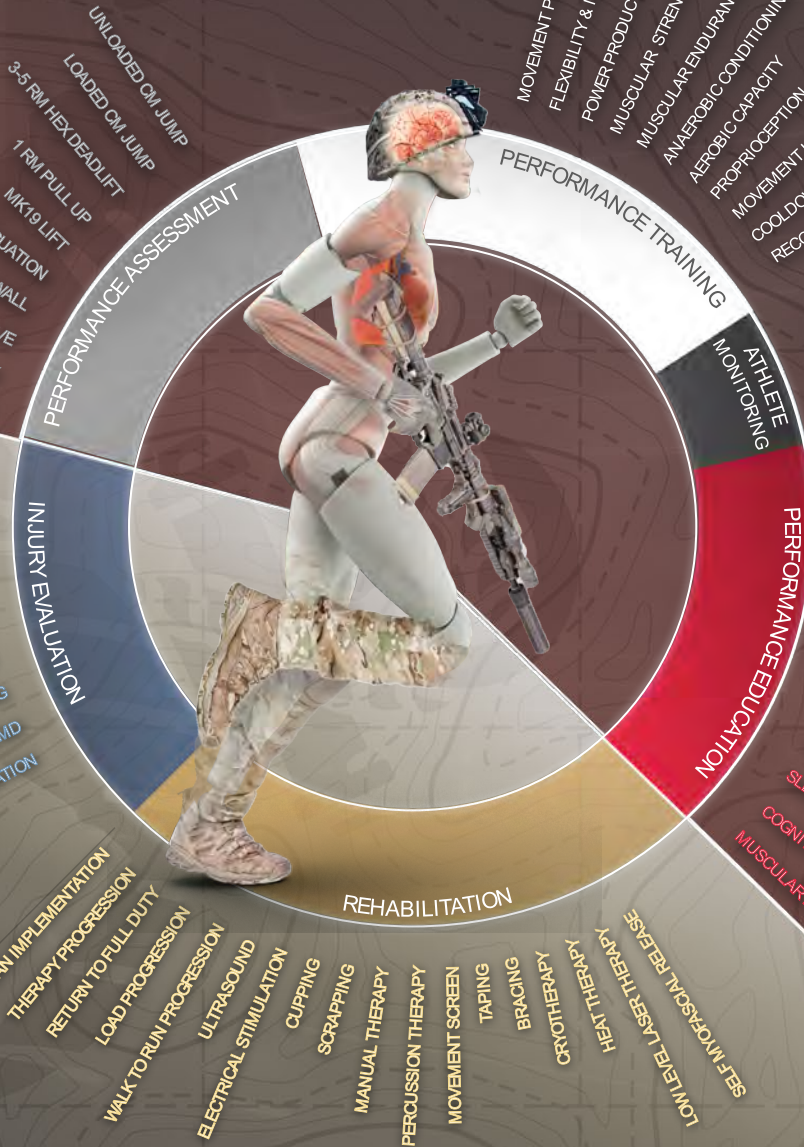
PROACTIVE

STRENGTH + CONDITIONING
ATHLETIC TRAINING

ATHLETIC TRAINER TO MARINE RATIO

4 : 4,500

REACTIVE



STRENGTH COACH TO MARINE RATIO

2 : 4,500

HOLISTIC APPROACH TO
HUMAN PERFORMANCE
AT **SOI-EAST**

INVEST IN THE INDIVIDUAL

2013

2014

2015

2016

2017

2018

2019

2020

2021

2013:
HIGHEST DROP %

TOTAL MARINES TRAINED

2013
19,619

2014
16,653

2015
16,948

2016
17,109

2017
17,772

2018
17,366

2019
17,545

2020
17,215

2021
17,190

JANUARY '17
NEW HPC FACILITY
&
EDUCATION MODULES
(mobility, sleep, recovery)



DECEMBER '17
COACHING
ADDITIONS
2nd Strength + Conditioning Coach added to HPC

JANUARY '18
FULL MCIC
INTEGRATION
& PROGRAMMING
HPC led Education and Practical Application

MID 2019:
DESIGN & IMPLEMENTATION
...of education and coaching for group mobility and dynamic warmups.



NOVEMBER '19
AMP²
WEST VIRGINIA UNIVERSITY CONTRACT
...with the Office of Naval Research, Code 34, to work with SOI-E HPC on workflow development, new technology implementation, and translation into Standard Operating Procedures (SOPs).

&
SMARTBASE ATHLETE MANAGEMENT SYSTEM IMPLEMENTATION WITH DIRECT DIGITIZED SPORTS MED EVALS
HPC began new SOP with direct digitized Sports Medicine Evaluations.

APRIL '20
4TH ATHLETIC TRAINER ADDED

JUNE '20
NEW HEAD OF S+C
Lacey Jahn was hired and immediately began revamping all training, monitoring, and recovery procedures.

JULY '20
REGULAR EDUCATION MODELS
...for advanced courses implemented (mobility, sleep, recovery)

AUGUST '20
IMPLEMENTATION OF DIGITIZED S&C
for PT cards and rehabilitation Application

SEPTEMBER '20
HPC SOP DEVELOPMENT
...for new procedures (RSO&I, full SPA's)

OCTOBER '20
HUMAN PERFORMANCE COURSE
Introduction course on Moodle

HIKE WARMUP+RECOVERY
Pre + Post Hike

FEBRUARY 2020:
IMPLEMENTATION OF SPA'S
Strength + Power Assessments

&
DEVIL DOG CLINIC RE-OPENED
On-Site Evaluation, Rehabilitation and Treatment of our Students, Staff, and Combat Instructors



MSK INJURIES 237

MSK DROPS (NON-EAS ATTRITION) 25

SUNK-COST LOSS (DUE TO NON-EAS ATTRITION) \$1,375,000

195

10

\$550,000

139

5

\$275,000

HPC'S 1,443 INSTANCES OF SUCCESSFUL INJURY REHABILITATION = \$79.4M SAVINGS TO THE SERVICE

(based on HQMC Force Preservation Directorate's assessment of \$55K cost to recruit and train through MCRD graduation)

HPC BY THE NUMBERS



TOTAL # OF MARINES IN SYSTEM ALL TIME

38,130

TOTAL # OF MARINES IN SYSTEM ACTIVE

8,198

1,310,633

TOTAL NUMBER OF DATA POINTS IN THE SYSTEM

19,604

BIOMECHANICAL FORCE ASSESSMENTS

2,259

DIGITAL SPORTS MEDICINE EVALS

18,897

TOTAL NUMBER OF DIGITAL ENCOUNTERS

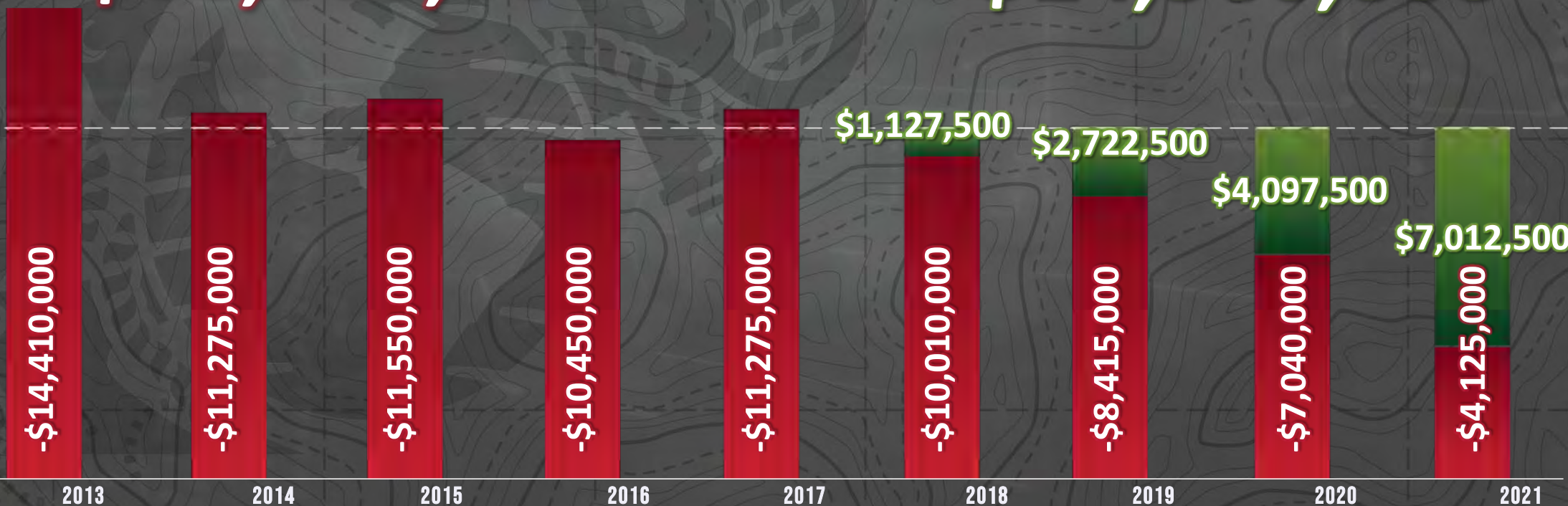
TOTAL COST OF ATTRITION BEFORE 2018

\$66,605,000

TOTAL SAVINGS ON ATTRITION ALONE (2018-2021)

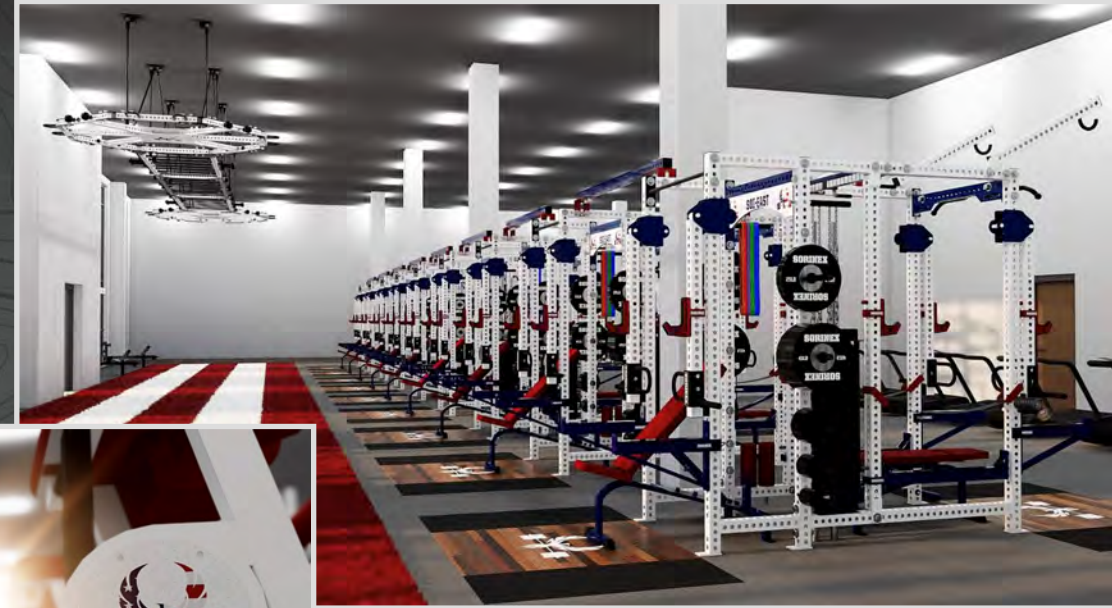
\$14,960,000

AVG LOSS
\$11,137,500



WAY FORWARD

Future of SOI-E HPC



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THANK YOU! QUESTIONS?



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