Proceedings of the 2020 Annual General Donald R. Keith Memorial Capstone Conference
West Point, New York, USA
April 30, 2020
A Regional Conference of the Society for Industrial and Systems Engineering

Relating Movement Analytics to Small Unit Lethality

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Abstract: Currently, the US Army does not have a comprehensive system to measure the operational behavior of small units through performance measures and data analytics. This research evaluates and constructs a performance model using data collected from over 20 cadet Sandhurst teams at West Point using surveys, GPS tracks, and interviews. The first step in this work included the scoping of the problem and identifying measures to quantify squad lethality. Analysis of GPS and survey data illuminated several independent variables with potential as a discriminator of lethality. Similar to analytical techniques used in sports science, the effects of sleep, nutrition, and other social factors demonstrated potential as factors to explain for individual and team performance. This analysis showed promising results, identifying emerging best practices for improved methods to explain soldier performance through sleep, nutrition, and physical activity; qualitative factors related to small unit performance, as well as small unit measures such as leadership, motivation, and cohesion, are also discussed. Overall, this methodology holds potential as a framework to evaluate soldiers and teams, supporting the measurement of small unit lethality for future decision making.

Keywords: Small Units, Lethality, Sports Analytics, Social Factors, Movement Analytics, GPS, Effectiveness

1. Introduction

Data analytics play a significant role in determining the effectiveness of players in sports (Roos, 2015). Determining the indicators of valuable players is vital for effective team building. Similarly, the Army would benefit from understanding what makes a lethal squad. Gaining the capability to analyze small units with analytics would improve the lethality and readiness of the Army. PEO Soldier needs a system to quantify small unit lethality. The system proposed in this paper quantifies lethality by assessing squad performance both quantitatively and qualitatively to provide operational and strategic decision support. Collecting qualitative and quantitative data from squad-level exercises conducted at the United States Military Academy (USMA) supported the creation of a statistical model. Modeling will aid in identifying the best variables and data analytical measures to properly assess the lethality of a squad. These variables and measures provide an implementation for future use as the identification of key variables and measures will streamline future efforts. This paper addresses movement analytics and social factors and their relationship to the operational readiness and overall lethality of a squad.

1.1 Background

A tactical small unit, or TSU, is the Army doctrinal name for a squad sized element that operates under the leadership of a squad leader. "The Army has consistently described the Soldier as a system (implying the TSU is a system of systems), and previous studies have concluded that the Army should use a system engineering methodology for the Soldier" (National Research Council, 2013, p. 65). Through these means, the Army conceptualizes a decomposition of soldiers as a system, ultimately identifying the functional components where potential for improvement resides. Within this paper, soldiers can be measured by utilizing the performance triad, which is the Army's system for optimizing health through the means of proper sleep, adequate activity, and good nutrition. By analyzing this system along with different social factors, the Army has a practical model with potential for analysis and improved understanding of these dynamics on squad lethality.

1.2 Related Work

Movement is one of the primary factors that impact a soldier's lethality. In an article by Maj. Gen. John A. George, reduced carrying weight while maintaining proper security is a critical part of increasing soldiers' lethality (George, 2020).George describes previous efforts that sought to improve a soldier's ability to shoot and maneuver on the battlefield with minimal limitation from additional weight or stocky equipment. This article provided a better understanding of the Army's needs for soldiers and the impact of movement on individual performance. George emphasizes the while technological advances have significantly improved soldier capabilities, the sheer weight of this equipment could offset the benefits.

Geospatial systems can also provide insight into individual performance, as seen through smart devices that have GPS capabilities and position-location tracking. Latitude and longitude reports bring more depth and flexibility for statistical data analysis. According to one article written on geospatial data and movement analytics, GPS information adds a third dimension in measurements by increasing value across time and dynamic locations (Sinha, 2020). Additional insights on movement speed, pause in movement, and overall spatial behavior can be made through GPS data collection. Similar data from soldiers can also be correlated with individual performance, such as comparing caloric intake and motivation to movement behavior.

Analysis of GPS and heart rate data allows researchers and system innovators to develop better training methods to improve endurance and physical performance. One related study examined the use of external devices, such as fitness trackers, and discovered that collected data from these devices can easily create algorithms that will aid in analytical capabilities (Witt et al., 2019). This research validates the attempt to collect data on the heart rate of soldiers by showing how physiological effects can impact a soldier's movement and thereby affecting overall lethality. Along with movement, other potential factors that impact heart rates such as stress, sleep deprivation, and malnutrition could be explored further depth.

2. Methodology

A systems engineering process known as the vee diagram was followed, beginning with a problem definition (shown in Figure 1 below). The main problem centers around the Army's ultimate need for a system that can determine the effectiveness of small-unit combat teams through different metrics. In the over-arching research, four major concepts contribute to the effectiveness model of a small unit: sleep, nutrition, social factors, and military physical readiness. The present research concepts reinforce the significance of the Army's performance triad, presenting a model focused on improving soldier health by monitoring sleep, nutrition, and activity. This research will help in attempting to improve awareness of each variable to achieve enhanced individual performance.

In this project, a survey was administered for a pre-assessment on the Fall Sandhurst Competition, a squad-level military skills competition which takes place at West Point in mid-October. The Fall competition consists of 36 squads or teams, one per cadet company, and each team consisting of 10 cadets from their respective company. The competition spans over 24 hours and includes events such as an obstacle course, rucking, rifle qualification, land navigation, and other military skills tests. After the competition, the study collected interview-based answers, performance data, and GPS tracks of the squads as they progressed through the competition. Answers to the interview questions provided qualitative insight and context related to the social aspects of the team, training, and experiences during the competition. The Sandhurst performance data that was inherent to the competition included data that evaluators must collect to determine team performance; this data served as a primary response variable. A Fenix-5Plus Garmin watch worn by squad leaders was used to track movement analytics and physiological factors in the Sandhurst competition. Qualitative data was collected through post-competition interviews and organized using affinity diagrams. Data was then collated and analyzed, focusing on exploration and potential modeling approaches as a proof of principle. The purpose of this analysis was to find which soldier competencies and traits had the highest correlation in determining soldiers and small unit lethality. By comparing the correlations of the results of the competition with the qualitative and quantitative data, soldiers can be more holistically evaluated. Through these means, researchers can understand the more intangible aspects of small unit lethality and be able to help foster decision making for future Army commanders.

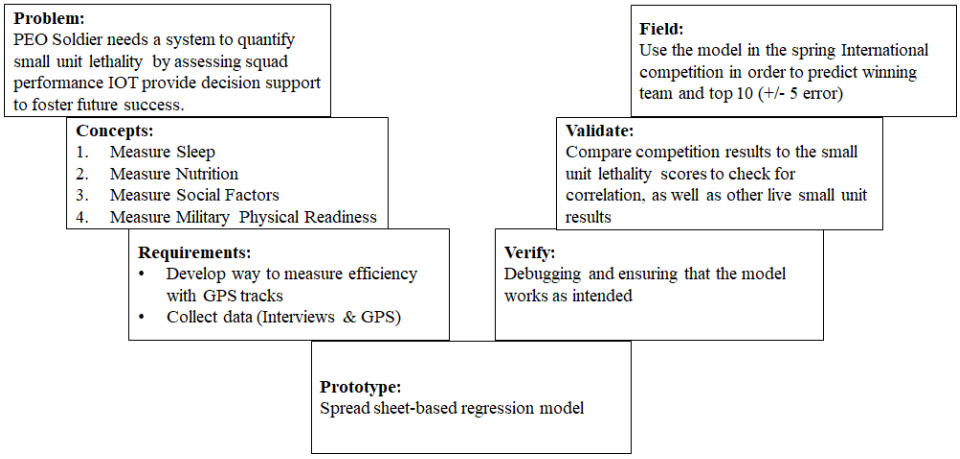

Figure 1. Vee Diagram

2.1 Garmin Watch Usage in Sandhurst Competition

To develop these lines of effort, PEO Soldier provided 50 Fenix-5Plus Garmin watches to track individual squad performance data during the competition. Out of the 38 Sandhurst teams competing, 25 consented to participate in the study that tracked each squad's GPS data during all events. Each Squad Leader or one designated team leader from these 25 teams were issued a hand receipt and Garmin watch before the competition, which was marked numerically for tracking purposes. These watches were manually locked by the research team before being issued to mitigate any tampering from competitors and were worn by the same individual for all events. Upon completion of the 24-hour competition, the watches were recollected from the 25 teams for data processing and analysis. The data from the watches spanned over the entirety of the competition, which allowed for movement and performance breakdowns during each event, which could then be compared to the team's final ranking in the competition. This research focused on the top and bottom three performing teams, extrapolating those teams' data for further analysis. The primary reason for narrowing analysis to the top and bottom teams was time available for this study. We selected top and bottom teams with hopes of more easily identifying discriminating behaviors.

2.2 Sandhurst Competition Results Analysis

Following the conclusion of the competition, the quantitative data was extracted from the 25 Garmin watches while the qualitative data was collected during interviews with the top and bottom three performing teams. Three quantitative performance measures were analyzed from the Garmin watch data during the initial timed-ruck march: overall moving average, moving percentage, and route efficiency. While this research does not include heart rate data, it is one noteworthy capability of these Garmin watches by monitoring and recording the user's heart rate which can be useful in comparing physical exertion and individual performance. Squad interviews provided qualitative data from the six teams regarding leadership, motivation, and cohesion. Together, performance data and social factors create an evaluation method for each squad by revealing the correlation between these measures and final execution during the competition. Due to the cancellation of the 2020 Spring Sandhurst Competition, there will be no field reports to serve as verification of the movement analytics code created during this stage or validation of the first competition's results.

3. Results

3.1 Overall Moving Average

Overall moving average measures each team's average speed during the initial timed-ruck march to analyze the speed of all the teams from the starting point until the first checkpoint. Figure 2 below shows the moving averages during the ruck march, with the teams in order of their final competition ranking. While there is some correlation between performance during this initial event, the downward trendline seen below is mainly due to the extremely low outlier of Team 25.

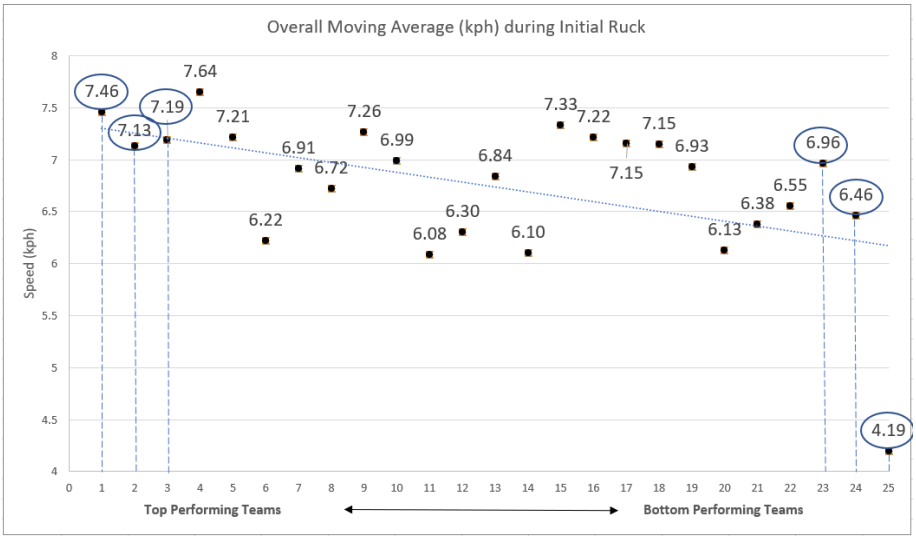

Figure 2. Overall Moving Average for Every Team

Zooming in further, comparing the top three performing teams against the bottom three performing teams, there is a clear differentiation between higher performance and lower rucking speeds.

3.2 Static versus Moving Percentage

After examination of the speed differentiation between teams, the second concept analyzed was the percent moving versus the percent static throughout the mission from the starting point to the first checkpoint. The goal of using static versus moving percentage was to attempt to understand the fraction of time squads spend planning movement (land navigation) versus the fraction of time squads spend physically moving. In this metric, static is considered as below 5 kph, assuming the average speed of a walking human is 5 kph. An example of the static versus moving percentage can be found in figure 3.

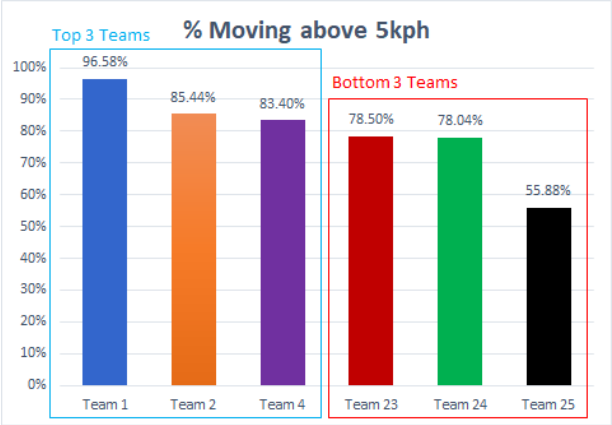

Figure 3. Static v. Moving Percentage per Team

ISBN: 97819384961-8-9

3.3 Route Efficiency

Route efficiency was calculated by comparing the distance traveled which is given by the watch with the true (great circle) distance which was calculated from the latitude and longitude. Teams who had better route efficiency and moved faster on average outperformed their peers who only moved quickly or had poorer route efficiency.

3.4 Social Factors and Movement Analytics

Concluded in a former study by Fred A. Mael and the U.S. Army Research Institute, cohesion and motivation are two essential factors in determining unit performance. "Cohesion in the military has been defined as a multidimensional construct encompassing peer, leader, and organizational bonding" (Mael, 1989, p. 18). In Mael's study, it was determined that cohesion can be measured based on a constructed horizontal squad member scale, comprised of six questions (Mael, 1989, 19). The scale takes these six binary questions and accumulates the total number of "yes" answers to create the total score. Examples of these questions can be found in table 1 (Mael, 1989, 19). Due to time and personnel constraints, the sample group comprised of six squads that were interviewed with only the Squad Leader and one member of squad providing answers. The research team found that the top and bottom three teams had little variation in aggregate cohesion scores which ranged from 4 to 5 on a 1-6 scale. Motivation in Mael's study is quantified both by how individual soldier's psychological involvement in their Army work helps them achieve their personal goals and how organizations arouse motivation and commitment in an individual (Mael, 1989, 23). Similar to cohesion, motivation can be measured based on constructed scales that pertain to job involvement, how an individual's job in the Army helps them to achieve their intrinsic goals, group conformance, and team attitude (Mael, 1989, 24). Motivation is scaled using five binary questions and accumulates the total number of "yes" answers to create the total motivation score. Examples of these questions can be found in table 1 (Mael, 1989, 24). The interview results from the sampled teams showed little variation in motivation scores among the six squads. One reason for such little variation in both cohesion and motivation is the small sample size of only twelve competitors used to collect this qualitative data. By expanding these interviews to the entire squad and including more squads from the Sandhurst competition, the accuracy of the results will increase, and greater variations will be present among the teams.

Table 1. Social Factors, Sleep, and Nutrition Interview Questions

Leadership (Y/N) *MOS ONLY*	**Motivation (Y/N)**	**Sleep (0-8+ hours)**
Maintains high standards of performance for our squad	I try to take on extra duties and responsibilities in my work with my unit	How many hours of sleep do you average per night during the week?
Insists that we follow standard operating procedures (SOP)	I am more ambitious about my work than I was before	How many hours of sleep did you get the night before the competition?
Knows Army tactics and warfighting	I look forward to coming to work every day	
Assigns group members to particular tasks	It really matters to me that we do well at the competition	How many hours of sleep did you get during the competition?
Takes full charge when emergencies arise	I put in extra effort to prepare for the competition	
Treats us fairly	**Cohesion (Y/N)**	**Nutrition (0-3 meals eaten)**
Looks out for the welfare of his people	The soldiers in my squad really care about each other	How many of your 3 MREs did you eat during the competition?
Encourages us to work together as a team	The soldiers in my squad work well together as a team	How many meals do you usually eat a day?
Is friendly and approachable	The soldiers in my squad hang out together	
Settles conflicts when they occur	Team members in this squad trust each other	
Personally supervises every detail of the squad's work	When I face a difficult task, other members of my squad help	
Constantly checks up on what the squad members are doing		

4. Conclusion

Considering the major lines of effort in the presented research, the following conclusions can be made: (1) there is a positive correlation between movement analytics and overall performance, and (2) social factors must be holistically assessed to provide meaningful insights. First, the general quantitative aspects of the GPS tracks and their respective conclusions can be generalized to soldiers in the common Army. With the GPS data gathered from the Garmin watches, moving average, route efficiency, and movement percentage versus static can be calculated. Such quantitative data holds the potential for further exploration into individual soldier performance metrics and their respective impacts on overall squad effectiveness and lethality. Second, qualitative assessments, such as social scores on cohesion and motivation can allow for further diversification in small unit competency when conducted on larger sample sizes. These intangible aspects of individual and team performance require further research to determine their level of impact on small unit lethality. Moving forward, a holistic method that includes both a qualitative and quantitative assessment should be used when placing individuals in small units to increase the competencies and lethality across all soldiers and small units in the Army.

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