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"STEAMS" METHODOLOGY OF ALTITUDE SICKNESS AND FATIGUE RESEARCH

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Abstract

This paper will address the risk of Altitude Sickness when people are hiking on the high Mountains. It’s difficult for most people to accommodate the high-Altitude environment suddenly. It’s very risky if the people are not aware of their altitude sickness symptom such as Fatigue, Headache, Dizziness, Insomnia, Shortness of breath during exertion, Nausea, Decreased appetite. The consequence of altitude sickness could be in very dangerous situation on the inconvenient high mountains. Pulse Oximeter was used to monitor the Oxygen% and Heart Beat at different altitude levels from sea level in San Jose to Denver (5,000 Feet), Estes Park (8,000 Feet), Rocky Mountains Alpine Center (12,000 Feet). 2.5mins Jumping Rope exercise was conducted to analyze the fatigue behavior with Altitude Sickness. Statistical analysis was conducted to verify several hypotheses to predict how high of the Altitude Sickness Risk at different altitude levels as well as the Exercise Fatigue Behavior. This method may provide the people how to assess their body strength and readiness before they may take a long hiking on the high mountains.

Keywords: Science, Technology, Engineering, Artificial Intelligence, Math, Statistics

1. Introduction

“STEM” (Science, Technology, Engineering, Math) or “STEAM” (Science, Technology, Engineering, Art, Math) are popular in School Education is a term used to group together these academic disciplines [1,2]. This term is typically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development. It has implications for workforce development, national security concerns and immigration policy. The acronym came into common use shortly after an interagency meeting on science education held at the US National Science Foundation. In the early 1990's, a summer program called STEM Institute is arranged for talented under-represented students in the Washington, DC area. Based on the program's recognized success and expertise in STEM education [3], that NSF was first introduced to the acronym STEM.

1.1 Criticism of STEM

The focus on increasing participation in STEM fields has attracted many criticisms:

(1) The efforts of the U.S. government to increase the number of STEM graduates, the science and engineering occupations have been flat or slow-growing, and unemployment as high or higher than in many comparably-skilled occupations [4].

(2) The STEM Crisis Is a Myth": there was a "mismatch between earning a STEM degree and having a STEM job in the United States, with only around ¼ of STEM graduates working in STEM fields, while less than half of workers in STEM fields have a STEM degree [5].

(3) Based on the data, science should not be grouped with the other three STEM categories, because, while the other three generally result in high-paying jobs, "many sciences, particularly the life sciences, pay below the overall median for recent college graduates [6].

(4) Efforts to remedy the perceived domination of STEM subjects has led to intense efforts to diversify the STEM workforce. Some critics feel that this practice in higher education, as opposed to a strict meritocracy, causes lower academic standards [7].

1.2 STEAM vs. STEM

STEAM fields are Science, Technology, Engineering, Art[8] , and Math [9]. STEAM is designed to integrate STEM subjects into various relevant education disciplines. These programs aim to teach students innovation, to think critically and use engineering or technology in imaginative designs or creative approaches to real-world problems while building on students' mathematics and science base [10]. STEAM programs add art to STEM curriculum by drawing on design principles and encouraging creative solutions.[11-14].

1.3 Artificial Intelligence and Digital Art

In the modern Big Data Society, Artificial intelligence (AI) is becoming a new dominant Data Science. AI sometimes called machine intelligence or machine learning, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans. In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals [15]. Artificial intelligence was founded as an academic discipline in 1956, and in the years since has experienced several waves of optimism.

Digital art is an artistic work or practice that uses digital technology as an essential part of the creative or presentation process. Since the 1970s, various names have been used to describe the process, including computer art and multimedia art [16-17]. Recently, a lot of articles are about AI in art and design: a lot of the feature imagery, unsurprising as they're largely created by people from a science rather than arts background. And their research is often presented in the ultra-detailed format of scientific papers - heavy on words and, strangely to us. This digital art application of AI is being referred to as 'generative'. Generative AI will drive the next generation of apps for auto-programming, content development, visual arts, and other creative, design, and engineering activities. By 2019, most leading AI providers will offer tools and libraries for building AI-powered natural-language generation, image manipulation, and other generative use cases. Already, generative AI has proven itself - in both research and in commercial applications. In Generative graphics**:** AI can abstract visual patterns from artwork and then apply those patterns in the fanciful re-rendering of photographic images with the hallmark features of that artwork.

2. Break Down Six STEAMS Elements

Instead of using classical STEM or STEAM, here, a new holistic “STEAMS” methodology is introduced. There are several novel concepts embedded in this new “STEAMS” methodology: (1) replace “Art” with “Artificial Intelligence”, (2) separate “Statistics” from “Math”, and (3) integrate all six “STEAMS” elements. “STEAMS” (Science, Technology, Engineering, Artificial Intelligence, Math, Statistics) methodology will be demonstrated through an Altitude Sickness and Fatigue project. The authors will break down six STEAMS elements in the following sections.

2.1 Understand Altitude Sickness and Fatigue "Science"

When go to higher altitudes, the environmental pressure drops and less oxygen available. Your body will need time to adjust to the change in pressure. Any time above 8,000 feet, you can be at risk for altitude sickness. In Figure 1, the Oxygen levels are plotted vs. Altitude (feet). There is only 70% Oxygen available at 10,000 feet. At the highest mountain Everest (29,029'), the Oxygen level is only around 32%. In 2019 Spring, with a single route to the Everest summit, delays caused by overcrowding could prove fatal after suffering from what appeared to be altitude sickness. Most climbers can only spend a matter of few minutes at the summit without extra Oxygen supplies in where is known as the "death zone". Even when using bottled Oxygen, supplemental Oxygen, there is only a few number of hours that mountaineers can survive up there before their bodies start to shut down. If caught in the traffic jam above25,000 feet, the consequences can be severe. Therefore, how to detect body altitude sickness earlier is critical for these climbers in certain critical situation.

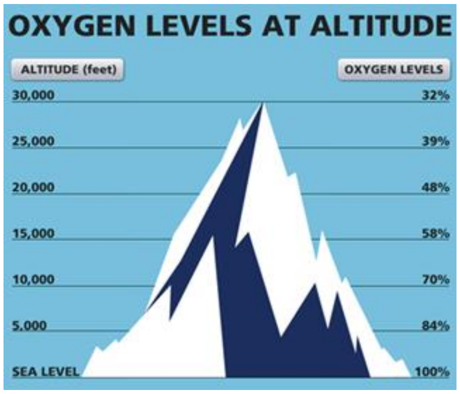

Figure 1. Oxygen level vs. Altitude.

There are three kinds of altitude sickness:

1. Acute Mountain Sickness (AMS) is the mildest form and it's very common. The symptoms can feel like a hangover – dizziness, headache, muscle aches, nausea [18].
2. High Altitude Pulmonary Edema (HAPE) is a buildup of fluid in the lungs that can be very dangerous and even life threatening [19].
3. High Altitude Cerebral Edema (HACE) is the most severe form of altitude sickness and happens when there's fluid in the brain. It's life threatening, and you need to seek medical attention right away [20].

In Figure 2, the typical symptoms and body behaviors of suffering altitude thickness is described. These information is useful to test your body handling the altitude sickness situation on the high mountains. The climbers should take actions if the situations are not going away and becoming worse.

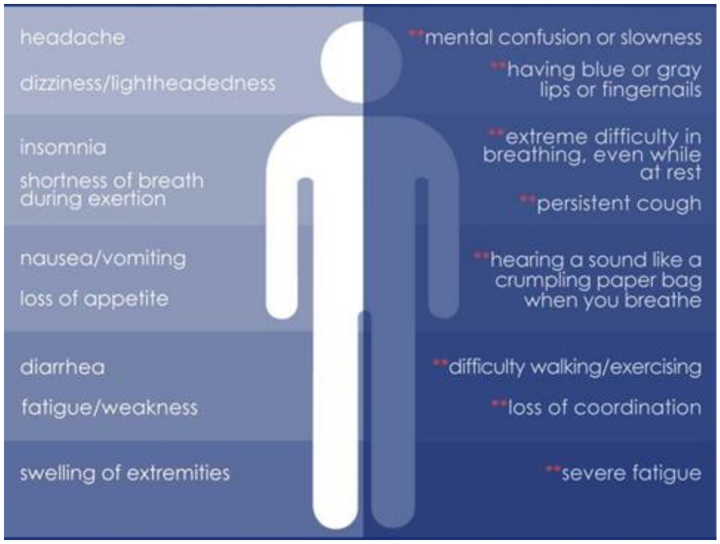

Figure 2. Symptoms and Body Behavior of Suffering Altitude Sickness.

Section 2.1 “Science” won’t deviate much from “STEM” to “STEAMS”.

2.2 Altitude Sickness “Technology”

Chance of getting altitude sickness depends: how quickly you move to a higher elevation, how high you go up, the altitude where you sleep, where you live and the altitude there, your age (young people are more likely to get it), and whether you’ve had altitude sickness before. Having certain illnesses like diabetes or lung disease doesn’t automatically make more likely to develop altitude sickness. But genes could play a role to handle higher elevations. There are several prevention technologies to lower chance of getting altitude sickness through proper acclimatization: let your body slowly get used to the changes in air pressure as travel to higher elevations as followings:

- Start your journey below 10,000 feet.
- If you walk, hike, or climb over 10,000 feet, only go up an additional 1,000 feet per day.
- For every 3,000 feet you climb, rest at least a day at that height.
- “Climb high and sleep low”.
- Drink 3-4 quarts of water daily, and about 70% of your calories are coming from carbs.
- Don’t use tobacco, alcohol, or other medications, such as sleeping pills.
- Know how to identify the first signs of altitude sickness.

The most effective detecting Altitude Sickness is to measure the Body Oxygen Level. Oxygen Pulse Technology. Pulse Oximeter was used to monitor the Oxygen Saturation% and Heart Beat Rate at different altitude levels. A clip-like device called a probe uses light to measure how much oxygen is in this blood and how well your heart is pumping oxygen through your body. Transmissive Mode is most popularly used: a small beams or light pass through the blood in the finger, measuring the amount of oxygen by measuring changes of light absorption in oxygenated or deoxygenated blood.

2.3 Systematic Engineering Problem Solving

To study the Altitude Sickness, the Pulse Oximeter was used to monitor the Oxygen Saturation% and Heart Beat Rate at different altitude levels from the sea level in San Jose to Boulder (5,000 Feet), Rocky Mountain Estes Park Center (8,000 Feet), and Rocky Mountains Alpine Center (12,000 Feet). To ensure the altitude sickness is successful, the authors have taken the following actions:

(1) Identify the person to be considered in the experiment. To avoid high risk of altitude sickness on the high mountains, all candidates were requested to collect the Oxygen% and Heart Beat Rate at Boulder the night before going to Rocky Mountain National Park. 5 people were selected because they did not detect any Altitude Sickness at Boulder (all their Oxygen% is in 97%-98%).
(2) To ensure the measurement is repeatable and reproducible, Gage R&R was conducted to certify each candidate. They are well trained on how to place their fingers and read the curves during the Pulse Oximeter measurement.
(3) Each candidate would also exercise 2.5mins Jumping Rope to study the Fatigue Behavior associated with Altitude Sickness. Statistical analysis was conducted to verify several hypotheses to predict how high of the Altitude Sickness Risk at different altitude levels as well as the Exercise Fatigue Behavior.

In Table 1, both Oxygen% and Heart Beat per Minute (HBPM) raw data were collected at different altitude before and after exercise.

Table 1: Oxygen % and Heart Beat per Minute (HBPM) Raw Data

ID	Sea Level O2%	8,000 Feet O2%	12,000 Feet O2%	12,000 Feet after Rope Jumping O2%	12,000 Feet after Climbing Stairs O2%	8.000 Feet HBPM	12,000 Feet HBPM	12,000 Feet after Rope Jumping HBPM	12,000 Feet after Climbing Stairs HBPM
Julianne	97%	97%	93%	89%	88%	88	92	168	158
Mason	97%	97%	94%	84%		90	96	151	
Brianna	97%	97%	92%	81%		75	88	190	
Alan	97%	96%	91%	80%		65	90	150	
Allison	97%	97%	94%	91%	82%	73	84	161	160

2.4 Artificial Intelligence

To analyze Altitude Sickness and Fatigue patterns, both the "Variable Clustering" [21] and "Two-Way Hierarchical" methods are used for grouping similar Oxygen and Heart Beat response variables into representative clusters which are a linear combination of all variables in the same cluster. The cluster can be represented most by the variables identified to be the most representative members (higher R-Square with own cluster in Figure 3). The most representative variable in the cluster can be used to explain most of the variation in the data analyzed. Typically, dimension reduction using Cluster Variables is often more interpretable than dimension reduction using principal components. Based on JMP Clustering Variable analysis, two clusters are identified as shown in Figure 3:

Cluster Members

Cluster	Members	RSquare with Own Cluster
1	8,000 Feet O2%	0.805
1	12,000 Feet O2%	0.876
1	12,000 Feet after Rope Jumping O2%	0.615
1	8.000 Feet HBPM	0.629
2	12,000 Feet HBPM	0.678
2	12,000 Feet after Rope Jumping HBPM	0.678

Figure 3. Clustering Variables of Oxygen and Heart Beat Responses.

Two clusters were identified among 6 response variables:

1. All Oxygen parameters are assigned to the 1st cluster together with the Heart Beat at 8,000 Feet
2. Heart Beat at 12,000 Feet are assigned to the 2nd cluster.

The above clustering analysis may indicate two Body mechanisms: Altitude Sickness and Fatigue. The first cluster is more on the Oxygen response of Altitude Thickness. The second cluster is more on the Heart Beat response of Fatigue behavior. Clustering Variables method can effectively explore the Oxygen and Heart Beat clustering patterns which can explain the common Altitude Sickness and Fatigue science well. Adopting this dimension-reduction clustering algorithm can help simplify the predictive modeling by enhancing the signal-noise ratio, particularly in a very complicated/coupled design or system behavior. The "Artificial Intelligence" element can discover the patterns which may match well with traditional "Scientific" research and help "Engineering" critical thinking more effectively and efficiently. This "A" element is becoming a core and critical element in the new "STEAMS" approach.

2.5 Mathematics

The basic Algebra "Math" algorithms are utilized in the modern "Artificial Intelligence" clustering method. In the new "STEAMS" approach, "Math" is the foundation of evolving the modern "Artificial Intelligence". Adding the "Artificial Intelligence" element can trigger the exploring of the Math elements and Science research. Figure 4, a Parallel Plot was conducted to recognize the Altitude Sickness and Fatigue behavior among five players. Two clusters are observed: four players are assigned to the 1st cluster as shown in red color, one player (Alan) is assigned to the 2nd cluster. Parallel plot was plotted by conducting "Z-transformation". The y-scale in the Parallel Plot was plotted based on the

$$Z_i = \frac{y_i - \bar{y}}{S_i}$$

Player No.4 has shown a relatively lower Oxygen% and HBPM performance against the other four players. Player No.4 may have a lower Altitude Sickness and Fatigue risk.

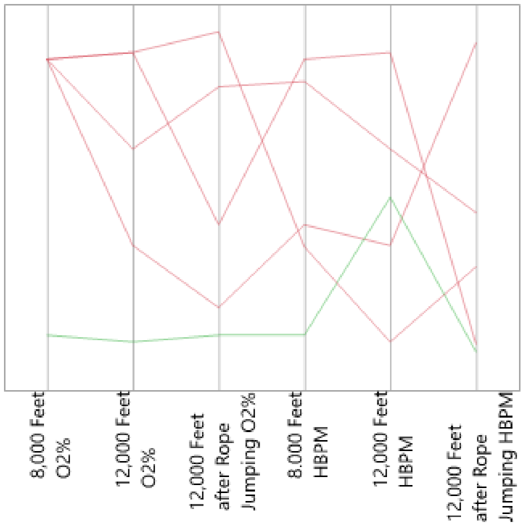

Figure 4. Parallel Plot of Oxygen and Heart Beat Responses among five Players.

2.6 Statistics

Descriptive Statistics was conducted to study any Altitude Sickness and Fatigue trending in Figure 5 which has shown clear Altitude Sickness Body Reaction: lower Oxygen% mean and Higher Heart Beat mean at higher Altitude. The heart beat rate has significantly increased during the 2.5mins Rope Jumping exercise.

Univariate Simple Statistics

Column	N	DF	Mean	Std Dev	Sum	Minimum	Maximum
8,000 Feet O2%	5	4.00	0.9680	0.0045	4.8400	0.9600	0.9700
12,000 Feet O2%	5	4.00	0.9280	0.0130	4.6400	0.9100	0.9400
12,000 Feet after Rope Jumping O2%	5	4.00	0.8500	0.0485	4.2500	0.8000	0.9100
8.000 Feet HBPM	5	4.00	78.2000	10.5688	391.000	65.0000	90.0000
12,000 Feet HBPM	5	4.00	90.0000	4.4721	450.000	84.0000	96.0000
12,000 Feet after Rope Jumping HBPM	5	4.00	164.000	16.3248	820.000	150.000	190.000

Figure 5. Descriptive Statistics

Another Multiple Box-Plot was conducted and shown a similar trending in visualization. As compared to Descriptive Statistics, Box-Plot can provide better insight information and correlation among Oxygen% and Hear Beat responses. Both the Altitude Sickness and Fatigue behaviors are well demonstrated in the Box Plot. 2.6 Statistics section can provide more quantitative information than 2.4 AI section.

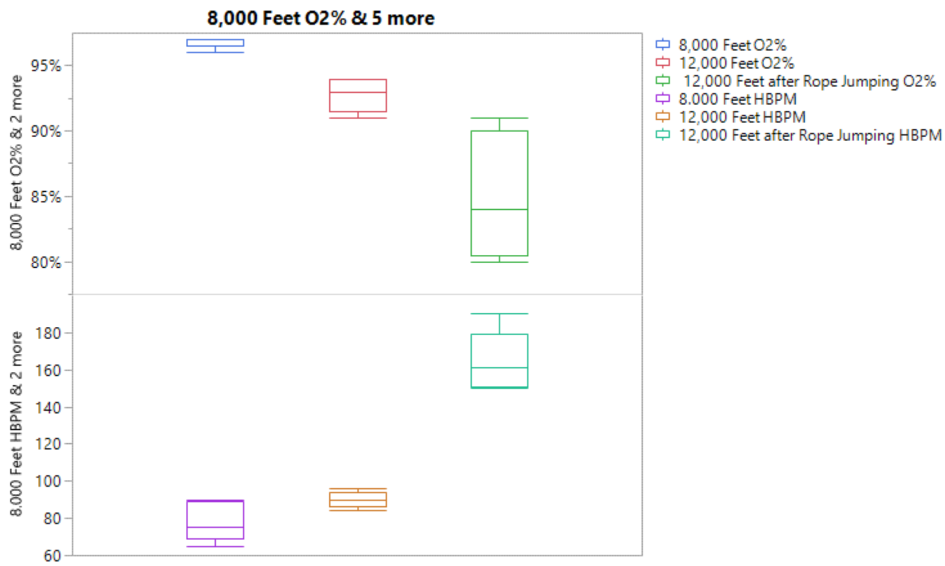

Figure 6. Multiple Box-Plot of Oxygen and Heart Beat responses.

3. Conclusions

"STEAMS" methodology is very successful on understanding Altitude Sickness and Fatigue "Science". Understanding the Human Body Oxygen% and Heart Beat responses on the high Mountains can be done effectively through a systematic "Engineering" problem solving framework. Modern "Artificial Intelligence" methods can explore the Altitude Sickness and Fatigue Patterns which can further help climbers evaluate their Altitude Sickness based on the Z-transformed mathematically Parallel Plot. Both "Descriptive Statistics" and "Box-Plot: can help draw more Oxygen and Heart Beat insight response to address Altitude Sickness and Fatigue. In the modern Big Data era, most scientists and engineers shall adopt this "STEAMS" methodology and integrate all 6 elements seamlessly and collectively.

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