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# THE INFLUENCE OF CAVES AS AN EXTREME ENVIRONMENT ON THE PHYSIOLOGICAL FUNCTIONS AND MENTAL STATE OF INDIVIDUALS

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# **1. INTRODUCTION**

Caves represent an extreme environment that can be used to train people from various specialised professions (e.g. astronauts (1,2), submarine personnel, soldiers etc.) in high-stress, high-risk tasks that are otherwise difficult to simulate. The objective of our study conducted in Croatia is to carry out systematic monitoring of 3 experienced cavers using activity trackers in order to find out what impact the unique cave environment (lack of light, high humidity and low temperatures) has on the overall speleological experience (physiological and psychological).

# **2. MATERIALS AND METHODS**

#### PARTICIPANTS

The research is based on data collected from three experienced caver. All participants are in good physical shape and engaged in many sports such as running, cycling, cardio, and strength training in addition to caving.

	PATICIPANT A	PATICIPANT B	PATICIPANT C
Age (yr)	40	34	32
Heght (cm)	174	162	176
Weight (kg)	57	62	71
Body mass index (kg m <sup>-2</sup> )	18.8	23.6	22.9
Gender	Female	Female	Male
Number of cave related activities taken into this study	38	44	15
Number of long-term cave related activities	24	35	6
Number of short-term cave related activities	14	9	9
Caving experience (yr)	15	5	5

### **3. RESULTS AND DISCUSSION**

Participants recorded 97 separate cave related activities on 50 trips, with a total length of 506 hours. A total of 16 caving trips included overnight stays and thus included at least two types of cave related activity (ascent, descent, horizontal movement, and/or mixed impact).

#### **AEROBIC TRAINING EFFECT**

Aerobic training effect is the excess post-exercise oxygen consumption accumulated during exercise, mapped onto a 0 to 5 scale. As one gets fitter, larger"doses" of exercise is needed to continue seeing improvement. The training effect value therefore indicates whether the workout had a maintaining or improving effect.



#### **ENERGY EXPENDITURE**

Energy is measured in calories, and the total daily energy expenditure is the number of calories burned each day (4).

No significant difference was observed in the consumption of calories between mixed activities during long-term and short-term stays in the cave.





Participants wore a Garmin Forerunner 645 activity tracker during the whole period of this study (from July 2019 to May 2021). Over the course of two years, various activities specific to caves such as descending and ascending into 1200 m deep caves, navigating through up to long caves, and long-term cave stays (up to 6 days) were tracked and analyzed.

The device is equipped with sensors for monitoring the heart rate on the and long-term stays. Short-term visits seem to have maintaining wrist GARMIN ELEVATE <sup>™</sup>, a gyroscope, a barometric altimeter and a thermometer. Several activities have been recorded using the Polar H10 chest strap to provide more accurate heart rate readings(3).



Major differences have been discovered when comparing short-term impact on the overall fitness level of an individual.

The highest value of the aerobic training effect was measured when ascending from a deep cave after a long stay.

The highest EE recorded during cave related activity was reported in Nedam cave while doing mixed activity on -400m, which included passing through 100 m long and very narrow meander (3138 calories in 14 hours) and ascending from -900 m to the surface (2775 calories in 10 hours).



Comparing EE per hour during cave related activities with the same value obtained during other activities, we find that the values are surprisingly low, which is the opposite to the subjective impression of the participants.

#### **HEART RATE**

Five commonly accepted heart rate zones are numbered from 1 (relaxed easy pace) to 5 (sprinting pace, unsustainable for longer periods of time) according to increasing intensity.

The majority of the speleological activities is measured in heart rate zones 1 and 2. Even in extreme exertion like ascending from -900 to the entrance in less than 10h, the heart rate of participant was mostly in zone 2 (comfortable pace).





Figure 1. As seen on the graph entering the pit inevitably activates the body (high blood pressure) toprepare and cope more easily with all the physical and mental challenges.



Figure 2. Cavers are faced with various obstacles. Narrow passages are definitely one of the more interesting ones where progress is slow, but physical and mental efforts are high.

1,386 m

0:00 h:m:s

,091 m

164 bpm

1:41:45 h:m:s

1,2024 bpm



Figure 5. As technology evolves so does the accessibility of various devices that are compact and durable enough for cave conditions.



Figure 3. Resting is a vital part of caving. During rest cavers have a chance to rehydrate, input nutrients and mentally relax before continuing with their exploration.



Figure 4. The data from the graph indicates that staying at the bivouac also affects physiological parameters.





# NEDAM

Hajdučki kukovi, Sjeverni Velebit

1997., 1998., 2005. lipanj 2019. - kolovoz 2020.

Broj pločice: 05-0035

**Dubina: -1226 m** Duljina: 2873 m

Horizontalna duljina: 1572 m

Most significant measuring was done in Nedam (-1226m) third deepest pit in Croatia situated on Velebit Mt. Which is characterized by extremely narrow sections, shorter stepped pitches and horizontal traverses, and consequently numerous rebelays.



# **4. CONCLUSION**

Preliminary findings show that one-day caving trips have a negligible effect on fitness levels as opposed to longer stays. This could be explained by the accumulation of activity during longer stays.

The heart rate results showed lower values, which was expected since cave related activity includes a combination of descent, ascent, horizontal moving and mixed effect activities.

The difference between the obtained measurements and the reported individual perception of the exertion required is of note. We expect the cause to lie in two facts. The first is the reliability of the used fitness watch to recognize, record and correctly analyze the complex activities that an individual engages in a cave. The second lies in the subjective impression of each caver, which includes one's experience, character, and fitness.

This study raises questions such as what influence the psychological exertion has on the overall experience of being in extreme conditions found in caves. There are also questions of practical intent such as how to most accurately measure relevant physiological and physiological parameters.

## **5. REFERENCES**

1. Sauro et al. (2021): Speleology as an analogue to space exploration: The ESA CAVES training programme. Acta Astronautica 184, 150-166.

2. Bessone et al. (2013): ESA CAVES: Training astronauts for space exploration. ICS Proceedings, 321-327.

3. Pope Z.C. et al. (2019): Validation of Four Smartwatches in Energy Expenditure and Heart Rate Assessment During Exergaming. Games for Health Journal 8(3), 1-8.

Simple tasks like cooking or going to\_

the toilet, under these conditions, are

far more stressful for our bodies than

in everyday life.

· · · · 12 144 otk./min Figure 6. Reaching the bottom is 4. Gillinov S. et al (2017): Variable Accuracy of Wearable Heart Rate 6:48:10 h:m:s bittersweet for every caver. Here our Monitors during Aerobic Exercise. Medicine & Science in Sports & physiological reaction (elevated blood Exercise 49(8):1, 1697-1703. pressure) is more under the influence of our psychological (emotional) state.