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Laboratory Investigation of the 900-km Lapland Extreme Challenge

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Dear Editor,

The Lapland Extreme Challenge (LEC) is a 900 km ultra-event through the Finnish Lapland wilderness. It was created in 2013; the time limit of the event is 30 days, but 2017 was the only year, in which this ultra-event had finishers. The athletes need to transport with them everything necessary to survive. As an outstanding stress model, it includes strenuous exercise, freezing temperatures, sleep restriction, and isolation/solitude, and all of them present simultaneously [1].

This study aimed to monitor biochemical parameters (BP) from the training (October 2016) through the restoring period (June 2017). However, owing to the high skill level required to perform the LEC, only one athlete (age: 51 years, sex: male, height: 177 cm) was monitored. During the race, he travelled 30–40 km in 10–12 hours a day, dragging a sled of about 50 kg, using skis for one half and snow boots for the other. He slept around five hrs a day, mostly in a tent. He ate mostly lyophilized food for a total of 3,800–4,200 kcal/day (about 25% carbohydrate, 65% fat, and 10% protein) and drank about 2.5 L/day of liquefied snow with mineral salt added. The environmental temperatures ranged from -15°C to -36°C. On the tenth day, after 450 km, he gave up due to frostbite (in his right thumb and part of the left foot, no permanent damage). BP were obtained at the following time points: 7:30 am, before the beginning of the training (T1: October 2016), each month before the LEC (T2: November 2016, T3: December 2016, T4: January 2017), immediately before and after the LEC (T5: February 2017, T6: March 2017), and each month after the LEC (T7: April 2017, T8: May 2017, T9: June 2017). Blood samples were centrifuged within two hours (in a hospital/on field); four aliquots of each blood sample drawn were frozen (two at -80°C and two at -20°C) for five days, after which all parameters were measured. In this way, all blood samples were analyzed at the same time, thereby reducing pre-analytical variability. Inter-sample differences bigger than the critical reference change value (RCV) were considered significant [2]. RCV was calculated as follows:

$$RCV = 2^{1/2} \times Z \times (CVa^2 + CVw^2)^{1/2}$$

where Z = 1.96 for 95% significance, CVa is the analytical variation and CVw is the coefficient of variation for intra-individual biological variation.

This study was performed according to the Code of Ethics of the World Medical Association (Declaration of Helsinki) for ex-

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periments involving humans; the athlete provided informed consent.

The results are summarized in Table 1. Cortisol, bone alkaline phosphatase, and osteocalcin trends are shown in Fig. 1. The weight and body fat percentage of the athlete were 84 kg and 14.3% at T1, 70 kg and 11% at T6, and 82 kg and 15% at T9, respectively.

The increased creatine kinase values suggested muscle damage due to the high training workout. This was observed especially during the competition when creatine kinase, lactate dehydrogenase, and myoglobin significantly peaked [3]. However, frostbite to the right thumb and part of the left foot could have contributed to the increased biomarker values. Creatinine shows changes within the RCV for subjects undergoing regular aerobic

Table 1. Biochemical parameters during the four-month training period (T1–T5), immediately after the Lapland Extreme Challenge (T6), and a few months after the Lapland Extreme Challenge (T7–T9)

Analyte	Reference range	RCV (%)	T1–T5 mean ± SD (CV%)	T6	T7–T9 mean ± SD (CV%)
Creatine kinase (μKat/L)*	0.42–3.31	39	6.66 ± 5.49 (82)	12.39	5.25 ± 2.23 (42)
Lactate dehydrogenase (μKat/L)*	< 4.17	23	3.40 ± 1.12 (33)	4.27	2.95 ± 0.13 (5)
Myoglobin (nmol/L)†	< 4.00	43	1.66 ± 0.17 (12)	2.40	1.83 ± 0.34 (18)
Sodium (mmol/L)*	135–145	5	140 ± 1 (0.8)	140	140 ± 1 (0.7)
Potassium (mmol/L)*	3.50–5.10	8	4.63 ± 0.49 (11)	5.57	4.5 ± 0.5 (11)
Phosphorus (mmol/L)*	0.81–1.45	15	1.16 ± 0.07 (6)	1.16	1.13 ± 0.01 (0.3)
Calcium (mmol/L)*	2.12–2.62	5	2.31 ± 0.11 (5)	2.21	2.31 ± 0.13 (6)
Magnesium (mmol/L)*	0.73–1.05	8	0.82 ± 0.02 (2)	0.90	0.86 ± 0.03 (4)
Enzymatic creatinine (μmol/L)*	44–115	12	86 ± 2 (3)	103	91 ± 4 (5)
Cystatin C (mg/L)‡	0.20–0.62	NA	0.25 ± 0.02 (7)	0.25	0.27 ± 0.03 (10)
Neutrophil gelatinase-associated lipocalin (μg/L)‡	≤ 60	NA	20 ± 0 (0)	20	20 ± 10 (34)
Bone alkaline phosphatase (μg/L)†	3.70–21.00	20	9.92 ± 0.96 (10)	7.1	10.30 ± 0.15 (1.5)
Carboxy-terminal collagen crosslinks (ng/L)§	120–750	30	530 ± 60 (11)	390	470 ± 30 (6)
25-hydroxy-vitamin D (nmol/L)‖	75–125	NA	82 ± 5 (6)	78	67 ± 12 (20)
Osteocalcin (μg/L)‖	4.60–65.40	31	17.20 ± 1.90 (11)	9.2	17.10 ± 1.40 (8)
Parathyroid hormone (ng/L)†	11–88	55	36 ± 10 (29)	32	51 ± 22 (42)
Cortisol (nmol/L)†	185–624	31	417 ± 77 (18)	178	452 ± 97 (21)

*Analytes were tested using the AU5800 analyzer (Beckman Coulter, Fullerton, CA, USA); †Analytes were tested using the UniCel DXI800 system (Beckman Coulter); ‡Analytes were tested using the CKD Array II, Chemiluminescence Biochip Array Technology (Evidence Series; Randox Laboratories Ltd., Crumlin, UK); §Analyte was tested using the Alisei system (Omnia Diagnostic, Cranbury, NJ, USA); ‖Analytes were tested using the Liaison XL analyzer (Diasorin, Saluggia, TO, Italy).
Abbreviations: RCV, reference change value; NA, not available.

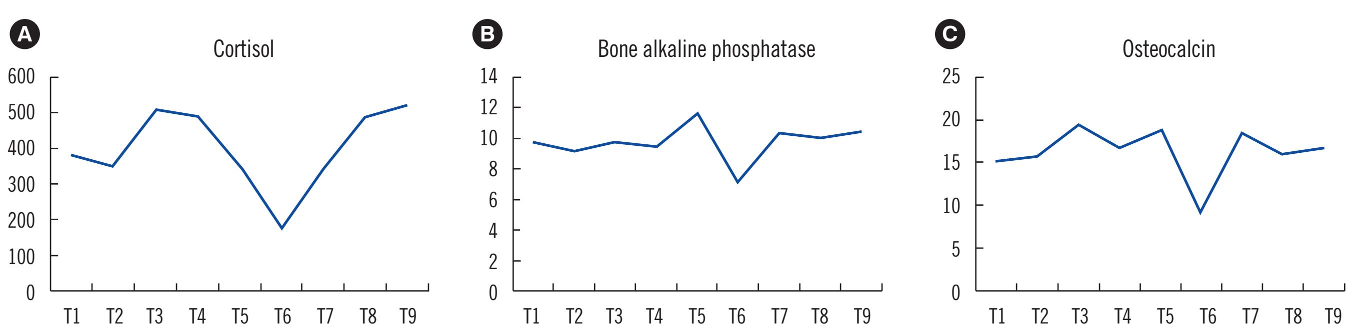

Fig. 1. Changes in biochemical parameters during the four-month training period (T1–T5), immediately after the Lapland Extreme Challenge (T6), and a few months after the Lapland Extreme Challenge (T7–T9): (A) Cortisol, (B) bone alkaline phosphatase, and (C) osteocalcin.

training [4]. Moreover, cystatin-C and neutrophil gelatinase-associated lipocalin remained basically unchanged, suggesting the absence of any exercise-associated renal impairment [5]. The significant increase in potassium observed after the LEC (T6) was at least in part due to the possible exercise-induced metabolic acidosis, which promotes extracellular accumulation of K+ (controlled by KATP channels) [6]. Sodium, phosphorus, and magnesium values were basically unchanged, suggesting electrolyte homeostasis.

The decrease in bone formation biomarker values (bone alkaline phosphatase and osteocalcin) after the LEC (T6) indicated a temporary suppression of bone formation, partly due to the exercise associated with the severe energy deficit that leads to a notable reduction (-12.5%) in total body weight after LEC [7].

Cortisol values remained within the reference range except after the LEC (T6), when they dropped significantly. This was in part unexpected considering that long duration exercise, sleep deprivation, and extreme conditions seem to increase the pituitary–adrenal cortex response [8]. However, another study regarding cortisol responses to extreme sports highlighted a significant drop during the performance, ending with values below the basal value [9]. A possible explanation could be that for these elite athletes, including the one we monitored, the extreme challenge is essential for their psychological well-being [10]. Consequently, it could be associated with less cortisol secretion, independently of the intense load and risk associated with severe environmental conditions.

In conclusion, apart from frostbite, this athlete seemed to respond physiologically to an extreme exercise load despite the transient decrease in bone formation biomarker values. It suggests that precaution should be taken in constant ultra-endurance training and frequent ultra-endurance competitions.

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Conflicts of Interest

None declared.

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