Prostatic-Specific Antigen Levels in Men from Two Andean Cities of Peru

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PROSTATIC-SPECIFIC ANTIGEN (PSA) is a biomarker that has been broadly used in aiding the diagnoses of benign prostatic hyperplasia (BPH) and prostate cancer. The incidence of both, which are, in part, androgen-driven diseases, has increased in men worldwide over the past 40 years (Peskoe et al., 2015; Sarwar et al., 2017).

Testosterone is active at low altitude and helps, in part, to explain the higher hematocrit (Hct) of men. At high altitude, testosterone is higher in men with excessive erythrocytosis and it is involved in the compensatory erythropoiesis, in which hemoglobin (Hb) and Hct increase as a response to the low partial pressure of oxygen and help to increase blood oxygen carrying capacity. However, estradiol (E₂) acts in the opposite manner (Verratti et al., 2007; Gonzales, 2015). In particular, as male mountain residents become older, both their Hct and chronic mountain sickness (CMS) scores rise, and the blood Hb oxygen saturation (SpO₂) diminishes (Gonzales, 2015).

Roughly 30% of the Peruvian population lives in the highlands, including a large number of older male farmers (National Institute of Statistics and Informatics [INEI], 2014). Evaluating PSA levels as a predictor of BPH and prostate cancer may help in enhancing the quality of life and reducing mortality rates, respectively, in this economically important and active population.

If age and high-altitude exposure alter testosterone production, it would be interesting to evaluate the relationship between these parameters in mountain residents, considering that only one study has assessed this association in climbers and found no significant difference (Verratti et al., 2007).

In this analysis, the first serum samples from 48 male subjects participating in two unpublished studies were analyzed: (1) study on genome in native at sea level and high altitude: association with Hb and serum testosterone levels, and (2) metabolomics, acceptability, and food security after

ingestion of Maca (*Lepidium meyenii*) in adult men and women at Cerro-de-Pasco (4340 m) and Lima (150 m). Both studies were part of the Circle of Plants with Effects on Health (1200-2014-FONDECYT-Peru), project approved by the Research and Ethics Committee of the Cayetano Heredia University in Lima, Peru.

Serum samples were collected from three cities in Peru: Lima (150 m), Huancayo (3200 m), and Cerro-de-Pasco (4340 m) between December 2014 and February 2015. The subjects were 18 to 65 years old, who resided in their city for at least 10 years. They reported themselves to be healthy, not taking any medications at the time of the study, and having no chronic diseases. All volunteers gave informed consent.

To evaluate PSA concentrations between high-altitude and sea level residents, we compared the median values in each city in two age groups, those less than and more than 40 years of age. All participants had PSA concentrations <4 ng/mL. We found significant lower concentrations in residents of Cerro-de-Pasco than in residents of Lima ($p=0.03$), but no differences between residents of Huancayo and Lima. We found no statistical differences in PSA levels by age (Fig. 1A, B).

In addition, we did not measure any significant differences between testosterone concentrations by city (Lima vs. Huancayo, $p=0.06$; Lima vs. Cerro de Pasco, $p=0.09$). In contrast and as expected, we found testosterone values decreased in the group >40 years old ($p=0.02$) (Fig. 1C, D).

We found that Hct and CMS scores were greater in the two highland cities (Huancayo and Cerro-de-Pasco), whereas SpO₂ was lower in both than the values in Lima ($p<0.05$).

These results show an inverse relationship between PSA levels and high altitude that has not been reported before. Although there are limitations in the sample size and study design, our study is the first to report on PSA levels in men

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FIG. 1. Levels of PSA and testosterone in two high-altitude cities compared with those at sea level. Lima (150 m), Huancayo (3200 m), and y Cerro de Pasco (4340 m). **(A)** PSA levels by city. **(B)** PSA levels by age. **(C)** Testosterone levels by city. **(D)** Testosterone levels by age. Median comparison Wilcoxon test. *Statistical significance ($p < 0.05$). PSA, prostatic-specific antigen.

living at high-altitude regions of the Peruvian Andes. Further researches are required to understand this association.

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