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ORIGINAL ARTICLE

The prevalence of obesity and metabolic syndrome in Tibetan immigrants living in high altitude areas in Ladakh, India

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Received 18 January 2017; received in revised form 22 February 2017; accepted 8 March 2017

KEYWORDS

Tibetan;
Immigrants;
Obesity;
High altitude;
Ladakh

Summary

Objective: To examine the prevalence of obesity and related cardiovascular disease risk factors among Tibetan immigrants living in high altitude areas.

Research methods & procedures: A total of 149 Tibetan immigrants aged 20 years and over were recruited in 2016 in Ladakh, India. Anthropometric indices and biochemical factors were measured. Using the provided Asia-Pacific criteria from the World Health Organization, overweight and obese status were determined. Metabolic syndrome (MetS) was defined according to the American Heart Association.

Results: In general, men were older, taller, and had a greater amount of fasting glucose, and uric acid when compared to women. The prevalence of overweight, general obesity, and central obesity was 23.4, 42.6, and 42.6% in men and 7.8, 64.7, and 69.6% in women, respectively. The prevalence of MetS was

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10.6% in men and 33.3% in women, respectively. In older subjects, the prevalence of obesity and MetS was found to be greater. In both genders, the prevalence of hypertension, central obesity, and MetS was significantly different among these body mass index (BMI) groups. Compared to the non-central obesity group, the central obesity group has higher weight, BMI, body fat, hip circumference, systolic and diastolic BP, and prevalence of hypertension. No relationship was found between the prevalence of diabetes and fasting glucose and BMI groups or central obesity groups in both genders. *Conclusions:* Among this group of Tibetan immigrants living in high altitude areas, women have a higher prevalence of obesity and MetS than men. No relationship was found between diabetes and obesity.

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Introduction

One of the most challenging public health issues in the 21st century is obesity. According to an estimation from World Health Organization, more than half of the world's adult population are either overweight or obese [1]. The mean body mass index (BMI) has dramatically increased in the past decades. The men's mean BMI has risen from 21.7 kg/m² to 24.2 kg/m² in just 39 years from 1975 to 2014, while the women's has risen from 22.1 kg/m² to 24.4 kg/m² [2]. The prevalence of obesity has been found to have increased from 3.2% in 1975 to 10.8% in 2014 in men and from 6.4% to 14.9% in women [2]. Obesity is increasing in a surprisingly high rate. Obesity is important because it increases a variety of risks including diabetes, hypertension, cardiovascular disease, cancer, and mortality [3,4].

People living in high altitude areas tend to be leaner when compared to those living in low altitude areas [5]. It has also been established that obesity is not as common in people who live in high altitude areas [5–7]. For example, Díaz-Gutierrez et al. found that the risk of developing obesity was inversely associated with the altitudes in Spain [7]. Sherpa et al. also found that low temperatures and low oxygen levels in high altitude area have a direct catabolic effect and that the total effect of altitude on BMI was -1.31 kg/m^2 per kilometre of altitude [8]. On the other hand, waist circumference (WC) had a direct relationship with the altitude ($+0.85 \text{ cm}$ per kilometre of altitude) [8]. Lower energy intake and increased physical activity do not explain this particular relationship. Many of the Tibetan immigrants emigrated due to political issues. Previous reports in the U.S. and U.K. showed that the immi-

grants were healthier and less obese than the natives [9–11]. But, once they arrive, they generally become more similar to the natives and grow to be less healthy and more obese, since they become accustomed to the indigenous diet and lifestyle [9,12]. For example, the amount of 3rd generation of Latino and Asian immigrants who were obese was significantly higher than the amount of those who were 1st or 2nd generation of immigrants [12]. Despite the reasons mentioned above, immigrants' obesity rate seems to rise slower compared to the aboriginals' [11]. Factors such as the difference in culture and altitude levels among the immigrants may influence the prevalence of obesity and related metabolic factors or chronic diseases. Ladakh is located in India next to the Karakoram in the northwest and the Himalayas in the southwest, which has an altitude of 3500 m. Many Tibetan immigrants have lived in Ladakh, which is one of the most remote regions in India for more than half a century. In this study, relationships of the prevalence of obesity and related metabolic diseases among Tibetan immigrants were investigated.

Materials and methods

Participant enrollment

This cross-sectional study was conducted in Sonamling Tibetan Settlement, Ladakh in August 2016. Sonamling Tibetan Settlement was established in 1969 and is made up of 12 camps which sums up to a total of nearly 7000 habitants [13]. The settlement is located in Choglamsar, 8 km from Leh city, Ladakh in Jammu & Kashmir State, India at

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