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Excess bioavailability of zinc may cause obesity in humans

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Abstract. The body weight or body weight/height ratio exhibits a positive linear correlation to hair zinc (Zn) concentration which is more strongly positive in men than in women. The obese of both sexes possess higher Zn concentrations in their hair than those with normal body weight/height. The degree of obesity increases with the increase in the hair Zn concentration.
Key words. Zinc; obesity.

Zinc is one of the trace elements which promotes food intake, linear growth and body weight increase in children suffering from marginal to severe Zn deficiency[1–5]. Supplementation of Zn during nutritional rehabilitation also ameliorates adolescent nutritional dwarfism with delayed sexual maturity[6]. But the long term effects on growth or body weight of Zn bioavailability greater than its actual requirement in adult humans have not been reported. Investigatory studies on laboratory animals, however, have provided evidence that anabolic effects of Zn result from elevated food consumption[6], higher absorption of nutrients, i.e., amino acids[7], fatty acids[8], triacylglycerol and glucose[9], in addition to the activation of protein and nucleic acid syntheses[10–14]. These anabolic effects of Zn are unlikely to diminish after cessation of growth. The continuous input of excess nutrients in tissues by Zn after adolescence may contribute to adiposity leading to body weight increase. We undertook this study with the aim of finding a relationship between tissue Zn and body weight.

Materials and methods

We randomly collected hair samples from the occipital regions of 90 (25–35 year old) volunteers consisting of 45 males and 45 nonpregnant females of middle income group by Indian standards when they came to get their hair cut at hair saloons in Sector 15, Chandigarh, India. They were free from chronic ailments and were strictly lactovegetarian. Their staple diet included whole wheat flour, rice, legumes, vegetable and milk products. Along with the hair samples, their body weight to the nearest gram and the height to the nearest centimetre were also recorded. The sampling was completely in five days to avoid any confounding effect of season on the hair Zn concentration.

The hair samples were washed with non-ionic detergent after clearing hair of nits and lice. They were successively treated with 0.1% EDTA, triple-distilled deionized water, acetone and ether, and finally were dried in an oven at 40 °C for 1 h. 50 mg of each sample were digested in 22.5 M HNO_3 and 11.6 M perchloric acid mixture (v:v/3:1). The hair Zn content was estimated by an atomic absoption spectrophotometer (Perkin Elmer Model-31).

The data were analysed statistically using coefficient of correlation and linear regression model $Y = a - bx$[15]. The regression line along with 95% confidence intervals and prediction intervals were plotted[15].

Results and discussion

The mean hair Zn concentration in women was 9.439 μmol/g (SE 0.250) and that of men 7.547 μmol/g (SE 0.290) of hair samples for the mean body weight 58.62 kg (SE 1.875) and 70.3 kg (SE 1.815), respectively. The body weight or body weight/height ratio and hair Zn in both sexes exhibited a positive correlation, which was more strongly positive in men ($r = 0.78$ and 0.814 respectively) than in women ($r = 0.57$ and 0.555 respectively). The scatter diagram of both the sexes representing the weight/height plotted against hair Zn concentration using the $Y = a + bx$ model displayed a linear trend. The points of independent variable lie well within the 95% confidence limits and within the 95% prediction intervals (fig. 1a and 1b). No relationship between hair Zn concentration and age or age and body weight was obtained in the present study. This relationship suggests that the thinner individuals had lower Zn concentrations in their hair than the heavier ones.

Based on the regression equation of body weight/height, we calculated the hair Zn of the normal body weight/height for both sexes using weight and height tables for the Indian population prepared by the Indian Council of Medical Research, New Delhi, India. This table was also used for assessing obesity. All the overweight individuals had higher Zn concentrations in their hair than those with normal body weight for their height. The

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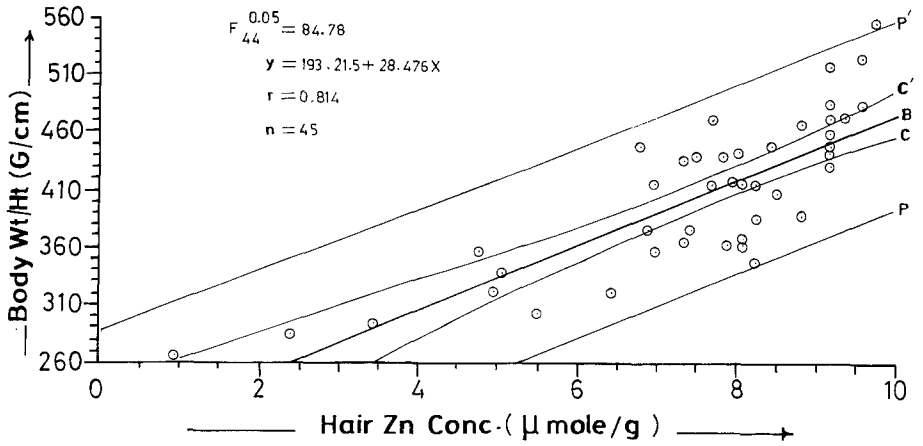

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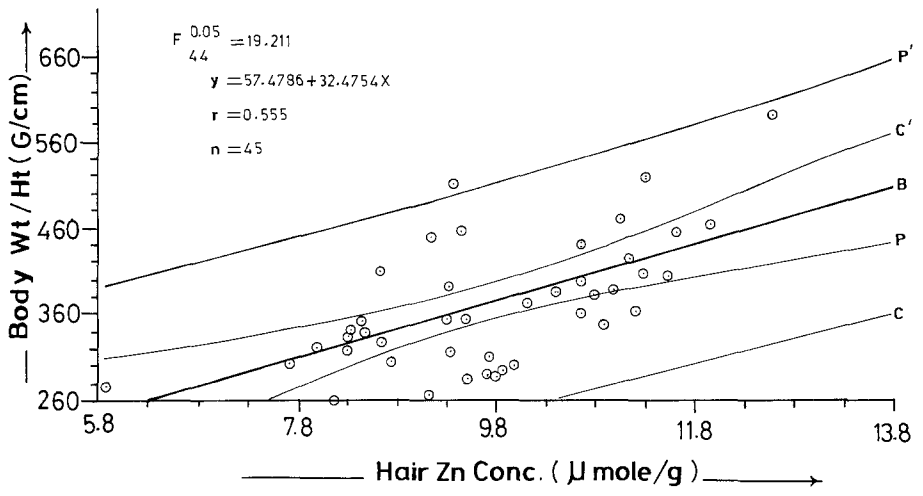

b

Figure 1. Scatter diagram representing the data of weight/height (g/cm) plotted against hair Zn concentration (μmol/g) showing the best fit trend lines, 95% prediction limits and confidence limits in males (*a*) and females (*b*). P', P = 95% prediction limits; C', C = 95% confidence limits; B = best fit trend lines.

degree of obesity increased with the increase in Zn concentration in hair, suggesting a profound effect of Zn bioavailability on obesity.

In contrast to our study, no difference in hair Zn or plasma Zn concentration has been reported previously in children of both sexes fed a Zn-supplemented diet[1]. Since skeletal muscle and hair are the main stores of Zn, their lower total weight in females than in males on maturity appears to contribute to the observed differences in hair Zn concentration in the two sexes in our study. This may in turn be the cause of the lower 'r' values in females than in males.

The weight gain, linear growth and synthesis of lean tissue are reported to accelerate with Zn supplementation during nutritional rehabilitation in Zn-deficient malnourished children, but amongst healthy children it has little impact on weight gain or height[1-5]. However, a higher intake of Zn increases fat in children[1]. Since fat is lighter, and the duration of the study was shorter (6 months only), the weight increment in this study[1] is expected to be insignificant compared to the control children. But greater bioavailability of Zn in adults over the period of a year in their natural diet, as reflected by the hair Zn concentration in our volunteers, also resulted in greater energy input in the form of nutrients which was significant enough to reflect changes in the body weight leading to obesity. The higher the hair Zn concentration, the greater was the degree of obesity and vice-versa in our volunteers.

Contrary to our study, Atkinson et al.[16] reported that obese subjects possess lower but normal plasma level of Zn compared to non-obese controls. In fact, the plasma Zn status does not truly reflect the long term body Zn status as it tends to maintain Zn homeostasis either by increasing or decreasing Zn excretion depending upon Zn intake[17]. A significant relationship of body weight/height to plasma Zn is, therefore, unlikely to exist. The hair, on the other hand, not only reflects the long term body Zn status but also entraps Zn according to its bioavailability so that it cannot be reclaimed during low Zn intake to maintain Zn homeostasis. This, therefore, explains the difference in observations between the two studies.

Our observations lend further support to the weight-reducing effect of Zn-binding dietary factors such as phytates, fibres, calcium and phosphates which reduce Zn bioavailability[18]. This further explains the higher body weight gain in humans consuming more animal protein, which contains relatively more bioavailable Zn, than those consuming the same amount of plant protein rich in Zn-binding dietary factors[1–3]. The high prevalence of obesity in developed countries and its increasing incidence in the developing world may possibly be due to the higher intake of Zn through foods as a result of indiscriminate use of Zn in animal husbandry and agricultural practices in the quest for better yields. Further studies are required to confirm our results by looking into the hair Zn concentration in population with varied dietary habits.

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