Original Research

Fingernail Growth Rate and Macroelement Levels Determined by ICP-OES in Healthy Chinese College Students

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Abstract

To determine the growth rate and element contents of fingernails in young adults, 109 apparently healthy college students were recruited for determination. As a result, the average growth rate of the left thumb was 3.14±0.63 mm/month with significantly faster rates in male and taller participants. The concentrations for Ca, Na, P, K, and Mg were 701.1±274.8 μg/g, 452.3±353.9 μg/g, 331.6±119.7 μg/g, 241.6±142.7 μg/g, and 111.1±43.5 μg/g, respectively. In general, the nail element levels were positively associated with growth rate. In conclusion, fingernail growth rate and the distribution of elements in fingernails are useful for assessing physical development and nutritional status.

Keywords: fingernail, nail growth rate, macroelement, calcium, young adults

Introduction

Human nails, which are formed by layers of keratinized cells, grow from a matrix as new cells replace the old ones. Unlike height, human nails grow during the entire lifetime. The growth of nails, as well as their matrix components, is influenced by several physiological, pathological, and environmental factors. It has been reported that the average growth rate of nails is 0.1 mm every day, depending on age and race [1]. To our best knowledge, little is known about the growth rate of nails in the Chinese population.

Because of the relatively low growth rate, nail clippings have been used as an important biomarker to reflect relatively long-term exposure [2-5]. As a biomarker, nails have the unique advantage of application in population monitoring studies due to noninvasive sample collection and easy storage [6]. However, nails have not been used as commonly as blood and urine in research and health diagnosis. Besides polluting metals, nails also contain essential elements including macroelements and microelements, whose determination may provide a way for assessing nutritional status [7, 8]. Element research in nails has received less attention for essential elements than toxic elements.

In the present study, we observed the growth rate of nails and determined the contents of their macroelements (Ca, Na, P, K, and Mg) in apparently healthy young adults. The aim of our study is to provide the basic data for evaluating the usability of nails as biopsy materials in the Chinese population.

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Table 1. Growth rates of left thumb by gender, height, and per meter of height according to gender.

	Total	Gender		Height (m)		Per meter of height	
		Male	Female	≤1.65	>1.65	Male	Female
Number	109	43	66	55	54	43	66
Growth rate (mm/month)	3.14±0.6	3.33±0.65	3.01±0.59 [a]	3.02±0.53	3.25±0.68 [a]	1.93±0.39	1.86±0.41

[a] P<0.05 Significant difference compared with the counterpart

Materials and Methods

College students from Soochow University were recruited. After the exclusion of nail-biters and left-handers, there were 43 males and 66 females in the present study. The age of participants was between 17.9 and 21.7 years (19.0±0.8 years). The height ranged from 1.50 to 1.81 m (1.65±0.08 m). The average height was 1.72±0.05 m in males and 1.61±0.06 m in females (P<0.05). All of the students self reported to be healthy and none were hospitalized during the period of study.

Clean stainless nail clippers were used to cut the fingernails of left hands. The nail clippings were collected individually in a clean labeled plastic bag securely sealed, until the determination of the contents of Ca, P, Na, K, and Mg. After nails were cut, the thumb fingernails of left hands were marked near the proximal nail fold by drawing the edge of the nail file across the nail. The distance from the proximal nail fold to the mark was recorded using an electronic caliper. Up to 2 months later, this distance was recorded again and nail growth rate was calculated according to the difference between two recorded distances. During this period, investigators checked the marks every week.

For the determination of element contents, fingernail samples were soaked in acetone and washed for 10 minutes in an ultrasonic cleaner. After sonication, the samples were rinsed thoroughly with de-ionized water and dried at 60ºC overnight. Approximately 100 mg of dried samples were accurately weighed and 7 ml of HNO_3 (71%) and 1 ml of H_2O_2 (30%) was added in acid-cleaned Teflon tubes fitted with a cap. After standing overnight at room temperature, samples were digested using a Microwave Labstation (Milestone Inc., Sorisole, Italy) with the following program: 250 W, 1 min; 0 W, 1 min; 250 W, 6 min; 400 W, 5 min; 600 W, 5 min. The cooled solutions were transferred to acid cleaned bottles and diluted to approximately 30 ml with de-ionized water. Quantitative analysis was carried out by Vista MPX type inductively coupled plasma-optical emission spectrometry (ICP-OES) (Varian Inc., Palo Alto, CA, U.S.A.) with the parameters described in our previous study (9). Because nail reference material is unavailable, hair powder GBW 09101 (Shanghai Institute of Nuclear, Academia Sinica, Shanghai, China) was used and it was treated as described above. Blanks were prepared with each digestion set. All reagents used were of analytical-reagent grade.

The values of thumb growth rate and its element contents were presented as arithmetic mean (mm/month for growth rate and μg/g for element content) with standard deviation (SD). The statistical significance was determined by t-test in the stratified observation. The associations of inter-element or between element and continuous variables (height and fingernail growth rate) were determined by Pearson's coefficients. Two-sided P<0.05 was considered statistically significant. All analyses were performed using statistical package SPSS (SPSS Inc., Chicago, IL).

Results

In the present study, all of the participants completed the study. The lowest growth rate of fingernail was 1.77 mm/month and the highest rate was 5.13 mm/month with a mean rate of 3.14±0.63 mm/month. The growth rate was significantly faster in male students than in female students. Using average height of 1.65 m as cut-off point, fingernail grew significantly faster in taller participants (Table 1). A significant positive correlation was found between height and fingernail growth rate (R=0.251, P<0.05). For further analysis, the ratio of fingernail growth rate (mm/month) to height (m) was calculated according to gender. As a result, fingernail growth rate was 1.93±0.39 m in males and 1.86±0.41 m in females based on the unit of height (P>0.05).

To evaluate the accuracy and the precision of analytical methods for elements, hair powder was determined as reference material. The determined values of 5 elements were in good agreement with the certified values of the reference standards (data not shown), suggesting the practicability of our method. The element contents in fingernails decreased in the order of Ca, Na, P, K, and Mg. For example, Ca content was 701.1±274.8 μg/g with a range of 185.7-1740.8 μg/g and Mg was 111.1±43.5 μg/g with a range of 42.8-293.7 μg/g. In general, the element contents were higher in male students, taller students, and students with faster fingernail growth rate. The contents of Ca, P, Na, and K were significantly higher in males than in females. The contents of P, Na, and K were significantly higher in the participants with height >1.65 m. The analysis of linear relation suggested the positive associations of these three elements with height. For fingernail growth rate, Na and K showed significantly higher contents in the participants whose fingernails grew faster than the average value of 3.14 mm/month, with positive association between fingernail growth rate and Na, K (Table 2). Furthermore, the Pearson's coefficient (R) of inter-element ranged from 0.27 to 0.78, and all the P values were less than 0.05, indicating the positive associa-

Table 2. Elemental content (μg/g) in left thumb by some characteristics.

	Ca	Na	P	K	Mg
Total	701.1±274.8	452.3±353.9	331.6±119.7	241.6±142.7	111.1±43.5
Gender					
Male	783.5±274.6	662.8±437.9	405.3±127.4	325.2±152.7	119.9±41.6
Female	647.4±263.3 [a]	315.2±189.2 [b]	283.5±85.9 [b]	187.1±105.5 [b]	105.3±44.0
Height (m)					
≤1.65	683.8±274.9	355.5±268.5	297.8±88.7	198.6±113.9	110.9±46.6
>1.65	718.7±276.1	547.2±405.7 [b]	366.0±137.0 [b]	285.3±156.2 [b]	111.2±40.5
R (P)*	0.126 (0.191)	0.366 (<0.01)	0.333 (<0.01)	0.354 (<0.01)	0.092 (0.340)
Fingernail growth rates (mm/month)					
≤3.14	695.1±260.1	372.2±231.5	317.5±102.3	209.9±112.0	108.2±43.4
>3.14	705.6±287.5	557.9±450.5 [b]	350.1±138.3	283.4±167.5 [b]	114.9±43.9
R (P)*	-0.029 (0.764)	0.333 (<0.01)	0.182 (0.582)	0.242 (0.011)	0.002 (0.993)

[a] $P<0.05$; [b] $P<0.01$ Significant difference compared with the counterpart

*R is pearson correlation between characteristics (continuous variable) and elements. P value was shown in the parenthesis.

tions among these elements. The highest three Rs (0.78 for Ca-Mg, 0.68 for Ca-P, and 0.67 for Na-K) are shown as scatter diagrams in Fig 1.

Discussion

In the present study, the growth rate of the left thumb was 3.14 mm/month in healthy Chinese young adults. Yaemsiri et al. recently reported that growth rate of the thumb fingernail was as high as 3.55 mm/month in healthy American young adults [10]. Hamilton, half a century ago, found that average thumbnail growth rates were 3.06 mm/month for young Japanese men and 2.94 mm/month for young Japanese women [11], which was slower than that for young Chinese men and women in our study. Thus, fingernail growth rates may be affected by race or country, and have an increasing trend over time. Our study first demonstrated that tall participants had a fast rate in fingernail growth. Also, fingernail growth rate was faster in males than in females. However, there was no significant difference of fingernail growth rate between males and females when adjusted for height. Thus, the fast rate of fingernail growth in Americans may reflect, at least in part, the height difference since American adults are generally taller than Chinese adults.

Ca, Na, P, K, and Mg are essential in the human body. The contents of 5 elements in our study were quite similar with that from the other determination using ICP-MS and lower than that determined by particle-induced x-ray emission (PIXE) [4, 8]. The analysis of inter-element correlations in fingernails showed positive association among elements (all of $P<0.05$). This equilibrium between elements suggests a co-occurrence of these divalent cations in nature

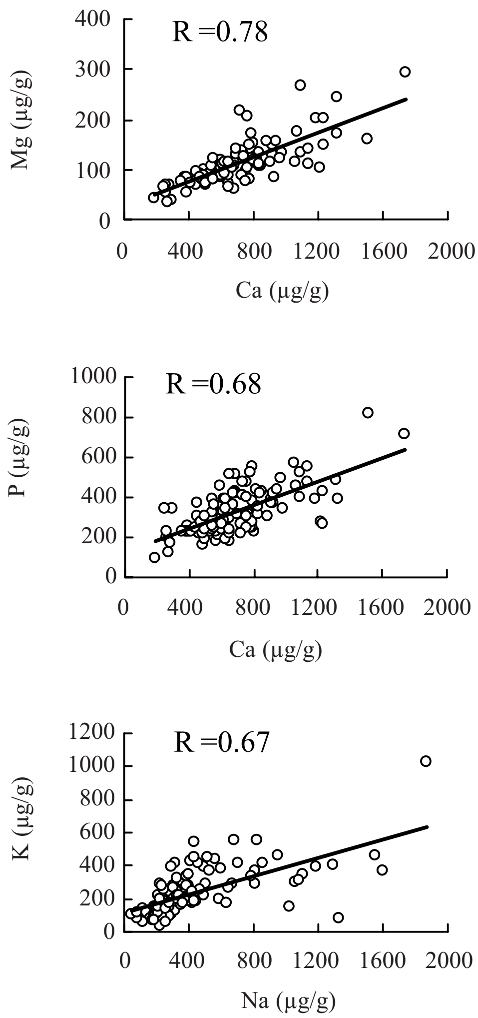

Fig. 1 Relation and pearson's coefficient (R) in Ca-Mg, Ca-P, and Na-K.

or biological tissues. Individually, Ca content, which is prominent in fingernails, was consistent with the results from Poland [2], Sweden [7], and Japan [12]. Mg, whose content is the lowest in 5 elements, is associated with Ca in nature and in living organisms. Ohgitani found a positive correlation between fingernail Ca and Mg contents ($R=0.14$, $P<0.01$), which was much smaller than that of our study ($R=0.78$). Because the fingernail is in direct contact with the periosteum of the phalangeal bone, it is conceivable that physiological and pathological processes involving blood and bone influence its mineral content [12]. Thus, fingernail Ca and other elements may reflect the bone status around the time of fingernail formation. This was somewhat supported by our study, where element contents were generally higher in tall male participants. Because a polluted environment and poor nutrition hinder bone development, element contents in fingernails were considerably lower in children in Kenya [3]. Of course, the relationship between fingernail element contents and bone status needs further study.

The limitations of the present study may be due to its cross-sectional nature and only fingernails were observed. Toenails were not collected because of poorer blood circulation than fingernails, making them unsuitable for this type of study [1]. Another limitation was large variations in element contents. This diversity was common in other studies [7, 8], and reflects such factors as dietary habits, lifestyle, and geochemical environment that affect element contents in fingernails. In conclusion, the distribution of elements in fingernails partly reveals general status of health and gives a better reflection of nutritional status than human fluids such as serum and urine.

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