

STUDY OF SOME MINERALS IN NORMAL EGYPTIAN SCALP HAIR

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Abstract. Scalp hair of 128 normal individuals of both sexes and of differing ages was examined for its mineral content by flame photometric and colorimetric procedures. The results obtained revealed that sodium and potassium may be considered as sex specific and of value as a medico-legal sign, while no marked difference was observed between male and female calcium content. The values of scalp hair copper were found to be slightly higher in females than in males. Similarly the mean value of scalp hair iron was found higher in females than in males, especially during the female reproductive period. Regarding the scalp hair phosphorus content, it has been found that a relationship between phosphorus and calcium does exist.

Key words: Hair; Mineral content

It has been known for many years that human hair contains a complex mixture of minerals, but little is known about the physiopathological processes that determine the concentration of a particular element in hair (24).

Published articles on this subject, although few and sporadic, have nevertheless reported that mineral content of scalp hair is liable to great variations due to multiple factors such as hair colour (12, 13), sex, length of hair (3), and race (2). Other factors are also of importance, such as environmental exposure, zonal factors (11) and drug administration (4). Also the mineral content of scalp hair was variable with certain diseases such as hepatolenticular degeneration (17), cystic fibrosis (14), and kwashiorkor (15). Moreover scalp hair minerals were reported to change with kidney calculi, hyperthyroidism, cancer prostate, infective hepatitis (23) and anaemia (16). The present study was intended to estimate some of the essential minerals such as sodium, potassium, calcium, copper, iron, and phosphorus in Egyptian normal scalp hair in both

sexes during different periods of life in an attempt to demonstrate the normal values of these minerals in normal scalp hair.

MATERIALS AND METHODS

128 normal individuals of both sexes and of different ages ranging from 3 months to 69 years were studied. They were divided according to age into 6 groups. Each group was further divided into two subgroups according to sex, as is shown in Table I.

Female adults not taking oral contraceptives were chosen. Smokers were excluded from the study. Every case was subjected to thorough clinical and laboratory investigations to exclude any local or systemic disease. Investigations done were blood picture, liver and kidney function tests, urine and stool analysis. Hair samples were obtained by cutting the hairs above the surface of the skin, using a clean chromium-plated razor. The length of the hair strands was standardised for all the cases to be 5 cm. The cases were informed not to wash their scalps with soap and water for 4 days before hair samples were taken. Each sample was rinsed in ether for 5 minutes to dissolve fats. Then each sample was subjected separately to thorough series of washings using soap and water, and bidistilled water three times. They were allowed to dry at ordinary room temperature. 0.5 g of each sample was separately digested using a mixture of concentrated sulphuric acid and hydrogen peroxide and the resultant colourless drop was diluted with bidistilled water to obtain a 1% solution on which determination of the different minerals was carried out. Estimation of Na and K was done by flame photometry (26), while the colorimetric procedure was used for the determination of the remaining minerals. Cu was determined by the diethyldithiocarbamate method (27). Fe was estimated by the a-a-Dipyridyl method (20). P was determined by the Gomori method, and Ca by the method of Erichrome Se (5).

RESULTS

The results of all the groups studied together with their statistical analyses are shown in Table II and Figs. 1-6.

Table I. The 6 groups of normal individuals according to age, sex, occupation, length of hair strands and site of specimens

Groups	Age	Locality	Sex	Occupation	Site of specimen	Length of hair strands	No. of cases
I	1 mo.-2 y.	Cairo	♂	-	Vertex	5 cm	11
			♀	-	Vertex	5 cm	9
II	3-12 y.	Cairo	♂	Pupils	Occiput	5 cm	10
			♀	Pupils	Occiput	5 cm	14
III	13-20 y.	Cairo	♂	Students	Occiput	5 cm	12
			♀	Students	Occiput	5 cm	36
IV	21-35 y.	Cairo	♂	Clerks, lawyers	Occiput	5 cm	10
			♀	Nurses	Occiput	5 cm	12
V	40-50 y.	Cairo	♂	Clerks, lawyers	Occiput	5 cm	5
			♀	Nurses	Occiput	5 cm	5
VI	51-70 y.	Cairo	♂	Clerks, lawyers	Occiput	5 cm	5
			♀	Housewives	Occiput	5 cm	9
Total number of cases							128

DISCUSSION

Among the methods used for determination of minerals is the spectrographic analysis used by Goldblum (9) who reported that the colorimetric and flame photometric methods are superior. The paper chromatographic method used by Kikkawa (12) was later found to give unreliable results (13). The colorimetric and the atomic absorption methods were used by Reinhold et al. (21), Sunderman & Roszel (25) and by Volini et al. (28) and the results obtained by both methods for iron

and copper, were found to be similar and there was no statistically significant difference between them ($P > 0.05$). Other methods were also used, such as the spectrographic method of Bate (2), the radioactive method of Kopito et al. (14) and the most recent method of neutron activation analysis of Mahler et al. (16).

In the present study the standard specific colorimetric technique was used for the estimation of Cu, Fe, Ca and phosphorus and the flame photometry as proposed by Dutcher & Rothman (7) and Rein-

Table II. Mineral content of scalp hair in different periods of life (mean value $\pm$ S.D.) (expressed in mg/kg hair)

Groups	No. of cases	Sex	Sodium	Potassium	Calcium	Copper	Iron	Phosphorus
I 3 mo. - 2 y.	11	♂	1 237 $\pm$ 685	265 $\pm$ 189	4 156 $\pm$ 486	138 $\pm$ 132	60 $\pm$ 36	150 $\pm$ 100
	9	♀	1 693 $\pm$ 669	458 $\pm$ 294	4 169 $\pm$ 857	127 $\pm$ 59	79 $\pm$ 41	234 $\pm$ 130
II 3-12 y.	10	♂	1 111 $\pm$ 380*	214 $\pm$ 53	4 449 $\pm$ 185	79 $\pm$ 93	113 $\pm$ 39	163 $\pm$ 110
	14	♀	1 917 $\pm$ 1 317	200 $\pm$ 72	4 325 $\pm$ 408	43 $\pm$ 22	111 $\pm$ 35	162 $\pm$ 192
III 13-20 y.	12	♂	1 223 $\pm$ 536**	188 $\pm$ 96	3 767 $\pm$ 492*	64 $\pm$ 33	88 $\pm$ 51	98 $\pm$ 59
	36	♀	2 019 $\pm$ 840	204 $\pm$ 109	4 246 $\pm$ 581	68 $\pm$ 65	130 $\pm$ 91	77 $\pm$ 27
IV 21-35 y.	10	♂	1 273 $\pm$ 1 009	197 $\pm$ 78	4 021 $\pm$ 747	87 $\pm$ 33	90 $\pm$ 39**	102 $\pm$ 55
	12	♀	1 757 $\pm$ 853	177 $\pm$ 119	4 519 $\pm$ 470	77 $\pm$ 70	162 $\pm$ 71	88 $\pm$ 63
V 40-50 y.	5	♂	787 $\pm$ 242	122 $\pm$ 46	4 341 $\pm$ 187	71 $\pm$ 37	115 $\pm$ 26	123 $\pm$ 74
	5	♀	1 268 $\pm$ 419	192 $\pm$ 53	4 693 $\pm$ 396	95 $\pm$ 38	116 $\pm$ 22	102 $\pm$ 48
VI 51-70 y.	5	♂	695 $\pm$ 130	92 $\pm$ 34*	4 117 $\pm$ 363	47 $\pm$ 20	140 $\pm$ 70	127 $\pm$ 81
	9	♀	1 420 $\pm$ 234	191 $\pm$ 127	4 150 $\pm$ 315	77 $\pm$ 40	88 $\pm$ 56	120 $\pm$ 62

* $P < 0.05$ significant. ** $P < 0.01$ highly significant.

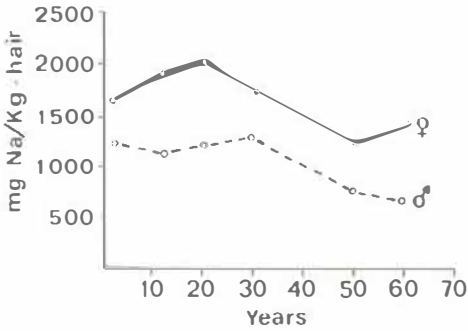


Fig. 1. The variation in sodium content of scalp hair according to age in both sexes.

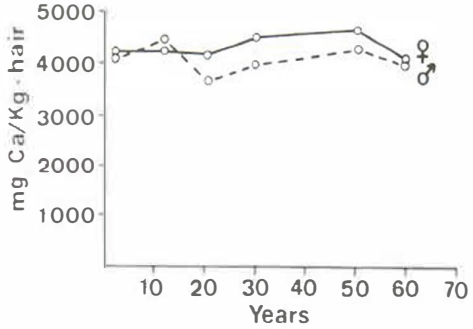


Fig. 3. The variation in calcium content of scalp hair according to age in both sexes.

hold et al. (21) was applied for the determination of sodium and potassium.

Sodium

If the content of sodium of normal scalp hair is followed up from birth to old age, it will be found that the amount of this element in females is much greater than the corresponding value in males in all age groups and is particularly statistically significant ($P < 0.05$) during childhood and adolescence (Fig. 1). This sex-specific finding could be considered of value as a medico-legal sign in identification and differentiation between males and females. However, the values of sodium are shown to be intimately related to periods of body growth, as the mean value of sodium was found to increase with increase of age up to the adolescent stage (from 1693 mg/kg hair in infants to 2019 mg/kg hair in adolescents), where this relationship is reversed—the increase in age was found to be associated with a decrease in sodium content up to the age of

40–50 years. This finding is expected, since the body requirement of sodium during old age may be responsible for this decrease in scalp hair sodium content. Moreover, it is well known that the rate of scalp hair growth is fastest during adolescence and declines gradually with increase in age (8), up to the age range 50–69 years where the rate of hair growth rises again to reach its highest level (19). Meanwhile, the decrease of sodium during old age and its increase with the increase in age subsequently could be attributed either to hormonal disturbances or enzymatic changes. The increase in sodium content of scalp hair in females as compared with males may be explained on the basis of the assumption that sodium is considered one of the essential minerals required for nutrition of body organs. It is well known that the rate of hair growth depends on the adequate supply of various nutritional factors, among them being sodium. It has been previously reported by Myer & Hamilton (18), and Saitoh et al. (22), that the rate of hair growth in the vertex of women is faster than in men. When the biological process of hair growth is considered, these nutritional factors must be regarded as essential for initiating and maintaining this process. It is therefore expected that the sodium content of scalp hair in females will be higher than that of males, which agrees with the results obtained in the present work.

Potassium

Concerning the results of the potassium content of normal scalp hair, it has been found that the increase in potassium in female scalp hair was statistically significant only during old age ($P < 0.05$). Therefore it could be stated that potas-

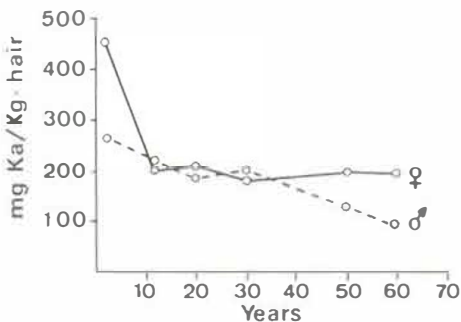


Fig. 2. The variation in potassium content of scalp hair according to age in both sexes.

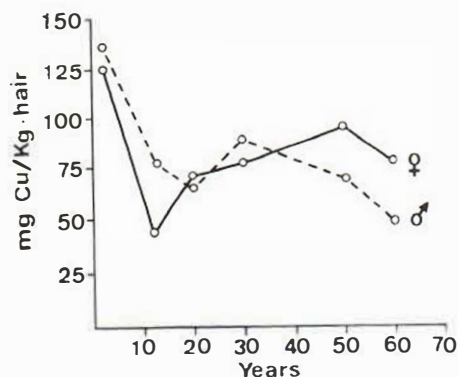


Fig. 4. The variation in copper content of scalp hair according to age in both sexes.

sium too is sex specific, as is sodium, and may be of help in identification and differentiation between males and females, especially during old age.

Calcium

Regarding the calcium content of normal scalp hair, the results obtained from the present work revealed that there is no marked difference in the value of calcium in either sex, except in male adolescents where the lowest amount of calcium was found (Fig. 3). These results are approximately similar to what has previously been reported by Goldblum et al. (9), that the calcium content of normal hair taken from normal individuals ranging from 15 to 70 years of age was from 700 to 4900 mg/kg hair. This slight difference between our results and those of Goldblum could be attributed either to the different methods used or to the small number of cases examined by him. Calcium was estimated colorimetrically in the present study and spectrographically by Goldblum.

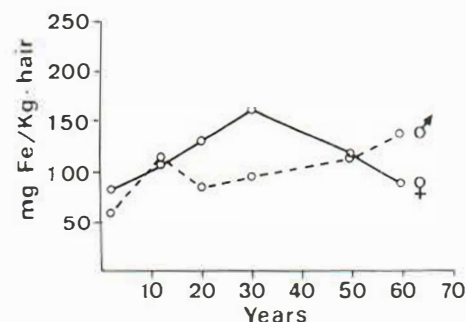


Fig. 5. The variation in iron content of scalp hair according to age in both sexes.

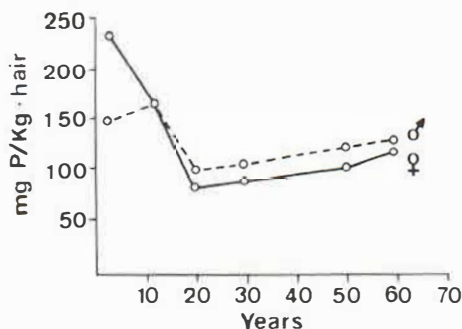


Fig. 6. The variation in phosphorus content of scalp hair according to age in both sexes.

Copper

The findings of copper in normal scalp hair obtained from the present work revealed that the highest copper content was found during infancy in both males and females (138 and 127 mg/kg hair respectively) and the lowest quantity of this element was detected in aged males (47 mg/kg hair) and in female children (43 mg/kg hair) (Fig. 4). The low Cu content in elderly individuals is acceptable, since all the cases studied had grey hair. It is well known that copper, which is a metallo-enzyme, plays an important role in the process of pigmentation (1), through its effects on the tyrosine-tyrosinase system. On the other hand, the low copper content in the hair of female children remains to be explained. In spite of the discrepancy in the values of copper during the different periods of life, the mean value of copper in all the cases examined was found to be slightly higher in females than in males (82.8 and 79.3 mg/kg hair respectively). These results are approximately similar to what has previously been reported by Briggs et al. (4). Although Goldblum et al. (9) have reported that the mean value of Cu content in normal hair ranged from 31.2 to 128 mg/kg hair which is similar to the findings obtained from the present work, they did not compare the values of copper in male and female hair.

Iron

The mean values of iron content of normal scalp hair were found to range from 60 to 162 mg/kg hair, findings higher than those of Goldblum et al. (9) who reported that the mean value of iron content ranged from 84 to 101 mg/kg hair. This high mean value obtained in the present work could be explained on the fact that the number of cases examined was greater than in the series of Goldblum

et al. (128 and 18 cases, respectively). Moreover the cases examined by Goldblum et al. were all males. Therefore sex and racial specificity may be the cause of such differing results. However, when the mean value of iron content in normal scalp hair is compared in both males and females, it has been found to be higher in females than in males (101 and 96.8 mg/kg hair, respectively). Moreover it has been noticed that the maximum increase was noticed during the female reproductive period of life, as shown in Fig. 5. Subsequently, the mean value of iron gradually decreases to reach a very low level more or less similar to that found during infancy. On the other hand, the mean value of iron content of scalp hair in males behaves differently. It increases with increasing age up to old age, where the maximum iron content was noted (140 mg/kg hair) (Fig. 5). It is well known that body iron stores reach their lowest levels between 12 and 24 months (6), and if the hair is considered as one of the body stores, then the findings in the present work could be easily achieved.

Phosphorus

Regarding the results of the phosphorus content of normal scalp hair, it has been found that there is a relationship between this element and calcium values. While a low concentration of calcium was detected during infancy in both males and females, the present work revealed that infancy is associated with the highest concentration of phosphorus, in both males and females (150 and 234 mg/kg hair, respectively) (Fig. 6). During the subsequent periods of life the concentration of phosphorus gradually decreases to reach its lowest level in adolescence (98 and 77 mg/kg hair), to increase again gradually up to old age. From adolescence to old age it has been found that male scalp hair contains higher values of phosphorus than does female hair.

From the data here set out it is clear that the biochemical aspects of hair are worthy of further study, not only in normal humans but also in diseased individuals. This work is a first stage in a series of investigations on trace metals being carried on in our department.

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