A Developmental Study of Sex Differences in Hair Tissue Mineral Analysis Patterns at Ages Six, Twelve and Eighteen

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Abstract

The close relationship between estrogen, copper and calcium suggested that significant gender differences would be found in Hair Tissue Mineral Analysis (HTMA) data for calcium, magnesium, and copper at different age levels. The estrogen, copper and calcium relationships also suggested that significant gender differences would be found in HTMA data at different age levels for certain ratios: calcium/potassium (Ca/K), calcium/phosphorus (Ca/P), calcium/magnesium (Ca/Mg), sodium/magnesium (Na/Mg) and zinc/copper (Zn/Cu). The data showed significant differences between males and females in levels of calcium and magnesium at ages 6, 12 and 18. Female calcium and magnesium levels were consistently higher at all three age levels. At age 18, significant gender differences were found in copper levels with females showing higher copper levels. Females also showed higher copper levels at ages 6 and 12, but the differences were not statistically significant. These elevated copper levels may be clinically significant for females. Significant differences between genders were found at all three age levels for the Ca/P ratios with higher female Ca/P ratios. Elevated Ca/Mg ratios for both sexes suggest increased risk for diabetes and addictions. As expected, at ages 12 and 18, significant gender differences were found in Zn/Cu ratios with females showing lower Zn/Cu ratios. At age 6, no significant gender difference was found for the Zn/Cu ratio. These findings indicate a strong trend towards the emergence of slow metabolic mineral patterns with increasing age. This trend is much more pronounced in females than in males.

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Introduction

In a recent study of gender differences in hair tissue mineral analysis (HTMA) patterns in 18 year-olds, several significant gender differences in nutrient mineral levels and ratios were found.[1] These gender differences were related primarily to the high correlation between copper and estrogen. It is a well-established fact that estrogen has a strong effect on nutrient minerals and the functions that they help to regulate.[1-6] The minerals most affected by estrogen are calcium, potassium, and copper. [7] Other minerals that are affected by estrogen are magnesium, sodium, zinc, and phosphorus. The functions that are most strongly affected by the estrogen/copper relationship are the activity of the thyroid, adrenals, and parathyroid glands, blood sugar regulation, blood pressure and psychological reactions such as depression, anxiety and panic attacks, and obsessive thinking. [8-11]

The earlier study noted several significant sex differences in mineral levels and in mineral ratios among 18 year-olds. The current study seeks to apply a developmental perspective by analyzing HTMA data on 6 and 12 year-old children and combining this new data with the earlier findings on 18 year-olds in order to determine whether the same types of sex differences occur in HTMA data at younger age levels or whether there are significant developmental trends in nutrient mineral patterns.

In this present study, it was anticipated that significant gender differences are more likely to be found in (HTMA) patterns of older rather than younger male and female students. In particular, it was anticipated that, with increasing age, female students will show higher calcium, magnesium, and copper HTMA levels than do male students. It was also anticipated that, with increasing age, female students will show significantly higher ratios of calcium/ potassium than do male students. It was further anticipated that, with increasing age, female students will show lower zinc/copper ratios and higher calcium/phosphorus ratios than would male students.

Method

A high-school science student collected hair samples from 5 males and 5 females at ages 6 and 12, respectively. The hair samples were cut from the occipital area of the scalp, using the first inch to inch and a half of the cut hair. The samples were analyzed by Trace Elements, Inc. (TEI) of Dallas, Texas, a licensed clinical laboratory that specializes in HTMA. Male and female data were already available on 18 year-old students from the recent earlier study.

Data Analysis and Results

The HTMA results were reported by TEI in mg/% (ppm/10) for nutrient minerals and toxic metals. **Table 1** (p.247) shows the HTMA results for calcium levels (ideal laboratory HTMA calcium level = 42) for the male and female groups at ages 6, 12, and 18. The mean calcium levels were 36.4, 93, and 111.6 for the males and 150.8, 241, and 288 for the females. The respective mean differences were 114.4, 148, and 176.4. The female calcium level means were consistently higher than the male calcium level means. The mean differences are statistically significant at a *p* value of .05 for 6 year-olds and a *p* value of .01 for 12 and 18 year-olds using a 1-tailed *t*-test. **Table 2** (p.247) shows HTMA magnesium levels (ideal HTMA magnesium level = 6) for males and females at ages 6, 12, and 18. HTMA magnesium levels also show tendencies to increase with age for both sexes. However, the mean differences in HTMA magnesium levels are not as consistent as are the mean differences in HTMA calcium levels. This finding may be due to the fact that calcium is much more closely related to estrogen and copper (both tend to be high in females) than is magnesium. Also, magnesium is much more directly affected by stress than is calcium.

Table 3 (p.247) shows HTMA mean copper levels (ideal HTMA copper level = 2.5) for males and females at ages 6, 12, and 18. Mean HTMA copper levels increase from 6 to 12 for females with a slight increase in mean copper levels from 12 to 18. Mean HTMA copper levels for males show a slight increase between 6 and 12 years of age with a slight decrease in copper levels from age 12 to 18. In females, the copper levels tend to remain stable at an elevated level from age 12 to 18. However, the magnitude of the differences between HTMA copper levels for males and females increases with age. This difference in magnitude may reflect the effect of increasing estrogens in females with age.

Table 4 (p.247) shows HTMA mean zinc levels (ideal HTMA zinc level = 20) for males and females at ages 6, 12, and 18. A significant gender difference is found at the 6 year-old level with females having a significantly higher zinc level that is very close to the ideal level. The lower mean zinc level for males at age 6 may be related to the much faster metabolic rate that is indicated by the male 6 year-old data (see Table 6). At the 12 and 18 year-old ages, the zinc levels are virtually identical for both sexes.

Table 5, (p.248) shows HTMA mean phosphorus levels (ideal HTMA phos-

Table 1. HTMA mean calcium levels in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	36.4	150.8	114.4	< .05
12	93.0	241.0	148.0	< .01
18	111.6	288.0	176.4	< .01

Table 2. HTMA mean magnesium levels in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	3.58	21.04	17.46	< .01
12	9.04	24.18	15.14	< .01
18	11.60	30.31	18.71	< .01

Table 3. HTMA mean copper levels in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	1.92	3.68	1.76	NS
12	2.14	4.44	2.30	NS
18	1.54	4.76	3.22	< .05

Table 4. HTMA mean zinc levels in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	12.60	19.80	7.20	>.01
12	16.80	16.40	0.40	NS
18	16.40	16.40	0.00	NS

phorus level = 16) for males and females at ages 6, 12, and 18. There were no significant mean phosphorus differences between males and females at any of the age levels.

Table 6 (p.249) shows HTMA calcium/phosphorus (Ca/P) ratios (ideal HTMA Ca/P ratio = 2.6/1) for males and females at ages 6, 12, and 18. There were very significant mean Ca/P ratio differences between males and females at each of the age levels. At each age level, the mean Ca/P ratio was significantly higher for females compared with males. The magnitude of mean Ca/P ratio differences increased with age. The Ca/P ratio is used by Trace Elements, Inc., to determine metabolic type. The Ca/P ratio may also be used to indicate metabolic rate. The more the Ca/P ratio exceeds the ideal HTMA Ca/P ratio of 2.6/1, the slower the metabolic rate. From this perspective, the data in Table 6 show that females at each age level have significantly higher mean Ca/P ratios, thus indicating that females tend to have much slower metabolic rates than do their male counterparts.

Table 7 (p.249) shows HTMA mean calcium/magnesium (Ca/Mg) ratios (ideal HTMA Ca/Mg ratio = 7/1) for males and females at ages 6, 12, and 18. There were no significant mean Ca/Mg differences between males and females at any of the age levels.

The mean zinc/copper (Zn/Cu) data shown in **Table 8** (p.249) showed no significant gender differences at the 6 year-old level, but very significant differences between males and females at ages 12 and 18. The females at these latter age levels showed significantly lower mean Zn/Cu ratios than the males. As expected, lower female mean Zn/Cu ratios reflect higher copper levels relative to zinc and, therefore, the estrogen effect.

Table 9 (p.249) shows mean HTMA calcium/potassium (Ca/K) ratios for males and females at ages 6, 12 and 18. The ideal HTMA Ca/K ratio is 4.2/1. Table 9 shows that these mean Ca/K ratios increase with age in both sexes. When the HTMA Ca/K ratio is substantially above 4.2, there is a tendency towards reduced thyroid activity with an associated drop in cellular energy production. Table 9 shows that, even at age 6, the female mean Ca/K is 13.15 or more than 3 times the magnitude of the ideal Ca/K ratio. There are much higher mean Ca/K ratios above 20 in the 12 and 18 year-old female groups. Table 9 also shows age increases in the male mean Ca/K ratios. Although only the 12 year-old mean Ca/K ratio shows a statistically significant gender difference, the magnitude of the mean Ca/K ratio differences at the 6 and 18 year-old levels would indicate clinically significant differences in energy production from thyroid activity. The females tend to have much slower thyroid activity and lower energy production.

Table 5. HTMA mean phosphorus levels in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	12.20	11.40	0.08	NS
12	13.40	11.20	2.20	NS
18	14.60	12.20	2.40	NS

Table 6. HTMA mean calcium/phosphorus ratios in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	2.99	13.15	10.16	>.05
12	7.35	21.87	14.52	>.01
18	7.71	24.46	16.75	>.01

Table 7. HTMA mean calcium/magnesium ratios in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	14.56	7.62	6.94	NS
12	10.10	9.87	0.23	NS
18	9.35	9.71	0.36	NS

Table 8. HTMA mean zinc/copper ratios in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	9.03	8.42	0.61	NS
12	10.36	4.29	6.07	>.02
18	11.13	5.22	5.91	>.01

Table 9. HTMA mean calcium/potassium ratios in mg/% by sex and age.

Age	Male	Female	Difference	*p* (n=5)
6	3.03	13.15	10.12	NS
12	6.64	24.15	17.51	>.05
18	17.28	27.60	10.32	NS

Discussion

The estrogen/copper/calcium relationship supports the hypothesis that female mean HTMA calcium levels would be significantly higher than male mean HTMA calcium levels. The data in Table 1 clearly support this hypothesis. At each age level, the female mean HTMA calcium level is significantly higher than the male mean HTMA calcium level. In fact, the highest male mean HTMA calcium level of 111.6 at age 18 is still substantially lower than the lowest female mean HTMA calcium level of 150.8 found at age 6. The more the HTMA calcium level exceeds the ideal HTMA calcium level of 42, the slower the metabolic rate. These data indicate that, at each age level, females with significantly higher calcium levels tend to have much slower metabolic rates than males. Since estrogen, copper, and calcium are closely related, these findings make sense. As female estrogen levels increase with age during pre-adolescence and adolescence, it is to be expected that HTMA calcium levels will also increase. We also note, however, that at the 6 year-old level, the female mean calcium level is significantly higher than the male mean calcium level. This finding is surprising considering the estrogen, copper and calcium relationship. The 6 year-old male HTMA mean calcium level of 36.4 is just below the ideal HTMA calcium level of 42, whereas the 6 year-old female HTMA calcium level of 150.8 is nearly 4 times higher than the ideal HTMA calcium level. This finding suggests that perhaps estrogen already is having a substantial metabolic effect on the HTMA calcium levels in females as young as 6 years of age. By age 12, the female mean HTMA calcium level has increased to 241 and by age 18, the female mean HTMA calcium level has increased to 288, nearly 7 times higher than the ideal HTMA calcium level.

Table 1 shows that male mean HTMA calcium levels also increase with age, although they start at a much lower level than the female mean calcium levels. A number of possible explanations may account for this finding in male calcium levels. Exposure to hard water may contribute to increasing calcium levels in both sexes with age, especially if the hard water flows through copper pipes. But the greater accumulation of calcium in females may be best accounted for by the estrogen/copper/calcium relationships. The increasing difference between males and females in HTMA calcium levels with increasing age may be accounted for by the effect of increased estrogen levels in adolescent girls. However, both males and females are also exposed to estrogens through eating meat or poultry from animals that were fattened up by being given hormones prior to slaughter. This latter point may help to account for increasing male calcium levels that were shown in Table 1.

Both males and females may absorb excess copper from their mothers *in utero*, thus pre-disposing some children to increasing calcium accumulations with increasing age.[4] The timing and amount of copper transfer *in utero* may vary significantly. The amount of excess tissue copper in the mother and the amount of stress occurring during a particular pregnancy are likely to be among the most significant factors related to *in utero* transfer of large amounts of copper. This phenomenon is also likely to account for considerable variability observed in HTMA data in children and adolescents.

Clinical Implications

There is great clinical significance to these findings with regard to increasing HTMA calcium levels with age. High HTMA calcium levels slow the metabolic rate, especially with regard to the effect of high HTMA calcium levels on the calcium/phosphorus (Ca/P) and on the calcium/potassium (Ca/K) ratios. The latter ratio has been designated as the "thyroid ratio." Childhood obesity may be partially accounted for by the trends seen in Table 1.

Diminished energy associated with a high HTMA Ca/K ratio often manifests as depression. The high HTMA calcium levels shown in Table 1 and high Ca/K ratios shown in Table 9 may contribute to increasing rates of depression found in children and adolescents today. These high HTMA calcium levels and high Ca/K ratios also suggest that the treatment of childhood depression with SSRI antidepressants is both inappropriate and very risky, considering the heightened suicide/homicide reactions associated with these drugs. It makes much more sense to treat the high TMA calcium levels and high Ca/K and Ca/P ratios with safer nutritional supplements and diet rather than the riskier SSRIs.

HTMA research has shown that calcium and magnesium tend to increase and decrease together. Therefore, it is not surprising that the HTMA magnesium results shown in Table 2 show the same significant gender differences that are seen in the calcium data. In both sexes, the HTMA magnesium levels increase with age. Magnesium is also more directly related to the stress response and its effects than is calcium. Magnesium metabolism is more volatile than is calcium metabolism, resulting in less clear HTMA gender differences and changes with age. Also, magnesium is an intra-cellular mineral, whereas calcium is extra-cellular. Magnesium slows the activity of the adrenal glands and is, therefore, a vital anti-stress mineral. The very high female mean HTMA magnesium levels indicate a strong trend toward adrenal insufficiency with increasing age, whereas the trend does not appear to be as strong in males.

It was only at the 18 year-old level that a significant difference between males and females in HTMA copper levels was found. This finding tends to support the estrogen/copper relationship. Even though, statistically, no significant gender differences in HTMA copper levels were found at ages 6 and 12, it is important to note that at all three age levels, the female mean HTMA copper level was above the ideal HTMA copper level of 2.5. In contrast, the male mean HTMA copper level was below the ideal HTMA copper level. Since excess copper tends to store in the brain and in the liver, the higher mean HTMA copper levels found in females may contribute to concentration and memory problems, attention deficit disorder without hyperactivity, sleep disturbances, and eating disorders. Other physical and psychological symptoms related to HTMA copper excess are listed in the health history checklist at the end of this paper.

The gender differences in mean HTMA calcium/phosphorus (Ca/P) ratios are significant at each age level. The female mean Ca/P ratios are higher than the male mean Ca/P ratios. The magnitude of the gender differences in Ca/P ratios increases with age. Since the Ca/P ratio is used by TEI to determine metabolic type (fast or slow) and can be used as an index of metabolic rate, the data in Table 6 indicate that females tend to have substantially slower metabolism than males even as young as at the age of 6. For example, among 12 year-olds, the female mean Ca/P ratio of 21.87 indicates a much slower metabolic rate than the male mean Ca/P ratio of 7.35 (ideal HTMA Ca/P ratio = 2.6/1).

These findings give us a much better understanding of some of the major metabolic mechanisms contributing to childhood and adolescent obesity, especially in girls. However, even in males, the mean HTMA Ca/P ratio more than doubles between 6 and 12 years of age. The ideal HTMA Ca/P ratio is 2.6/1. At the 6 year-old level, the male mean HTMA Ca/P ratio (2.99) is just above the ideal ratio, but by 12 years of age, the male mean HTMA Ca/P ratio has increased to 7.35.

The mean calcium/magnesium (Ca/Mg) ratios were not significantly different at any of the three age levels. However, it should be noted here that, even with the large magnitude of difference between the mean calcium and magnesium levels for the male and female groups, the Ca/Mg ratio means were very close for both the male and female groups at the 12 and 18 year-old levels. The mean Ca/Mg ratio for the 18 year-old male group was 9.35 and the mean Ca/Mg ratio for the 18 year-old female group was 9.71, a difference of only .36. This finding illustrates an important aspect of HTMA and the metabolic phenomena it reflects, namely, that even where there are significant differences in the levels of related minerals when male and female comparisons are made, the ratios between minerals tend to be very close.

From a clinical standpoint, when the Ca/Mg ratio is substantially above the ideal Ca/Mg ratio of 7/1, there is a greater tendency towards problems with glucose metabolism. Therefore, the elevated Ca/Mg mean ratios of both the male and female groups suggest that they already have an increased risk for problems with glucose metabolism. With regard to the Ca/Mg mean ratios for 6 year-olds (14.56 and 7.62 respectively for males and females), even though there was no statistically significant difference between these mean ratios, clinically, the male mean Ca/Mg ratio of 14.56 is twice the ideal Ca/Mg ratio of 7/1. This elevated Ca/Mg ratio poses a much greater risk for glucose metabolism problems than the close-to-ideal female mean Ca/Mg ratio of 7.62. From a similar clinical perspective, even though no statistically significant differences were found between male and female Ca/Mg ratios at the 12 and 18 year-old levels, the fact that the mean Ca/Mg ratios for these four groups ranged from 9.35 to 10.1 indicates a heightened risk for glucose metabolism problems.

Conclusions and Recommendations

In this study, the addition of HTMA data from 6 and 12 year-old males and females to the previously available 18 year-old data provides a valuable developmental perspective in regard to HTMA test results and how they may be affected by specific hormone/mineral relationships. Very clear gender differences in HTMA mineral levels and ratios were found. The nature of these gender differences provides substantial support for the expected estrogen/copper/calcium relationships. The increase in both estrogen and copper exposure to females over the past 60 years appears to have contributed to the development of very slow metabolic mineral patterns observed in HTMA test results of children and adolescents. These slow HTMA mineral patterns help to account for the current epidemic of health problems among these young people, especially obesity and diabetes. Depression and other psychological problems in children and adolescents may also be related to these HTMA slow metabolic patterns. The estrogen/copper/calcium relationships that are so apparent in the data in this study also have strong implications for health education and health care provided to children and adolescents.

Since HTMA slow metabolic patterns have both physical and psychological effects, it is important that this information be incorporated into health education for students as well as for their parents and healthcare providers. HTMA data reveal very specific nutritional information that gives people a better understanding of what they are experiencing and why. HTMA data also can be used to design dietary and nutritional supplement programs to speed up metabolic activity in a healthy manner. For females, these HTMA data indicate that the onset of puberty and hormonal changes is likely to substantially exacerbate the adverse trends associated with slow metabolic HTMA patterns. Depending on the particular individual, the increase in estrogen with puberty may trigger physical health problems and/or psychological problems. Also, these HTMA data strongly indicate that, for females, great caution needs to be exercised in selecting contraceptive devices. Both the birth-control pill with estrogen and a copper IUD can seriously exacerbate health problems that are associated with the slow metabolic patterns revealed here.

HTMA data and the mineral patterns that they reflect serve to provide early detection of significant adverse health trends. These trends may be related to coping with stress and capacity for energy production. These trends also relate to both psychological and physical health risk. Clinical use of HTMA has shown that adverse health trends can often be reversed when the HTMA mineral pattern is used as a guide to selecting those vitamins and minerals that will reverse the adverse trends by altering vital mineral levels and ratios to better regulate neuro-endocrine functions.

Since this study involved very small samples of males and females, additional research is needed to further investigate the basic findings and relationships noted here. It would be important to investigate whether similar results and health trends are found in different communities in different parts of the United States and in other countries. Doing longitudinal studies involving appropriate nutritional supplement interventions would be helpful to determine the extent of HTMA mineral pattern change and whether there is a gender difference in the rate of HTMA mineral pattern change.

Health History Checklist

(related to high copper, slow metabolic mineral pattern)

1. Feelings of doom
2. Fatigue and exhaustion
3. Hypothyroid (slow thyroid)
4. Mind is in a fog
5. Headaches, migraines
6. Mood swings
7. Supersensitive, weepy
8. Cold hands, and/or feet
9. Depression
10. Dry skin
11. Chocolate cravings
12. Feeling of loss of control
13. Paranoia
14. Despair, suicidal feelings, hopelessness
15. Arthritis, calcium spurs
16. Constipation
17. Racing heart, pounding heart
18. Adverse reaction to vitamins & minerals
19. Problems with concentration and memory
20. Short attention span, "spaciness"
21. Eating disorders: anorexia, bulimia, overeating
22. Panic attacks, high anxiety, free floating anxiety
23. Yeast infections (*candida*)
24. Aching muscles or muscle cramps
25. Hypoglycemia
26. Mind races–insomnia, interrupted sleep
27. PMS
28. Mononucleosis
29. Low blood pressure
30. Obsessive thoughts

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