ОРИГИНАЛЬНАЯ СТАТЬЯ

INCOMMENSURABILITY OF HUMAN HAIR AND WHOLE BLOOD IODINE

НЕСОПОСТАВИМОСТЬ ОПРЕДЕЛЕНИЯ ЙОДА В ВОЛОСАХ И В ЦЕЛЬНОЙ КРОВИ У ЧЕЛОВЕКА

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КЛЮЧЕВЫЕ СЛОВА: йод, пол, волосы, цельная кровь.

ABSTRACT. Lack of iodine is one of the most common endemic diseases in the– developed and underdeveloped world today. We analyzed the iodine content in the hair (H·I) and whole blood (WB·I) in the prospective, cross-sectional, observational, and epidemiological study. Hair was analyzed in 246 subjects (men 90, women 156). In 137 of all the subjects (51 men, 86 women) iodine was detected simultaneously in both of the biological indicator tissues. The respective hair and whole blood iodine common median was $H{\cdot}I_{n137} = 0.501$, $WB{\cdot}I_{n137} = 0.052$ μg/g looking separately men and women H·I medians were 0.511 and 0.500 whereas their respective WB·I medians were 0.050 and 0.057 μg/g. Apparently, there was no gender dependent difference between the hair and whole blood iodine medians. The short time indicator of the whole blood iodine is not commensurable with the long term biological indicator of the iodine status. Hair iodine analysis was superior to the whole blood analysis in assessing the iodine body status.

РЕЗЮМЕ. Дефицит йода является одним из наиболее распространенных эндемических заболеваний в высокоразвитых и слаборазвитых странах мира. Мы проанализировали содержание йода в волосах (H·I) и цельной крови (WB·I) в проспективном одномоментном наблюдательном эпидемиологическом исследовании. Волосы были исследованы у 246 испытуемых (90 мужчин, 156 женщин); у 137 из них (51 мужчины, 86 женщин) йод был определен одновременно в обоих биосубстратах. В этой выборке медианное содержание йода в волосах и цельной крови составило: $H{\cdot}I_{n137} = 0{,}501$, $WB{\cdot}I_{n137} = 0{,}052$ мкг/г; отдельно у мужчин и женщин медианы H·I составили соответственно 0,511 и 0,500 мкг/г, а медианы WB·I – 0,050 и 0,057 мкг/г. Гендерных различий в медианах йода в волосах и цельной крови установлено не было. Показано, что данные по цельной крови, отражающей кратковременные изменения йодного статуса, не соотносятся с данными по волосам как долговременному индикатору. Определение йода в волосах превосходит анализ цельной крови по эффективности оценки йодного статуса организма.

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INTRODUCTION

Iodine deficiency disorder is one of the most common endemic diseases in the world (Itaka, 2004). It is present in both the underdeveloped third world countries and in the developed European countries (Zimmermann, Delange, 2004). Humans get most of the iodine by the iodized salt intake (Emsley, 2001; Reilly, 2002). Neither lack nor excess of iodine is good for human health since they both impede the normal function of the thyroid gland (Hetzel, 1991). Indeed, iodine deficiency may be linked to many health conditions (Braverman, Utiger, 2005). Recently we demonstrated that iodine deficiency is strongly associated with the clinically manifest human depression (Momčilović et al., 2010), and that the so called euthyroid goiter is the goiter induced by the unrecognized iodine deficiency (Momčilović et al., 2008a).

Thus far various methods have been proposed to assess the human iodine status and to detect the iodine deficiency and/or excess to combat the iodine deficiency disorders (Andersson et al., 2012). Two of them, i.e., the urinary iodine excretion (an indicator of a very recent iodine exposure), and the thyroid gland size, are currently recognized methods for the assessment of the human body iodine status by the World Health Organization (Brauer, Pasche, 2009). However, neither of them is a reliable long term indicator of the iodine status – especially in the underdeveloped world where the facilities for collecting, storing, and analyzing urinary iodine and/or assessing the size of the thyroid with the ultrasound, are scarce.

In the recent paper we demonstrated the advantages of the hair iodine analysis for the assessment of the long term human body iodine status (Momčilović et al., 2012). The aim of this paper was to explore the relationship between the hair iodine as a long term biological indicator and the whole blood iodine as yet another short to median term biological indicator of the human body iodine status, respectively.

SUBJECTS AND METHODS

This prospective, cross-sectional, observational and epidemiological study was approved by the Ethical Committee of the Institute for the Research Development of the Sustainable Eco Systems and conducted by the strict adherence to the Declaration of Helsinki on Human Subject Research (Brown, 2009), and to the complementary Croatian national bylaws and regulations; every subject gave his writing consent to participate in the study.

Hair iodine and whole blood iodine were analyzed in a random sample of apparently healthy 246 adults (90 men, 156 women) who were concerned with their health status and who came from across Croatia; most of them from the Croatian capital city Zagreb.

The scalp hair was collected over the (lat. *protuberantia occipitalis externa*), and whole blood was collected from the cubital vein. Both hair (H·I) and whole blood (WB·I) were analyzed for their iodine content with the inductively coupled plasma mass spectrometry (ICP-MS) at the Center for Biotic Medicine, Moscow, Russia (an ISO certified high-tech lab), as described previously (Momčilović et al., 2006). Samples were kept in refrigerator at 4 °C before the analysis. Current CBM iodine reference values (μg/g) for H·I are 0.65 – 9.00 and 0.65 – 8.00 for men and women, respectively; WB·I are 0.020 – 0.600, i.e., the same for both genders. Our detection limit for H·I and WB·I was 0.005 μg/g, and the coefficient of variation was 40.8 % (Momčilović et al., 2009). Iodine has 208 isotopes that belong to the complex cluster of elements sharing the same mass number (number of isotopes/elements name): 1 Ag, 7 Cd, 12 In, 21 Sn, 27 Sb, 26 Te, 24 I, 25 Xe, 17 Cs, 17 Ba, 12 La, 11 Ce, 6 Pr, and 2 Nd (Momčilović et al., 2008b; Wilson, 2010).

We used the power function regression analysis to compare the relationship between the hair and whole blood iodine, respectively; the difference between the regression lines was considered to be significant when $p < 0.05$ (Glantz, 2005).

RESULTS

Out of 246 subjects where both hair iodine and whole blood iodine were analyzed (90 men, 156 women), iodine was detected in the hair of all the 246 subjects, but only in 137 of them iodine could be detected in the whole blood (about 60%). Hair iodine concentration for all the subjects (n = 246) varied over a wide range from 0.022 to 15.45 μg/g, and whole blood iodine (n = 137) varied from 0.0056 – 0.74 μg/g.

Most of the subjects (about 75%) in whom iodine was detected in both the hair and whole blood, were within the 1/4M – 4M iodine H·I and WB·I concentration «window» (Fig. 1). The power function regression analysis showed that essentially, there were no significant correlation between the hair iodine and the whole blood iodine for either men ($Y = 0.067\ X^{0.236}$, $r^2 = 0.197$) or women ($Y = 0.058\ X^{0.098}$, $r^2 = 0.020$). The respective hair and whole blood iodine common median for both genders was $H{\cdot}I_{n137} = 0.501$, $WB{\cdot}I_{n137} = 0.052$ μg/g. Separately, men and women H·I medians were 0.511 and 0.500 whereas their respective WB·I medians were 0.050 and 0.057 μg/g. Indicating that there was no gender dependent difference for both hair and whole blood iodine content.

DISCUSSION

Today, and after lot of refinement, the prevailing consensus is that trace element hair analysis is the valuable method for assessing the nutritional metabolic status and assessing toxicity in a non-invasive way (Cuttler, 2004; Wilson, 2010). It should be noted that the common hair median iodine concentration for men and women, as observed in this study ($M_0 = 0.501$ μg/g) was almost identical with the common median for men and women as observed in a previous study ($M_0 = 0.499$ μg/g) where hair iodine was analyzed in 870 apparently healthy subjects (Momčilović et al., 2012).

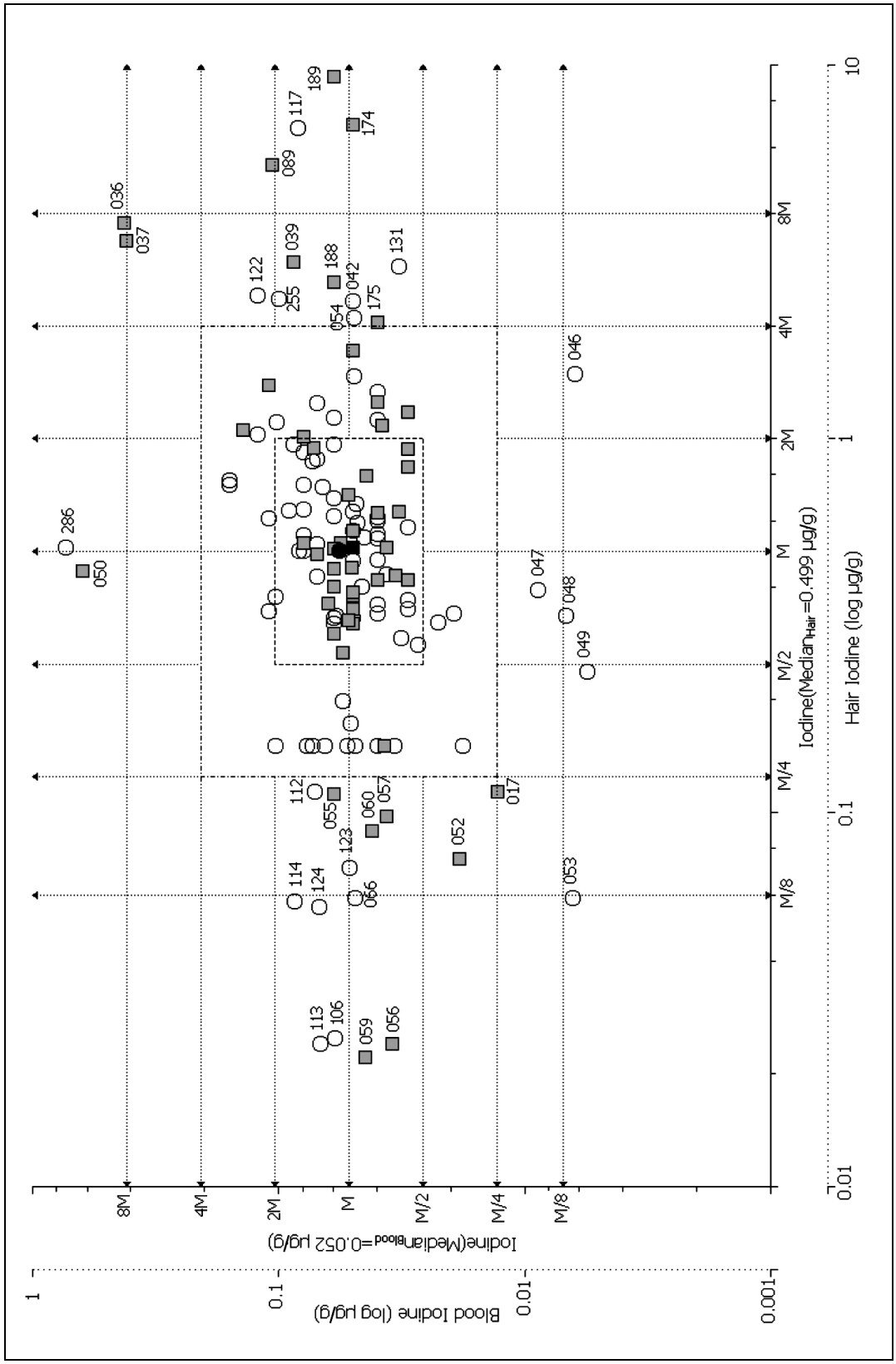

Figure 1. *The relationship between the hair Iodine (H·I) and whole blood Iodine (WB·I): ■ Men (n=51), ○ Women (n=86),*
■ Men median WB·I = 0.050 µg/g, H·I = 0.511 µg/g, ● Women median WB·I = 0.057 µg/g,
H·I = 0.500 µg/g. Note that the units on both x and y axis are expressed as in median and its derivatives. Numbers denote the subjects in the study

Usually, when writing about the hair trace element analysis and the place of hair as a biological indicator, the question arose on how did it match to some other possible biological indicator, like blood and urine? It should be noted that hair and whole blood and/or urine are two distinctly different types of biological indicator tissues. Hair is the memory tissue since the element that gets into the hair remains in there like in «the river of no return». Indeed, hair is the memory log reflecting the intermediary metabolism of any element that enters the circulation, regardless if it is homeostaticaly controlled like the essential elements, partially controlled like the conditionally essential elements, or inert or toxic like the non-essential elements, respectively. At the same time, the trace element blood and/or urine concentrations reflect the short time interval in balancing of the element between the various tissues compartments before they would be excreted from the body. This difference in time scale for different biological indicator tissue of hair *vs.* blood and/or urine readily explains why there was no correlation in the iodine content between them. The rate of the human hair cell division in the hair follicle is second only to the bone marrow cells, and what makes hair a very sensitive indicator of the cumulative long term metabolic changes of element concentration within the body (Hordinsky, 2003).

SUMMARY AND CONCLUSION

We found no commensurability between the iodine content of the hair as a long term indicator of the iodine status, and the whole blood iodine as a short to median term indicator of the iodine status. Hair appears to be a better choice of the biological indicator tissue for assessing the long term human body iodine status than the whole blood since hair sampling is noninvasive and painless, transportation and storage are simple, and the iodine content is about ten times higher in the hair than in the blood what makes the analysis more reliable.

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ETHICAL CONSIDERATIONS

This study was approved by the Ethical Committee of the Institute for the Research and Development of the Sustainable Eco Systems, Zagreb, CROATIA; the study permission was granted by the Croatian Ministry of Science, Education and Sport.

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