High hair selenium mother to fetus transfer after the Brazil nuts consumption

Momčilović, Berislav; Prejac, Juraj; Višnjević, Vjeran; Brundić, Sanja; Skalny, Andrey A.; Mimica, Ninoslav

Source / Izvornik: **Journal of Trace Elements in Medicine and Biology, 2016, 33, 110 - 113**

Journal article, Accepted version
Rad u časopisu, Završna verzija rukopisa prihvaćena za objavljivanje (postprint)

https://doi.org/10.1016/j.jtemb.2015.10.004

Momčilović B., Prejac J., Višnjević V., Brundić S., Skalny A. A., Mimica N. (2016) ***High hair selenium mother to fetus transfer after the Brazil nuts consumption.*** **Journal of Trace Elements in Medicine and Biology, 33. pp. 110-3. ISSN 0946-672X**

http://www.elsevier.com/locate/issn/0946672X

http://www.sciencedirect.com/science/journal/0946672X

http://dx.doi.org/10.1016/j.jtemb.2015.10.004

HIGH HAIR SELENIUM MOTHER TO FETUS TRANSFER AFTER THE BRAZIL NUTS CONSUMPTION

[1]Momčilović B, [2]Prejac J, [1]Višnjević V, [1]Brundić S, [3]Skalny AA, [4]Mimica N.

[1]Berislav Momčilović (Corresponding author)
Institut za istraživanje i razvoj održivih ekosustava (IRES), Srebrnjak 59, 10000 Zagreb, Croatia
phone: +385 1 2430288, e-mail: berislav.momcilovic@gmail.com

[2]Juraj Prejac
Klinički bolnički centar Zagreb, Klinika za onkologiju, Kišpatićeva 12, Zagreb, Croatia
e-mail: juraj.prejac@gmail.com

[1]Vjeran Višnjević
Institut za istraživanje i razvoj održivih ekosustava (IRES), Srebrnjak 59, 10000 Zagreb, Croatia
e-mail: vjeranv@gmail.com

[1]Sanja Brundić
Institut za istraživanje i razvoj održivih ekosustava (IRES), Srebrnjak 59, 10000 Zagreb, Croatia
e-mail: sanja.brundic@gmail.com

[3]Andrey A Skalny
ANO Center for Biotic Medicine, Zemlyanoi val 46-48, 103604 Moscow, Russia
e-mail: andrey.skalny@orc.ru

[4]Ninoslav Mimica
Klinika za psihijatriju Vrapče, Bolnička cesta 32, 10 090 Zagreb, Croatia
e-mail: ninoslav.mimica@bolnica-vrapce.hr

SHORT TITLE

Mother to baby dietary selenium transfer

SUMMARY

Lactating mother and her two month old healthy daughter (APGAR 10) gave their scalp hair for a multielement profile analysis; 25 elements were analyzed with the ICP MS. Mother's hair was divided into 5 cm long segment proximal to the scull (*Young*), and the distal segment further up to the hair tip (*Old*). One cm of hair records one month of the metabolic activity of the bioelements in the body. Mother's *Young* hair and daughters hair have 2.70 and 9.74 $\mu g \cdot g^{-1}$ Se, a distinctly higher Se concentrations than the *Old* hair of 0.87 $\mu g \cdot g^{-1}$. The adequate hair Se concentrations in Croatia women population vary from 0.08 to 0.63 $\mu g \cdot g^{-1}$; values below or above that range indicate deficiency or excess, respectively. Dietary recall revealed that during the last trimester of pregnancy and over a period of a week, the mother has consumed 135 g of Brazil nuts (*Bertholletia excelsa*) (BN); BN is an exceptionally rich Se dietary source. The amount of Se in BN varies and one week consumption of 135 g of BN may result in Se daily intake of 367 to 492 $\mu g \cdot g^{-1} \cdot d^{-1}$ over a period of seven consecutive days, and what is about or exceeds the Upper Limit of daily selenium intake of 400 $\mu g^{-1} \cdot g^{-1}$. The excessively high infant hair Se mirrored a natural high mother to fetus transplacental transfer of bio elements in the last trimester of pregnancy. The potential toxicological risks of such a high Se transfer remains to be elucidated.

KEY WORDS

Hair Se; Brazil nuts; pregnancy; lactation; transplacental Se transfer; fetus/infant

INTRODUCTION

Selenium is an essential trace element indispensable for life [1]. The daily selenium requirements are well defined for adult persons, however, infant selenium requirements are the subject of expert consensus based on selenium in milk concentrations [2, 3].

This paper is about an unusual observation which caught our attention. Lactating mother and her two months old breastfed baby gave their hair for a mutielement profile analysis. Mother's scalp hair proximal to the skull, i.e, *Young* hair, contained three times more selenium than the distal part of the same hair sample (*Old* hair); also her two months old daughter has even the higher excessive hair Se. Evidently, substantial amounts of dietary selenium may be transferred *via* placenta from mother to fetus hair during pregnancy. This observation initiated our thorough dietary history recall of mother's nutrition with the aim to elucidate this unusual finding along the same thread of hair.

SUBJECT (MOTHER AND DAUGHTER)

On April 12, 2014 a young 30-year old healthy white Caucasian woman (♀SB, 63 kg, 175 cm), Zagreb, Croatia, gave a natural birth to her healthy first baby daughter (♀KBM, birth weight 2670 g, birth length 46 cm, APGAR 10). Two months later, both mother and daughter gave their hair for hair multielement profile analysis; the informed consent was given by the mother. Mother's long hair has been divided into two parts: (A-Proximal, *Young*) some five cm up from the *protuberantia occipitalis externa* on the skull, and (B-Distal, *Old*) involving the rest of the hair up to the hair tips. Thus, Part A represents the younger hair whereas the Part B represents the older hair. Twenty-five elements were analyzed with the ICP-MS in every hair sample (the essential elements are underlined - Al, As, B, Be, <u>Ca</u>, Cd, <u>Co</u>, <u>Cr</u>, <u>Cu</u>, <u>Fe</u>, Hg, <u>I</u>, <u>K</u>, Li, <u>Mg</u>, <u>Mn</u>, <u>Na</u>, <u>Ni</u>, <u>P</u>, Pb, <u>Se</u>, <u>Si</u>, Sn, <u>V</u>, <u>Zn</u>), at the Center for Biotic Medicine, Moscow, Russia. CBM is an ISO Europe certified commercial laboratory for analyzing bioelements (major and trace and ultratrace elements) in different biological matrices, as described in full detail earlier [4]. In brief, hair analysis was performed following the International Atomic Energy Agency recommendations [5] and other validated analytical methods and procedures [6]. Approximately 0.5-1.0 g of the hair was cut off from the occipital head region above the *protuberantia occipitalis externa* and stored in numbered envelopes and kept refrigerated at 4°C before they were randomly assigned for analysis. The individual hair samples were cut prior to chemical analysis to be less han 1 cm long, stirred 10 min in an ethylether/acetone (3:1, w/w), rinsed three times with the redistilled H_2O, dried at 85°C for one hour to constant weight, immersed one hour in 5% EDTA, rinsed again in the redistilled H_2O, dried at 85°C for twelve hours, wet digested in HNO_3/H_2O_2 in a plastic tube, and sonicated. The samples were analyzed for their element contents by the inductively coupled plasma mass spectrometry (ICP MS)(Elan 9000, Perkin Elmer, USA). All chemicals were proanalysis grade (Khimmed Sintez, Moscow, Russia). We used certified GBW0910b Human Hair Reference Material (Shanghai Institute for Nuclear Research, Academia Sinica, Shanghai 201849, China)(CV [SD/Mean] 0.077) [7].

Our adequate hair selenium reference values for women are 0.08 to 0.63 $\mu g \cdot g^{-1}$ [8]. Values below or above this range are considered to indicate selenium deficiency or excess, respectively; our detection limit for Se is 0.026 $\mu g \cdot g^{-1}$.

Selenium belongs to the pleiad of 124 elements sharing the same mass number (number of isotopes/elements): 4 Zn, 7 Ga, 13 Ge, 16 As, 22 Se, 18 Br, 17 Kr, 11 Rb, 10 Sr, 6 Y, and 1 Zr [9].

RESULTS AND DISCUSSION

The highlights of the hair multielement profile analysis are shown in Table 1. Immediately, our attention was directed to the fact that selenium concentrations were quite different in Part A and Part B of the same thread of mother's hair and exceptionally high in the hair of her daughter. Indeed, the Se concentrations of 0.870 $\mu g \cdot g^{-1}$ in the mother's hair Part B-Distal, *Old,* were close to the expected adequate selenium status of the body [10]; however, the Se concentrations in Part A-Proximal, *Young* of the mother's hair were 2.70 $\mu g \cdot g^{-1}$ and 9.74 $\mu g \cdot g^{-1}$ in her daughter's hair, respectively. Adequate hair selenium concentrations of Croatian women population range from 0.08-0.63 $\mu g \cdot g^{-1}$, Median 0.266 $\mu g \cdot g^{-1}$ [8]; these hair selenium values are in good agreement with the reported values by the other authors [11, 12, 13]. Since Ms. ♀SB denied using any selenium containing supplements, ointment and/or shampoos, this observation initiated an extensive dietary recall task of what she was eating in the apparently last trimester of her pregnancy. Indeed, approximately 5 cm long hair sample would cover a period of about five months, i.e., in this particular case three months of pregnancy and two months of lactation. She regularly consumed just the usual mixed Mid European diet. Ultimately, we discovered that somewhere around her third trimester of pregnancy Ms. SB consumed a single pack of Brazil nuts

(*Bertholletia excelsa*) weighing about 135 g. Brazil nuts (BN) happen to be notorious for their exceptionally high selenium content of 2.550 $\mu g \cdot g^{-1}$ Se! This is a 3643% of a daily value recommended for this element [3, 14]. The amount of Se in BN varies and one week consumption of 135 g of BN may result in Se daily intake of 367 to 492 $\mu g \cdot g^{-1} \cdot d^{-1}$ over a period of seven consecutive days, and what is about, or exceeds, the Upper Limit of daily selenium intake of 400 $\mu g^{-1} \cdot g^{-1}$ [15]. Recently, the potential role of Brazil nuts for human selenium supplementation also has been recognized [16, 17, 18].

Hair is growing at approximately 1 cm per month [19, 20] so that the 5 cm long segment of mother's (Ms. ♀SB) hair, would cover the time period from the third trimester of pregnancy till the end of the second month of lactation. According to this data of hair growth, the inadvertent exposure occurred in the last trimester of pregnancy and this event could be followed in the early lactation. Evidently, the mother can get her selenium from the diet whereas the fetus and breastfed infant can get it only from the mother.

For the first time, to our knowledge, it became possible to see what was an *in vivo* bioelement metabolism at the late stage of pregnancy and early stage of lactation. It should be noted that the absorption of many bioelements is also increased during the late stages of pregnancy. Indeed, infant period of life is characterized by substantially higher absorption of elements than it is later in the adult life [21]. Ward and Ward (1991) also found scalp hair selenium concentrations to be increased in children (Mean, Range; 1.18, 0.31-1.98 $\mu g \cdot g^{-1}$) and what is still far below the hair selenium of here reported infant hair selenium of 9.74 $\mu g \cdot g^{-1}$ [22].

Evidently, high pregnancy (third trimester) put a high toll upon mother to provide her baby with all the essential nutrients. All the elements in mother's hair, except boron and phosphorus, appeared to be increased after the termination of pregnancy, indicating that the fetal body growth put huge metabolic demands upon the mother's body in the later two months of lactation when the infant girl ♀KBM was exclusively breastfed (Table 1). The excessively high values of mother hair calcium are likely to indicate the massive calcium transfer from mother to infant by placenta and later by the mammary gland. The results showed that mother's iron status was low in both pregnancy and lactation, and it is unknown if such an imbalance may have an effect on other element transfers from mother to the fetus. Our results corroborate with the traditional pediatrician views that baby nutritional needs have a precedence over the mother's body nutritional requirements [23]. Indeed, hair iron concentrations in the infant were in the observed normal adult iron range whereas those of the mother were definitively low (see Table 1 for reference values). Also, this infant has a much better iodine status than her mother [10]. Although the mother was receiving Se at about Upper Limit (on average) of selenium day after day for seven consecutive days, a healthy infant of low birth weight [24] was born.

CONCLUSION

The hair multielement profile analysis has passed a long way to get established as a reliable and reproducible analytical tool [25, 26, 27]. The here presented results of a naturally occurring experiment provides an insight in selenium metabolism in pregnancy, lactation, and neonatal periods of life. Very high amounts of Se were absorbed by the pregnant mother and transferred via placenta into the infant. Hair multielement profile analysis offers a new possibility for the study of the trace element metabolism in gestation, lactation and the infant periods of life in a non-invasive way and in full compliance with the current ethical considerations [28]. Indeed, we suggest that the metabolism of bioelements need to be studied in their mutual and contextual relationships and not in isolation. Also, here presented data may be considered as an invitation for necessary future research and validation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The first author would like to thank RCM, Isle of Man, UK for a philanthropic support. We also wish to thank Prof. David F. Marshall, UND, ND, USA for his English language editing.

REFERENCES

[1] Schrauzer GN. Selenium. In: Merian E, Anke M, Ihnhat M, Stoeppler M, editors. Elements and their Compounds in the Environment, 2nd Edition. Wiley-VCH, Weinheim, Germany, 2008;1365-1406.

[2] Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington DC, The National Academy Press, 2000.

[3] National Institutes of Health. Office of Dietary Supplements. Selenium: Dietary Supplement Fact Sheet. http://ods.od.nih.gov/factsheets/Selenium-HealthProfessional/. Accessed 10 July 2015.

[4] Momčilović B, Morović J, Ivičić N, Skalny AV. Hair and blood multielement profile for metabolic imaging of the major unipolar depression, Study rationale and design. Trace Elements in Medicine (Moscow) 2006;7(4):35-42.

[5] IAEA. Elemental analysis of biological materials, IAEA-TEC DOC 197. Vienna, Austria: International Atomic Energy Agency; 1980.

[6] Burges C. Valid analytical methods and procedures. Cambridge, UK: The Royal Society of Chemistry; 2000.

[7] Momčilović B, Prejac J, Ivičić N. A case report on analytical reproducibility of the human multielement profile. A two years follow up. Trace Elements in Medicine (Moscow) 2009;10 (1-2):33-38.

[8] Momčilović B, Prejac J, Višnjević V, Skalny AA, Drmić S, Mimica N. A novel concept to assess the human iodine and selenium nutritional status by analyzing their frequency distribution properties in the hair. Trace Elements in Men and Animals (TEMA 15), Orlando, Florida, USA 2014;June 22-26, Abstract Book, p. 79.

[9] Momčilović B, Prejac J, Momčilović R, Ivičić N, Veber D, Lykken GI. On the same element isotope mass number (Pleiad) and the clusters of elements bearing the same mass numbers in the Periodic system – the "chesshyja" (fish skin) model. Trace Elements in Medicine (Moscow) 2008;9(3-4):5-20.

[10] Momčilović B, Prejac J, Višnjević V, Skalnaya MG, Mimica N, Drmić S, Skalny AV. Hair iodine for human iodine status assessment. Thyroid 2014;24:1018-1026.

[11] Iyengar GV. Normal values for the elemental composition of human tissues and body fluids – New look at an old problem. Trace Elements in Environmental Health 1985;29:277-291.

[12] Goulle J-P, Mahieu LO, Castermant J, Neveu NH, Bonneau, Laine G, Bouige D, Lacroix C. Metal and metalloid multi-elementary ICP MS validation in whole blood, plasma, urine and hair Reference values. Forensic Science International 2005;153:39-44.

[13] Wolowiec P, Michalak I, Chojnacka C, Mikulewicz. Hair analysis in health assessment. Clinica Chimica Acta 2013;419:139-171.

[14] SELFNutritionData. Nutrition facts for Brazil nuts, dried, unbalanced, 100 g serving. Conde Nast, US Department of Agriculture National Nutrient Database 2014. http://nutritiondata.self.com/facts/nut-and-seed-products/3091/2. Accessed 16 March 2015.

[15] Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoides. Washington DC, The National Academy Press; 2000.

[16] Colpo E, Vilanova CD, Brenner Reetz LG, Medeiros Frescura Duarte MM, Farias IL, Irineu Muller E, Muller AL, Moraes Flores EM, Wagner R, da Rocha JB. A single consumption of high amounts of the Brazil nuts improves lipid profile of healthy volunteers. Journal of Nutrition and Metabolism 2013;2013:653185.

[17] Thompson CD, Chisholm A, McLachlan SK, Campbell JM. Brazil nuts: an effective way to improve selenium status. The American Journal of Clinical Nutrition 2008;87:379-84.

[18] Rita Cardoso B, Apolinário D, da Silva Bandeira V, Busse AL, Magaldi RM, Jacob-Filho W, Cozzolino SM. Effects of Brazil nut consumption on selenium status and cognitive performance in older adults with mild cognitive impairment: a randomized controlled pilot trial. European Journal of Nutrition 2015 Jan 8. [Epub ahead of print] doi: 10.1007/s00394-014-0829-2

[19] Rook A, Dawber R. Diseases of hair and scalp. Blackwell Sci Publ, Oxford; 1982.

[20] Robbins CR. Chemical and physical behavior of human hair, 5th ed. Springer, Berlin; 2012.

[21] Kostial K, Blanuša M, Maljković T, Kargačin B, Piasek M, Momčilović B, Kello D. Age and sex influence the metabolism and toxicity of metals. In: Trace Elements in Man and Animals 7 (TEMA 7), Momčilović B, editor. Institute for Medical Research and Occupational Health, Zagreb, Croatia; 1991, 11.1 - 11.5.

[22] Ward NJ, Ward AE. Element content of children's scalp hair and saliva in assessing reading development. In: Trace Elements in Man and Animals 7 (TEMA 7), Momčilović B, editor. Institute for Medical Research and Occupational Health, Zagreb, Croatia; 1991, 28.4 - 29.5.

[23] Kliegman RM, Stanton BMD, Geme JSt, Schor NF, Behrman RE. Nelson textbook of pediatrics, 19th edn. Saunders, Philadelphia, PA; 2012.

[24] Geigy JR SA. Documenta Geigy: Scientific tables, 5th ed. CIBA Geigy, Basle; 1956.

[25] Caroli S, Almonti A, Coni E, Petrucci F, Sanfonte O, Violante N. The assessment of reference values for elements in human biological tissues and fluids: A systematic review. Critical Reviews in Analytical Chemistry 1994;24:363-398.

[26] Druyan ME, Bass D, Puchyr R, Urek K, Quig D, Harmon E, Marquardt W. Determination of reference ranges for elements in human scalp hair. Biological Trace Elements Research 1998;62:185-197.

[27] Bass D, Hickok D, Quig D, Urek K. Trace element analysis in hair: facts determining accuracy, precision, and reliability. Alternative Medical Reviews 2001;6:472-481.

[28] Esteban M, Castaño A. Non-invasive matrices in human biomonitoring: a review. Environment International 2009;35:438-449.

[29] Momčilović B, Prejac J, Višnjević V, Skalnaya MG, Drmić S, Mimica N, Brundić S, Skalny AV. Gender dependent differences in hair calcium, potassium, magnesium, sodium, phosphorus and zinc. 5th International Symposium of the Federation of European Societies on Trace Elements and Minerals (FESTEM 5), Avignon, France, 2013;May 22-24. Poster 1-22.

[30] Prejac J, Višnjević V, Drmić S, Skalny AA, Mimica N, Momčilović B. A novel concept to derive iodine status of human population from frequency distribution properties of a hair iodine concentration. Journal of Trace Elements in Medicine and Biology 2014;28:205-211.

[31] Momčilović B, Prejac J, Višnjević V, Mimica N, Skalny AV. Hair as a novel long term biological indicator for assessing the human Na and K nutritional status. Experimental Biology 2015, Annual Meeting. Boston, MA, USA, 2015;March 28-April 1. Poster C189.

Table 1. Hair multielement profile changes in a pregnant/lactating woman and her daughter two months after delivery. High dietary intake of selenium from Brazil Nuts (*Bertholletia excelsa*) has occurred in the last trimester of pregnancy. Mean of the 2 replicates ($\mu g \cdot g^{-1}$).

Before the *Brazil Nuts*		After the *Brazil Nuts were consumed in the third trimester of pregnancy*[a]			
Pregnant Mother (Hair B-Distal)		Lactating Mother (Hair A-Proximal)		Daughter	
☐ Deficiency ■ Excess [(b)]					
B	0.37	B	0.36	B	5.35 ■
Ca	658	Ca	2838 ■	Ca	690
Co	0.004 ☐	Co	0.007	Co	0.01
Cr	0.020 ☐	Cr	0.04	Cr	0.11
Fe	5.25 ☐	Fe	5.82 ☐	Fe	15.12
I	0.30 ☐	I	0.57	I	3.53
K	74.13 ☐	K	90.67	K	3359
Li	0.005	Li	0.01	Li	0.22 ■
Mg	63.63	Mg	166	Mg	70.05
Mn	0.05 ☐	Mn	0.06 ☐	Mn	0.48
Na	14.74 ☐	Na	20.94 ☐	Na	881
P	154	P	144	P	186
Se	0.87	Se	2.70 ■	Se	9.74 ■
V	0.003 ☐	V	0.005 ☐	V	0.01

[a]Time line (1 cm hair = 1 month) indicates that high dietary selenium was onsumed five month before hair was sampled at two months after the delivery. [b]Adequate hair reference ranges ($\mu g \cdot g^{-1}$): // Ca ♀ 290-4400, Mg ♀ 40-450 [29]; // I ♀ 0.15 – 2.06, Se ♀ 0.08 – 0.63 [8, 30]; // P ♂♀ 120-200 [14]; // K ♀ 20-500, Na ♀ 60-1400 [31] // CBM reference values for women: B (0.00-5.00), Co (0.006-0.200), Cr (0.15-1.00), Fe (10.0-50.0), Li (0.005-1.00), Mn (0.25-1.80), V (0.00-0.10) [4].