成人與嬰兒之汞、硒、鉛暴露動力學與健康風險分析

Exposure kinetics and health risk analysis for mercury, selenium, and lead in adults and infants

中文摘要

本研究採用問卷調查及樣本分析，利用數學模式進行健康風險分析，評估不同族群汞、硒、鉛之體內負荷。2000 年至 2004 年分別收集魚市、漁港及沿海地區的海產樣本分析魚體肌肉汞、硒濃度，魚類汞濃度範圍(濕重)：0.005-0.858 g/g (n=199)、貝類濃度範圍(濕重)：0.021-0.363 g/g (n=16)、蝦蟹類濃度範圍(濕重)：0.004-0.035 g/g (n=17)。海產硒濃度範圍(濕重)：0.63-2.01 g/g。本研究亦利用魚貝類的汞、硒濃度推估一般民眾及嗜吃魚貝者的汞暴露量及每日硒攝取量，利用蒙地卡羅模式進行汞暴露量之不確定與敏感度分析，以美國毒物和疾病登記署(Agency for Toxic Substances and Disease Registry, ATSDR)的最小風險值(minimal risk levels) 0.5 g/kg/day 作爲標準時，一般民眾的男性和女性僅有1.3%和 2.1%超過，而嗜吃魚貝者的男性及女性則有 7.1%和 9.1%超過此值，一般民眾及嗜吃魚貝者的每日硒攝取量分別爲 60.2 和 145.2 g/day，總汞暴露量中魚汞濃度及魚攝取量是主要影響因子，同時也是硒的重要貢獻來源，根據美國環保署(United States Environmental Protection Agency)的參考劑量(reference dose) 0.1 g/kg/day 估算，建議 8 歲以下的孩童魚食用量應低於 50 g/day，19-44 歲的育齡婦女建議魚食用量爲 90.8±15.7 g/day，若僅食用旗魚和鯊魚等掠食性魚類則食用量更需低於 10 g/day。

母乳幾何平均汞濃度在都會區婦女爲 2.03±2.12 g/L，漁民婦女爲 2.04±3.14 g/L，若母乳中甲基汞含量爲 50 %時，都會區的男嬰有 12.9%機率危害商數大於1，漁民男嬰則有 18.8%的機率危害商數會大於 1，可能會有神經發展和免疫系統的潛在威脅。在影響男嬰神經發展和免疫系統危害指標之參數敏感度分析結果發現母乳汞濃度是造成嬰兒體內甲基汞暴露的主要來源，比例爲 97.9%和 99.1%。母乳幾何平均硒濃度都會區婦女爲 22.3±10.2 g/L、漁民婦女爲 24.8±4.8 g/L，根據 2000 年美國飲食建議量(recommended dietary allowances, RDA) 0-6 月嬰兒硒爲 15 g/day 的標準來看，本研究的嬰兒個案中有 80.4%未達到建議量。在另一個研究的 72 位婦女其母乳幾何平均鉛濃度在服用中草藥組爲 8.59±10.95 g/L 顯著高於未服用中草藥組 6.84±2.68 g/L ($p < 0.05$)，推估嬰兒每日鉛攝取量與危害指標(hazard index, HI)，結果顯示母親服用中草藥組有 5.7% (2/35, HI = 2.57, 2.25)嬰兒的危害指數超過 1，表示嬰兒在攝取初乳時可能具有潛在的健康風險，建議應監測母乳鉛濃度避免嬰兒暴露過量的鉛。

英文摘要

This study was designed to predict the body burden of mercury, selenium, and lead

in adults and infants by using the mathematic models. Samples involved three subgroups, including fish, crustaceans, and bivalve molluscs were obtained from 2000 to 2004 at fish markets, seaports, and marine coastal areas of Taiwan. Mercury concentrations in fish ranged from 0.005 to 0.858 g/g wet wt (n=199), the range for bivalve molluscs was 0.021-0.363 g/g wet wt (n=16), and the concentration in crustaceans was 0.004-0.035 g/g wet wt (n=17). In general, selenium concentrations ranged from 0.63 to 2.01 g/g wet wt. The daily selenium intakes resulting from a high-seafood diet and an average diet were 145.2 and 60.2 g/day, respectively.

From the Monte Carlo simulation, approximately 1.3-2.1% (general population) and 7.1-9.1% (heavy seafood consumers) of the simulated results exceeded ATSDR's minimal risk level (0.5 g/kg/day). We recommend that young child under eight-year-old and women of childbearing age eat up to 50 g/day and 90.8 g/day of a variety of fish in Taiwan, based on the EPA's reference dose (0.1 g/kg/day). For the general population consume relatively small quantities (< 10 g/day) of a number of the larger predatory fish species, such as swordfish and shark. We applied Monte Carlo simulations to the sensitivity analysis, which showed that the mercury concentrations in fish, and consumption rate for fish were major determinants of mercury exposure to humans.

The concentrations of mercury in the breast milk of the metropolitan women and the fisherman's women were 2.03± 2.12 g/L and 2.04± 3.14 g/L, respectively. If methylmercury forms accounted for about 50% of total mercury, in total, 12.9 % and 18.8% of the hazard quotient estimates exceed 1.0 for the metropolitan and the fisherman's baby. Note that a hazard index exceeding 1.0 indicates that infant consuming breast milk has a potential health risk, such as neurological development and immunological effects. The concentrations of selenium in the breast milk of the metropolitan women and the fisherman's women were 22.3± 10.2 g/L and 24.8± 4.8 g/L, respectively. In our study, the daily selenium intake from breast milk approximately 80.4% infants is under than the USRDA of 15 g/day. The geometric mean of lead concentrations in all colostrum samples (n=72) was 7.68± 8.24 g/L. The concentration of lead in the breast milk of the consumption group (the mothers who consumed traditional Chinese herbs) was 8.59± 10.95 g/L, a level significantly higher than the level of 6.84± 2.68 g/L found in the control group (mothers who did not consume traditional Chinese herbs). We used an estimation of the hazard index (HI) to analyze the health risk of infants. In total, 5.7 % (2 out of 35) of the HI estimates exceed 1.0 for the consumption group. In conclusion, the consumptions of traditional Chinese herbs by the mothers in this study significantly affected the body burden of lead in their infants.