The Role of Food Habits in Internal Manganese Exposure of Preadolescents in an Industrialized Area of Northern Italy

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Background:

Manganese (Mn) is a nutritionally essential trace mineral, which at high levels of exposure can become neurotoxic [23]. This study investigated the relationship between dietary Mn intake and overall Mn exposure among individuals across three separate areas in the Lombardy region of northern Italy, including Garda Lake (GL), Valcamonica (VC), and Bagnolo Mella (BM). Both VC and BM show high industrial pollutant exposure as a result of historical ties to the ferroalloy industry.

Methods:

This study estimated overall Mn exposure through analyses of biomarkers in blood, saliva, hair, urine, and nails from a population of 341 children (ages 11-14). Dietary Mn intake was determined through the analysis of a food frequency questionnaire (FFQ) administered to the parents of each child. Individual dietary Mn intake was calculated using the Food Composition Database for Epidemiological Studies in Italy (BDA) as well as the United States Department of Agriculture (USDA). A descriptive statistical analysis as well as correlations between dietary Mn intake and biomarkers of exposure were performed. This study analyzed Mn dietary intake by region and by split region, across/between high consumers of Mn (above 3 ug/day) and low consumers of Mn (below 3 ug/day).

Results:

Median (Med) daily dietary Mn intake levels, as estimated through the FFQ, were 2.107 (interquartile range – IQR: 1.632 – 2.656), 2.128 (IQR: 1.609 – 2.88), and 2.415 (IQR: 1.856 – 3.048) ug/day for BM, GL, and VC respectively. Mn-rich foods constituted a greater proportion of the individual diets in VC compared with those in BM and GL, notably driven by increased consumption of legumes and white bread. There appeared to be positive relationships between dietary Mn intake and internal Mn exposure as described by hair, saliva, and nail Mn levels. Notably, the strongest correlation of these biomarkers was between dietary Mn intake and levels of salivary Mn. Individuals with a dietary Mn intake above 3.0 ug/day in VC and BM, have greater salivary and hair Mn levels than individuals in their respective areas who consume below 3.0 ug/day, suggesting that diet may contribute to internal Mn exposure especially in a polluted area.

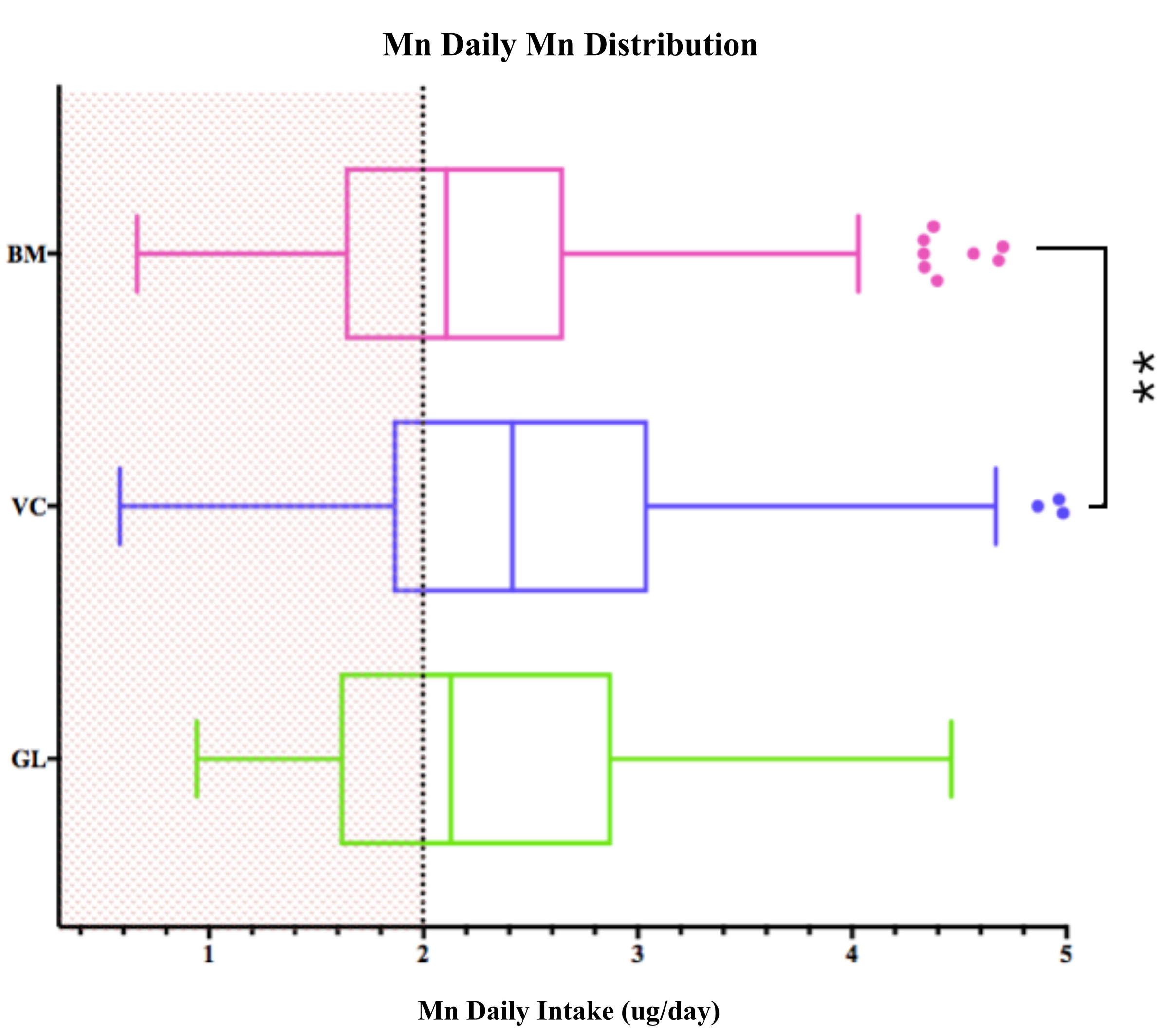

Figure 1. Mn daily intake by area of residence. Recommended Mn daily intake is 2 to 6 ug/day.

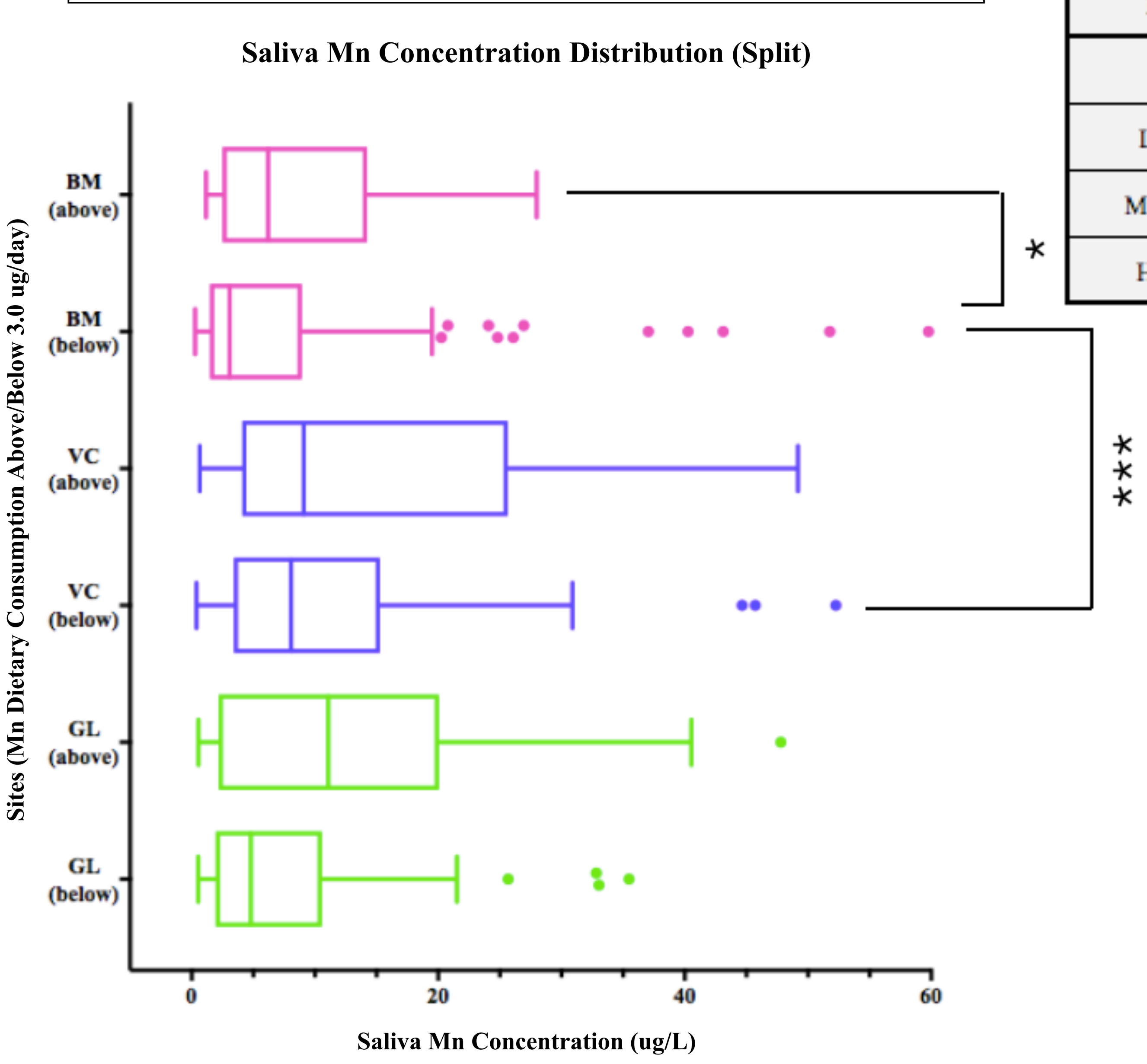

Figure 2. Saliva Mn concentration by area of residence and Mn consumption above or below 3 ug/day. (left)

Demographics			
	Garda Lake	Valcamonica	Bagnolo Mela
N Subjects	80	95	177
Sex (n)			
Male	42 (47.5%)	54 (43.2%)	88 (50.3%)
Female	38 (52.5%)	41 (56.8%)	89 (49.7%)
Age (Year)			
Mean (SD)	12.3 (±0.9)	12.3 (±1.0)	12.3 (±1.0)
Weight (kg)			
Mean (SD)	51.2 (±12.5)	51.4 (±11.9)	50.8 (±12.5)
Height (cm)			
Mean (SD)	157.3 (±8.2)	157.9 (±8.6)	157.1 (±9.0)
BMI (Kg/m2)			
Mean (SD)	20.7 (±3.9)	20.5 (±4.0)	20.5 (±3.8)
BMI Percentile (%)			
Mean (SD)	63.4 (±27.5)	61.6 (±29.1)	62.2 (±28.5)
SES (n)			
Low Income	8 (10.5%)	22 (23.7%)	36 (21.2%)
Middle Income	45 (59.2%)	47 (50.5%)	94 (55.3%)
High Income	23 (30.3%)	24 (25.8%)	40 (23.5%)

Table 1. Demographics by area of residence. (above)

Table 2. Linear mixed model. (right)

Testing the association between the Mn intake and biomarkers grouped together, a linear mixed model considered the biomarkers as a grouped dependent variable accounting for the non-independence of the repeated measures within the same subject. A new independent variable was designed to identify the interaction between the five biomarkers and dietary Mn intake.

Figure 2 Description:

When comparing groups who consume more/less than 3 ug Mn/day, increased consumption (above 3 ug/day) seems to result in higher levels of overall Mn exposure based on Mn levels in hair and saliva.

Linear Mixed Model	
Dependent Variable: Blood, urine, hair, nails, and saliva Mn concentration	
Independent Variable	**Mn daily intake**
GL vs BM	-0.224*** (-0.354, -0.094)
VC vs BM	0.169** (0.044, 0.294)
Mn Daily Intake X Saliva vs. Blood Mn	0.619*** (0.288, 0.949)
Mn Daily Intake X Hair vs. Blood Mn	0.305 (-0.027, 0.637)
Mn Daily Intake X Nails vs. Blood Mn	0.273 (-0.066, 0.612)
Mn Daily Intake X Uring vs. Blood Mn	-0.03 (-0.369, 0.309)
Male vs Female	0.08 (-0.023, 0.184)
Age	0.154*** (0.101, 0.207)
SES Med vs Low	0.0005 (-0.154, 0.155)
SES High vs Low	0.023 (-0.099, 0.144)
Saliva vs Blood Mn	-1.203*** (-1.503, -0.902)
Hair vs Blood Mn	-5.228 (-5.531, -4.925)
Nails vs Blood Mn	-4.135 (-4.444, -3.827)
Urine vs Blood Mn	-3.708 (-4.017, 3.399)
Mn Daily Intake	-0.063 (-0.302, 0.176)

*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

Conclusion:

These data support a correlation between dietary manganese intake and overall manganese exposure. This suggests a more sensitive and individualistic approach when recommending diet type and supplementation use. The importance of these results highlights the overall lack of research regarding Mn ingestion and internal exposure and the necessary consideration of dietary Mn ingestion, a form of Mn exposure, with other Mn portals of entry. These results lay the groundwork for innovative education methods and public health initiatives for Italian populations based near areas exposed to industrial.

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