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学龄前儿童体内铅水平及其营养干预的效应*

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提 要 目的: 探讨生活在重庆城区学龄前儿童铅的暴露程度和营养干预能否减轻铅的危害。方法: 重庆市城区相同年龄段(6~7岁)学龄前儿童240名,男、女各半,观察儿童血铅、发铅含量及与生长发育的关系;同时将秋季120名受试儿童随机分为3组,即补锌组、锌+复合微量营养素组和单纯补充微量营养素组,进而研究营养干预对儿童体内铅水平的影响,实验采用双盲法,实验周期为10周。结果: 以推荐的0.483μmol/L为全血铅可接受上限值,则春季有50.9%(平均0.483μmol/L)儿童,秋季有高达81.66%(平均为0.650μmol/L)儿童血铅浓度超过标准,发铅的测定也显示相似结果。给学龄前儿童补锌或改善其营养状况,能有效降低血铅、发铅浓度,促进儿童生长发育,其中尤以在补锌的同时再服用铜、锰、硒、叶酸等多种微量营养素效果更为明显。结论: 生活在重庆闹市区的学龄前儿童受到的铅污染已相当严重,给学龄前儿童补锌或多种微量营养素能有效降低其体内铅的含量,促进儿童生长发育。

关键词 锌;复合微量营养素;儿童;铅

中图法分类号 R153.2

铅(Pb)是广泛存在于环境中的一种有毒重金属,发育中的神经系统对 Pb毒性尤为敏感,处于生长发育时期的儿童接触过量 Pb不但可导致发育迟缓,而且可以造成器官功能的异常[1]。近来有研究显示,血铅浓度升高与儿童生长迟缓有一定关系,全血铅浓度在(0.135~1.863)μmol/L范围时与5~12岁儿童身高呈负相关。另外低剂量铅暴露可损害儿童智力发育,乳牙中铅增高,平均智商(IQ值)降低[2]。现发现营养不良时动物对铅毒性作用的敏感性提高,锌缺乏实验动物肠道对铅吸收增加,长期铅暴露环境作业的工人,血铅含量升高至一定水平后可使血中铁、锌、溴、铷等元素含量改变,以上研究提示营养不良或锌缺乏可加重铅的危害,铅、锌可能存在相互拮抗效应,推测补充锌或改善机体营养状况可降低血铅浓度及其危害。重庆市是西南地区的最大工业重镇,同时也是全国受污染最严重的城市之一,随着工业化进程加快,铅污染所带来的危害日趋突出。本研究旨在对生活在重庆闹市区的学龄前儿童的铅污染状况作出评估,同时初步观察营养干预能否降低铅的危害。

1 对象与方法

1.1 观察对象

选择重庆市城区学龄前儿童240名,年龄6~7岁,男女各半,受试儿童无不良嗜好,其生活及学习的周围环境与公路毗邻,但无明显的铅污染源,家庭成员中也无从事铅污染工作者。本次调查观察了一年中春、秋两个季节血铅、发铅含量(每个季节120名儿童),同时对秋季120名受试儿童进行了营养干预实验。干预实验开始前须对受试儿童进行全面体检,排除患先天性及急、慢性疾病者。上述120名儿童随机分为3组:① 补锌组(Zn),每人每日补充锌16 mg;② 锌+复合微量营养素组(ZnM),除补充16 mg锌外,尚需同时补充多种微量营养素见表1;③ 复合微量营养素组(M),单纯补充微量营养素。各组补充的营养素均压制成相似的营养片剂(由 Sandstead教授提供),实验采用双盲法,每组制剂由学前班老师每日分发给受试儿童,并指导定时服下,实验期为10周。

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表1 复合微量营养素配方

Tab 1 Composition of micronutrients

Ingredients	Content	Ingredients	Content
Copper	1 mg	Phytonadione	20μg
Selenium	20μg	a-Tocopherol	7 mg
Iodine	90μg	Thiamine	0.9 mg
Floride	1 mg	Pyridoxine	1.1 mg
Manganese	1.5 mg	Rboflavin	1.1 mg
Molybdenim	30μg	Niacin	12 mg
Chromium	30μg	Folic Acid	35μg
Retinol	2500 IU	Cyanocobalamin	1μg
Cholecalciterol	400 IU		

1.2 检测指标及方法

1.2.1 全血铅及血清锌含量测定 实验前、后分别抽取受试儿童空腹静脉血,用美国 IL-AA 951型原子吸收分光光度计测定全血铅 (B-Pb,以μmol/L表示)及血清锌 (S-Zn,以μmol/L表示)含量[3]。

1.2.2 头发铅及锌含量测定 取枕后部近头皮处头发少许,经硝化处理后,同样用原子吸收分光光度计测定发铅,发锌含量(分别简写 H-Pb、H-Zn,均以μg/g表示)。

1.2.3 膝高 (Knee height, KH)测定 采用美国公司生产的膝高测度仪(Knee Height Measure Device, KHMD)测定(该仪器由 Sandstead教授提供)。

1.2.4 数据统计处理方法 采用 SPLM统计程序对测定结果进行统计处理。

2 结果

2.1 学龄前儿童血铅和发铅含量见表2

表2 学龄前儿童血铅及发铅含量

Tab 2 Contents of blood lead and hair lead in pre-school children

Time	Blood lead contents (c_B/μmol·L^{-1})			Hair lead contents (w_B/μg·g^{-1})		
	H-Pb	95% reliable range	≥0.483 (%)	H-Pb	95% reliable range	≥10 (%)
Spring	0.483 (107)	0.459~0.511	50.90	2.432 (98)	2.292~2.858	5.00
Fall	0.650 (109)	0.628~0.728	81.66	7.180 (89)	6.694~7.908	33.63

Note: The results are expressed by using Median for the divergent distribution of the data

由表2显示,秋季学龄前儿童血铅及发铅水平均明显高于春季儿童,若以血铅浓度0.483μmol/L为可接受上限值,则秋季有81.66%儿童血铅超标,春季为50.90%。

2.2 血铅、发铅与儿童生长发育的关系见表3

表3 儿童膝高 (KH)和身高 (HT)

Tab 3 The values of knee height and height

Time	n	KH (mm)	HT (cm)
Spring	120	339.864±18.429	116.57±7.96
Fall	120	326.178±16.721*	112.07±6.21*

*: $P<0.05$ *vs* spring

表3为春、秋两季节儿童膝高及身高值,相关分析显示,儿童血铅、发铅含量与膝高呈显著负相关(相关系数分别为-0.764、-0.616)。

2.3 营养干预对血铅、发铅含量的影响见表4

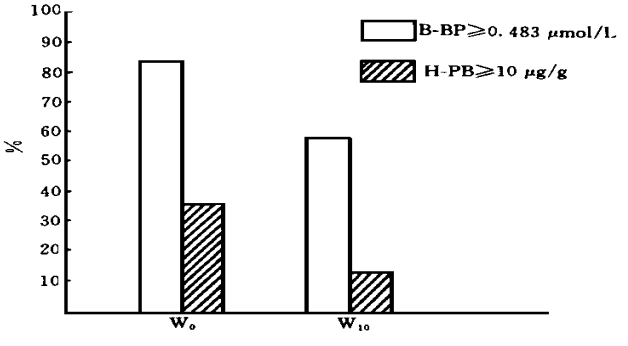
表4 血铅和发铅含量变化

Tab 4 Changes of blood lead and hair lead contents

Group	B-Pb (c_B/μmol·L^{-1})			H-Pb (w_B/μg·g^{-1})		
	W_0	W_{10}	Δ B-Pb	W_0	W_{10}	Δ H-Pb
Zn	0.676	0.531	0.145	7.48	4.31	3.17
ZnM	0.627	0.434	0.193	6.77	3.15	3.62
M	0.627	0.483	0.145	7.24	4.96	2.28

Note: The results are expressed by using Median for the divergent distribution of the data

表4显示,锌及复合微量营养素干预后,儿童血铅、发铅明显降低,其中在补锌的同时添加多种微量营养素更能有效降低全血及头发中铅含量。营养干预前、后 B-Pb和 H-Pb临界值变化见附图。



附图 营养干预前后血铅、发铅临界值变化

Fig Changes of upper marginal values of blood and hair lead before and after nut1rition intervention

2.4 对血清锌、发锌含量的影响见表5

表5显示,儿童在补锌同时给予铜、锰、硒、叶酸等多种微量营养素,或仅服用上述多种微量营养均较单纯补锌更有效增加血清锌、发锌含量,提示复合微量元素、维生素能促进肠道锌的吸收。

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表 5　血清锌和发锌含量变化

Tab 5　Changes of serum Zinc and hair Zinc contents

Group	S-Zn (c_B/μmol·L^{-1})			H-Zn (w_B/μg·g^{-1})		
	W_0	W_{10}	Δ S-Zn	W_0	W_{10}	Δ S-Zn
Zn	12.03± 3.97	13.55± 4.07^a	1.81± 3.37$^{a'}$	71.26± 19.91	88.81± 20.31^a	17.55± 6.03$^{a'}$
ZnM	12.03± 3.91	23.62± 3.94^b	11.14± 3.28$^{b'}$	66.09± 16.37	104.73± 20.96^b	38.64± 11.25$^{b'}$
M	12.28± 3.86	21.70± 3.95^c	9.60± 3.24$^{b'}$	66.97± 20.92	106.80± 18.65^b	39.82± 11.10$^{b'}$

Note: The different letters in the same column represent the significant difference ($P < 0.05$)

2.5　营养干预对儿童生长发育的影响见表 6

表 6　营养干预对膝高的影响 (mm)

Tab 6　Effects of nutrition intervention on knee height(mm)

Group	KH$_{W0}$	KH$_{W10}$	Δ KH
Zn	327.203± 15.109	330.186± 15.381	2.983± 1.277^a
ZnM	323.753± 17.743	328.490± 15.230	5.535± 1.284^b
M	326.499± 14.920	330.812± 14.990	4.487± 1.278^c

Note: The different letters in the same column represent the significant difference ($P < 0.05$)

本研究显示,营养干预能有效促进儿童生长发育,其中以锌加多种微量营养素或单纯补充微量营养素作用更显著。且膝高的变化与血清锌、发锌的净增值存在显著正相关,但与血铅、发铅改变无明显相关。

3　讨论

铅(Pb)污染是一个世界性环境问题,Pb中毒常见于 1~ 6岁儿童[4]。80年代后期,国外许多研究相继证明血 Pb水平在 0.483μmol/L以上时即能对儿童生长发育产生不良影响[5],据美国疾病控制中心(CDC)一份报告,血 Pb浓度为(0.483~ 0.724)μmol/L儿童神经精神行为和脑电图可出现异常,提示 Pb对儿童健康的影响是显著的[6]。

本次调查研究显示,生活在重庆闹市区的学龄前儿童受到的 Pb污染已相当严重,若以 CDC推荐的 0.483μmo/L为血 Pb可接受上限值,则春季有 50.9%儿童、秋季有 81.66%儿童血 Pb浓度超标,即便放宽可接受值为 0.724μmol/L,秋季也有 28.44%儿童血 Pb超出此界限。发 Pb的测定也显示,重庆城区 Pb污染是严重的(以 10μg/g为可接受上限值,秋季有 33.63%儿童超标)。实验还发现重庆春、秋两季及男、女性别儿童之间受 Pb污染程度有较大差异,春、秋两季儿童血 Pb分别为 0.483μmol/L、0.650μmol/L,发铅为 2.432μg/g、7.180μg/g,秋季男、女血 Pb分别为 0.676μmol/L、0.627μmol/L。以上差异可能由于春季空气清新、秋季重庆地区雾大、雨水多、空气不易流动,同时降尘多等,另外,男性儿童由于户外活动量大,可能受 Pb污染机会较女性儿童多。

本研究同时显示,学龄前儿童血 Pb、发 Pb水平与其膝高存在显著负相关,提示体内铅含量过高可能会阻碍儿童生长发育。给学龄前儿童补 Zn或改善其营养状况,能有效降低血 Pb、发 Pb浓度,其中尤以在给 Zn的同时再服用铜、锰、硒、叶酸等多种微量营养素效果更为明显,但未发现营养干预前后,血 Pb浓度的变化值与血清 Zn、发 Zn及膝高净增值呈明显相关,这种偏差作者认为可能是缘于体内铅负载过多抑制生长发育是一长期作用的结果,是一剂量—— 效应连续的过程,营养干预能有效降低血 Pb、发 Pb浓度,但短时间体内铅的降低并不能使儿童生长发育明显改善,相反,本项研究儿童血清 Zn、发 Zn浓度的变化与膝高净增值呈显著正相关,提示短期营养干预促进生长发育的主要原因在于机体营养状况改善。目前关于营养改善或补锌后,体内铅含量降低的机理不清,但发现除锌缺乏可影响铅吸收外,铁缺乏同样可以影响肠道对铅的吸收,且营养不良时铅对机体的毒性损害更大。血 Pb浓度常与恶劣生活环境,低经济收入及营养水平较差等有关[7],有人还认为铅、锌、铁等存在相互拮抗的效应,改善营养状况可以部分消除铅暴露诱导的体重减轻[8],推测良好的营养状况可以增加肠道上皮的屏障功能,同时可能锌或其它一些微量营养素与铅相互拮抗减少铅的吸收,另外或许通过"营养—— 神经、内分泌"途径,使沉积在骨骼(正常情况体内 90%铅在骨组织)铅的动员或转移至血液减少。当然确切的生物机制有待进一步深入研究,但为了减轻环境铅污染对人体,尤其是儿童健康的损害,除采取措施减少铅污染

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源,控制大气中铅的含量外,改善机体营养状况,适当增加锌、铜、硒、叶酸等微量营养素的摄入是有益的。

参考文献

1 Needleman H L, Schell A, Bellinger D. The long-term effects of exposure to low doses of lead in childhood. N Engl J Med, 1990; 322(1): 83

2 Bailey A J. Poisoned landscapes: The epidemiology of environmental lead exposure in Massachusetts children 1990-1991. Soc Sci Med, 1994; 39(6): 757

3 Yee H Y. Measurement of lead in blood by graphite furnace atomic absorption spectrometry. J Anal Toxicol, 1994; 18(7): 415

4 Mohamed A E, Doris T C, Wellela D H. Lead in inner-city soil and its possible contribution to children's blood lead. Arch Environ Health, 1995; 50(2): 165

5 Bellinger D, Sloman J, Leviton A. Low-level exposure and chidren's cognitive function in the pre-school years. Pediatrics, 1991; 87(2): 219

6 Frisancho A R and Alan S R. Decreased stature associated with moderate blood lead concentrations in Mexican-American children. Am J Clin Nutr, 1991; 54(2): 516

7 Sargent J D. The role of nutrition in the prevention of lead poisoning in children. Pediatr Ann, 1994; 23(11): 636

8 Hammaond P B, Succop P A. Effects of supplemental nutrition on lead-induced depression of growth and food consumption in weanling rats. Toxicol Appl Pharmacol, 1995; 13(1): 80

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Body lead level and its nutritional intervention in pre-school children in Chongqing

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Abstract **Objective**: To determine the extent of lead exposure and the effects of supplemented nutrition on the body lead level in pre-school children in downtown of Chongqing. **Methods**: The lead contents of blood and hair lead were measured in 240 pre-school children aged 6 to 7 years including 120 boys and 120 girls. Nutrition trial was carried out in only half the children of equal numbers of boys and girls who were divided into zinc-supplemented, zinc- and micronutrient-supplemented and micronutrient-supplemented groups. The experiment lasted for 10 weeks in a double-blind manner. **Results**: Taking 0.483μmol/L as the upper limit of blood lead level, 50.9% and 81.66% of the children had the blood lead content above this level in spring and fall respectively and the measurement of hair lead content showed the similar results. The lead contents of blood and hair lead were negatively correlated to the knee height (KH), which indicated that the body lead content directly affected the growth of children. It was also found that the contents of blood and hair lead could be significantly lowered after nutrition intervention of zinc or micronutrients and the growth of children improved, especially in those children who received zinc and micronutrient supplementation simultaneously. **Conclusion**: These children living in downtown of Chongqing are exposed themselves to a dangerous environment of high lead level and zinc or micronutrient supplementation can decrease their body lead and improve their growth.

Key words zinc; micronutrient; child; lead

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