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Review Article

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Associations of K/Mg fertilization ratio with non-CHD mortality in Finland during 1952-99

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Abstract

As CHD, non-CHD (nCHD-the difference between total and CHD mortality), hasits own inter-annual variation and possiblyassociated with dietary factors, e.g. food mineral element contents. Mg is a cofactor in more than 300 enzymatic reactions, so Mg deficiency can be associated with resistance and recovery of a multiplicity of diseases.Antagonism of potassium (K)and Mg is known in plant science. Human nCHD - the mean of female (F) and male (M) nCHD (FM.nCHD) and fertilization rates are based on old data. The dataon Mgrates from liming agents are opened and estimated figures are slightly corrected (to earlier publications). The mineral element ratios were used as 3-year means (3ym), but nCHD as such.Associations of nCHD with [(K/Mg).fm.3ym] are analyzed from periods 1952-99 and 1969-99. In appendix are represented annual relative changes of smoothed (K/Mg).fm and nCHD.

Results: In 1952-1999 (regression by) [(K/Mg).fm.3ym] explained 63.3 % ($p < 0.001$) and in 1969-99 92.4 % ($p < 0.001$) of nCHD variation. Regression coefficients were positive. Variation of annual relative changes of smoothed (K/Mg).fm and nCHD were similar and rather simultaneous.

Conclusion: Changes in K and Mg fertilization associated significantly with Finnish non-CHD mortality in 1951-2000. Mechanisms are discussed. Epidemiology of non-CHD needs attention.

Keywords: Non-CHD mortality; Potassium; Magnesium; Balance; Fertilization; Food; Time-related

Abbreviations: 3ym - arithmetical 3-year mean; alb - albumin; crea - creatinine ; CHD -age adjusted coronary mortality (I20-I25) of humans, 35-64 yrs; F - female; FM - human; K - potassium; M - male; Mg - magnesium; nCHD (mortality) - difference between total and CHD mortality; S - serum; U -; urineY.i - value of variable Y in year i; $Y_{.(i-1)}$ - variable Y value in year preceding year i, (respectively $Y_{.(i-2)}$...)

Introduction

In human medicine K has a good fame. High dietary potassium is an indicator of high dietary proportion of vegetable food [1]. An randomized double blind survey has shown that daily 2500 mg K supplements by (KCl and $KHCO_3$) have improved endothelial function and reduced osteoclast activity and ratios of U-alb/crea and U-Ca/crea [2]. Magnesium is a cofactor in more than 300 enzymatic reactions [3], so its balance can be associated with resistance and recovery of a multiplicity of diseases. It proper Mg level has several anti-atherosclerotic mechanisms [4].In plant physiology K and Mg have antagonistic effects on their plant contents [5]. Increase inK fertilization of pasture is known to decrease serum Mg content in cow and increase risk of grass tetany, especially when equivalent ratio of K/(Ca+Mg) of grass is over 2.2 [6]. In animals intake of K can decrease Mg absorption from gastro-intestinal tract [7]. The aim of this study is to clarify the association of (K/Mg) fertilization ratio with nCHD and provoke discussion on the role of Mg-K balance in nCHD mortality.

Materials and Methods

Age adjusted totalmortality of 35-64-y. females and males are from Valkonen & Niemi [8] and CHD death-ratesfrom Valkonen & Martikainen [9] for period 1951-68. Respective total and CHD mortality in 1969-2000 are from Statistics Finland [10] (Table 1). Mg rates per hectare from carbonate liming agents are calculated by the annual sales of liming agents [11] and arable land area [12,13]. Lauronen [14] estimated Mg contents of liming agents in different periods as follows: in 1951-71 2%, in the 1980´s 7 % and 6 % in the 1990´s, "by accuracy of 20 %".Figure for 1980calculated anyhow from [13,15]. Mg values from liming agents for 1972, 1976, 1979 and 1980 have been calculated primarily by dividing figures from [15] by arable land area [13]. Calculated figures (and figures by Jokinen) are as follows: 1972: 4.10 (4), 1976: 14.38 (14), 1979: 18.55 (19) and 1980: 24.61 (25)kg Mg/ha. Because Mg-containing calcitic limestones were included in calcites before 1976 [14], Mg addition from them for 1972 (ca 2,000tn) has been estimated by

Mg-containing calcitic limestones from 1976 (52,700 tn, a´ 3-7 % Mg, by selecting 4 %). By dividing this figure with arable land area we get estimate 0.84 kg Mg/ha for addition and get 4.95 kg Mg/ha for 1972. Values between the fixed figures in the 1970´s are linearly interpolated (Appendix 1).

Annual data of Mg (kg/ha) from other sources: (a) fertilizers: 0.85 kg for 1956 [16], figures for 1951-55(0.63-0.91) are approximated by consumption of phosphates [17] because remarkable part of Mg came from bone meal [16]. Value 1.7kg (with 0.85kg addition) for 1957 comes from the beginning production of dolomitic nitro chalk in Oulu [16]. Figures for 1970-80 (2.3-4.1) are from [15] and for 1981-2000 (2.7-8.7) from [18,19]. Values for years with missing figures are linearly interpolated. Annual estimate (0.77 kg) for Mg deposition is included [15]. Consumption of K fertilizers are from Sillanpää (kg/ha) for 1951-60[17], and for 1961-2000 from FAOSTAT [20]. (Table 1 shows rates of Ca, Mg and K mineral fertilizers including liming agents).

Table 1.

Total and CHD mortality of females (F) and males (M) and (partially revised) mineral fertilization (.fm) of Ca, Mg and K									
	F.TOT	F.CHD	M.TOT	M.CHD	approximate Mg-% of liming agents	Ca.fm	Mg.fm	K.fm	F.TOT
1951	727	122	1467	410	2,00	1787	252	338	1951
1952	713	113	1373	388	2,00	1791	251	451	1952
1953	683	104	1363	363	2,00	2454	307	451	1953
1954	653	96	1308	371	2,00	2707	328	464	1954
1955	637	103	1363	385	2,00	2599	319	445	1955
1956	630	92	1323	368	2,00	2842	341	470	1956
1957	647	86	1348	358	2,00	2882	415	489	1957
1958	603	88	1303	361	2,00	3050	432	520	1958
1959	587	90	1268	383	2,00	3578	480	520	1959
1960	583	92	1303	392	2,00	3575	480	621	1960
1961	583	98	1303	421	2,00	3842	506	605	1961
1962	583	107	1338	468	2,00	2940	432	602	1962
1963	570	103	1348	472	2,00	4354	551	731	1963
1964	557	99	1343	501	2,00	4801	588	815	1964
1965	550	101	1368	501	2,00	4500	564	856	1965
1966	540	97	1318	505	2,00	3884	513	842	1966
1967	527	105	1343	515	2,00	3607	486	894	1967
1968	523	98	1343	512	2,00	3786	495	1039	1968
1969	524	91	1371	495	2,00	3895	506	1082	1969
1970	491	88	1299	477	2,00	3938	511	1126	1970
1971	484	90	1350	506	2,00	4459	596	1175	1971
1972	456	85	1256	470	2,84	4174	726	1207	1972
1973	427	84	1235	465	3,40	4647	907	1353	1973
1974	442	82	1242	462	3,96	3202	722	1412	1974
1975	430	81	1183	453	4,53	4883	1260	1264	1975
1976	416	80	1190	469	5,09	5459	1535	1050	1976
1977	401	73	1185	469	5,57	3818	1176	1110	1977
1978	377	73	1119	442	6,06	5327	1726	1208	1978
1979	378	74	1070	416	6,54	5270	1870	1281	1979
1980	357	63	1026	390	6,47	6789	2426	1271	1980
1981	352	65	1015	392	7,00	4108	1607	1196	1981
1982	342	59	974	376	7,00	6172	2291	1382	1982
1983	352	56	939	349	7,00	10115	3846	1420	1983
1984	327	56	938	347	7,00	7196	2774	1337	1984

1985	329	56	960	347	7,00	9791	3720	1346	1985
1986	333	54	931	322	7,00	6990	2659	1363	1986
1987	336	58	890	291	7,00	7980	3051	1401	1987
1988	338	53	893	280	7,00	6827	2647	1324	1988
1989	326	45	887	275	7,00	7188	2879	1325	1989
1990	318	43	864	254	6,00	7920	3014	1114	1990
1991	314	37	829	236	6,00	6018	2169	820	1991
1992	310	35	801	223	6,00	4386	1595	829	1992
1993	306	33	765	202	6,00	7028	2485	822	1993
1994	287	31	728	191	6,00	6930	2422	832	1994
1995	291	29	727	181	6,00	6345	2319	843	1995
1996	273	27	701	171	6,00	7416	2633	822	1996
1997	284	23	685	157	6,00	7800	2616	799	1997
1998	272	28	683	150	6,00	7008	2379	784	1998
1999	268	23	672	146	6,00	7026	2361	801	1999
2000	277	25	641	149	6,00	5217	1807	778	2000

Figure 1 shows the relative values of CHD,nCHD and [(K/Mg).fm.3ym], in percentsto their respective values in 1957. Figure 2 represents relative changes in CHD and nCHD during 1969-2000. In 1969-83 nCHD decreased faster than CHD, after 1985 CHD decrease was faster. Interesting is the stagnation and a small increase in nCHD between 1984 and 1992.

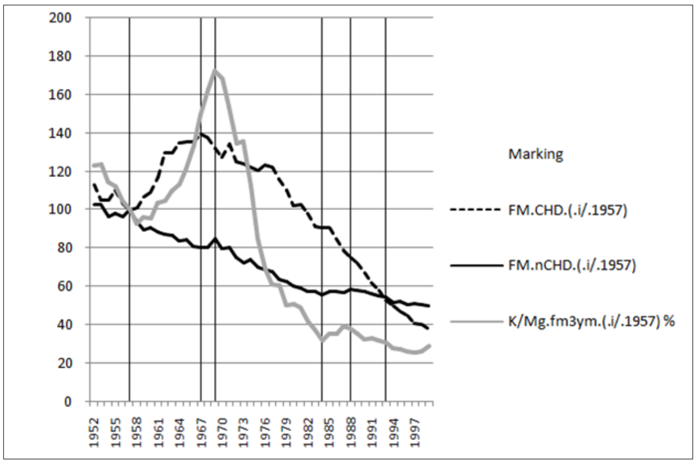

Figure 1: K and Mg mineral fertil uization equivalent ratio (3-years means), CHD and nCHD morality relative to their values in 1957.

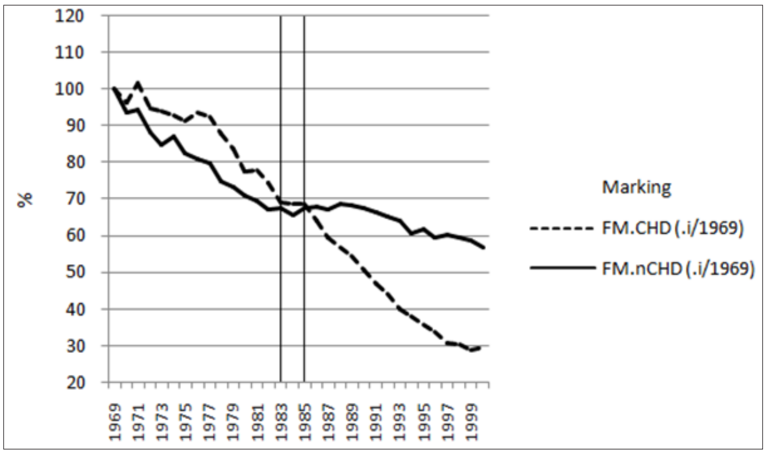

Figure 2: Relative Changes in CHD and non-CHD morality during 1969-2000.

Results

In 1952-1999 (regression by) [(K/Mg).fm.3ym] explained 63.3 % ($p < 0.001$) of nCHD variation (Figure 3). In 1969-99 (regression by) [(K/Mg).fm.3ym] explained 92.4 % ($p < 0.001$) of nCHD variation (Figure 4).

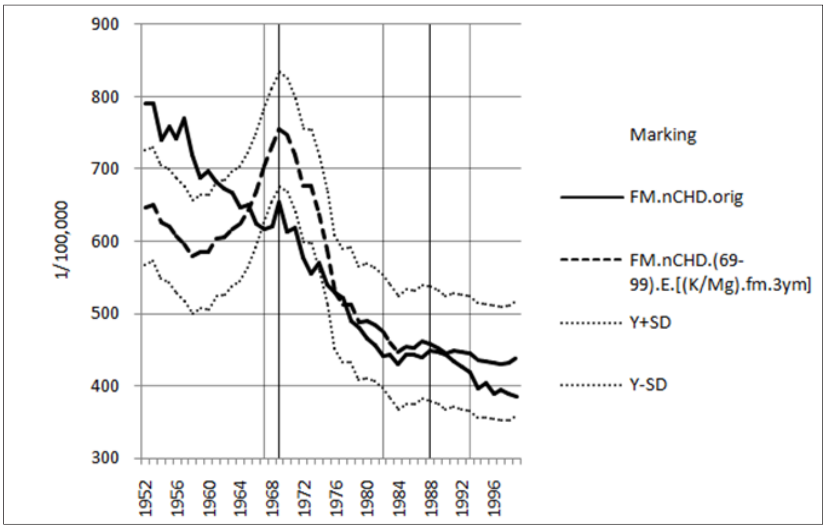

Figure 3: Human nCHD and its regression by (K/Mg).fm in 1952-99

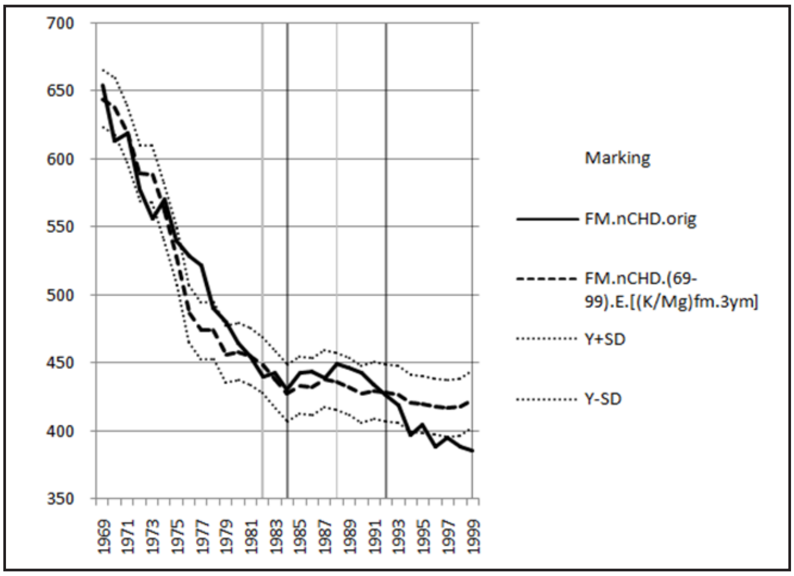

Figure 4: Human nCHD and its regression by (K/Mg).fm in 1969-99.

Discussion

K [2] and Mg [4] and have shown cardiovascular benefits in humans, so this statisticaldisadvantage of (K/Mg) fertilization ratio concerning nCHDseems to be a surprise. Study of He et al. [2] seems to show that Mg absorption was possibly not disturbed by K supplements. Figure 1 possibly supports CV benefits in 1967-69, when during rapid (K/Mg) increase CHD begun to decrease (Figure 1) but increase of nCHD continued. On the other side during the rapid decrease of nCHD in 1969-82 associated with rapid decrease of (K/Mg). fm ("causing" increase in CHD/total mortality ratio).

In the 1970's Finnish daily food (600 g dry weight - DW) contained 4,500mg K, 1500mg Ca and 440mg Mg, i.e. equivalent ratio of K/(Ca+Mg) was 1.0 [1]. First additional 5 g K could raise this ratio ad 2.2, i.e.the danger of "grass tetany" by Finnish people is very limited without strong K supplementation and calcium reduction from the level in the 1970's. According to my old textbook of physiology the minimum daily requirement of K is 1g [21]. Textbook of biochemistry wrote that "2 to 4 g. of potassium ... in the diet per day is more than sufficient" [22a]. Late veterinary surgeon Seppo Haaranen told often: "Potassium causes an enormous stress to cow kidneys, because so much K is needed to be excreted" [23]. Renin-angiotensin system works via adrenal gland regulation [22b]. Possibly K is associated stronger than Mg with renin-angiotensin-adrenergic system [24] and in "pharmacological" doses could better inhibit it (?). Although inhibition of renin-angiotensin-adrenergic system can produce cardiovascular benefits, this inhibition could make some unbeneficial effects in the physiological defence system [25]. Anyhow some of the Mg benefits could be based on K balance control [26].

Distribution of Mg-rich mines and quarries has been and is different in different areas of Finland. In the 1950's the highest Mg contents of liming agents (> 10 %) situated in the northern Finland, northward from Joensuu-Kuopio-Kokkola line, (with high CHD mortality!). But the effect of liming agents on soil Mg could have been shorter than the average period between supplementations (5 years?) on those coarse northern soils [27]. Because of the relative supplementation of all NPK-fertilizers [17,20] have been similar, the graphics and associations of K/Mg are similar with NPK/Mg. The roles of N and P need further discussion [28].

The need of adjustments to Mg-% caused by Mg-containing calcitic lime stones in (1972 and 1951-71) has been a big problem, when during the last years advises of late Lauronen have not been available. Obviously 2,000 tn for 1972 is an overestimation, because it based on data from 1976, and after 1972 Mg percents of liming agents were remarkably increasing. Slight estimations downwards are included in [4,28]. In [4], opposite to [28], I concluded (and wrote) that years 1951-71 needed the same 0.5 % addition as 1972. But it was an error [29]. The figures of annual sales of liming agents have been compliant with [8], but figures concerning area used before 2008 have had biases and caused a part of the discrepancies between [15] and [4,28].

Fields get Mg via deposition [15], but possible is that losses per air can be remarkable, too. Association parameters calculated by 3-y means values can make bias, but raw fertilization figures make their own bias, because duration of action is longer than one year. This is justified even by the fact that the amount of explained by regression is not the same as its causal impact.

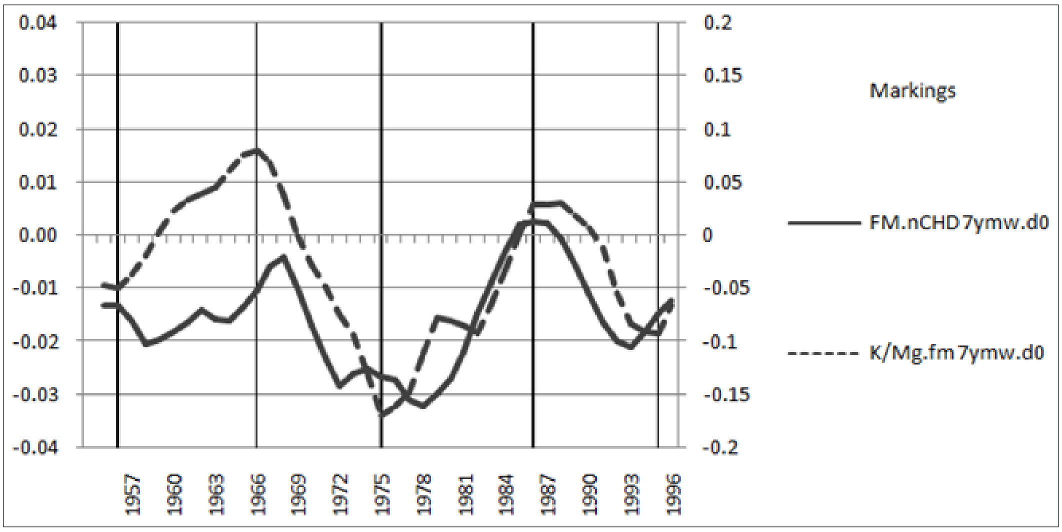

Figure 5: Relative changes of [nCHD.7ymw] and [(K/Mg).fm.7ymw] in 1955-96.

Conclusion

Changes in K and Mg fertilization associated significantly with Finnish non-CHD mortality in 1951-2000. Epidemiology of non-CHD needs attention.

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