Ⅳ. Dose-response relationship between cadmium exposure and adverse health effects

TABLE IV

PREVALENCE RATES OF β-MICROGLOBULINURIA IN RELATION TO URINARY CADMIUM CONCENTRATIONS AMONG INHABITANTS OVER 50 YEARS OF AGE

Men													
Cd (μg/g.cr.)	0.0–0.9	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–14.9	15.9–19.9	20.0–
Median Cd (μg/g.cr.)	0.8	1.7	2.5	3.5	4.4	5.4	6.4	7.5	8.5	9.4	11.5	18.5	
N	10	111	240	231	208	153	110	82	61	42	116	39	
Prevalence rates (%)													
β_1-mg ⩾ 927 μg/l	0.0	4.5	2.9	3.5	6.3	8.5	14.5	14.6	16.4	23.8	43.1	48.7	
β_1-mg ⩾ 1129 μg/g.cr.	0.0	3.6	4.6	4.3	7.2	8.5	15.5	14.6	21.3	26.2	42.2	53.8	
Women													
Cd (μg/g.cr.)	0.0–0.9	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–14.9	15.9–19.9	20.0–
Median Cd (μg/g.cr.)	0.9	1.7	2.6	3.5	4.5	5.3	6.5	7.4	8.4	9.5	11.8	17.0	23.4
N	4	27	99	140	177	176	188	159	142	112	347	83	62
Prevalence rates (%)													
β_1-mg ⩾ 503 μg/l	0.0	3.7	3.0	5.0	7.3	8.0	9.0	8.2	22.5	21.4	32.0	37.3	56.5
β_1-mg ⩾ 1059 μg/g.cr.	0.0	7.4	3.0	5.0	7.3	9.1	8.5	8.8	21.1	18.8	31.4	41.0	59.7

N: Number of persons examined.

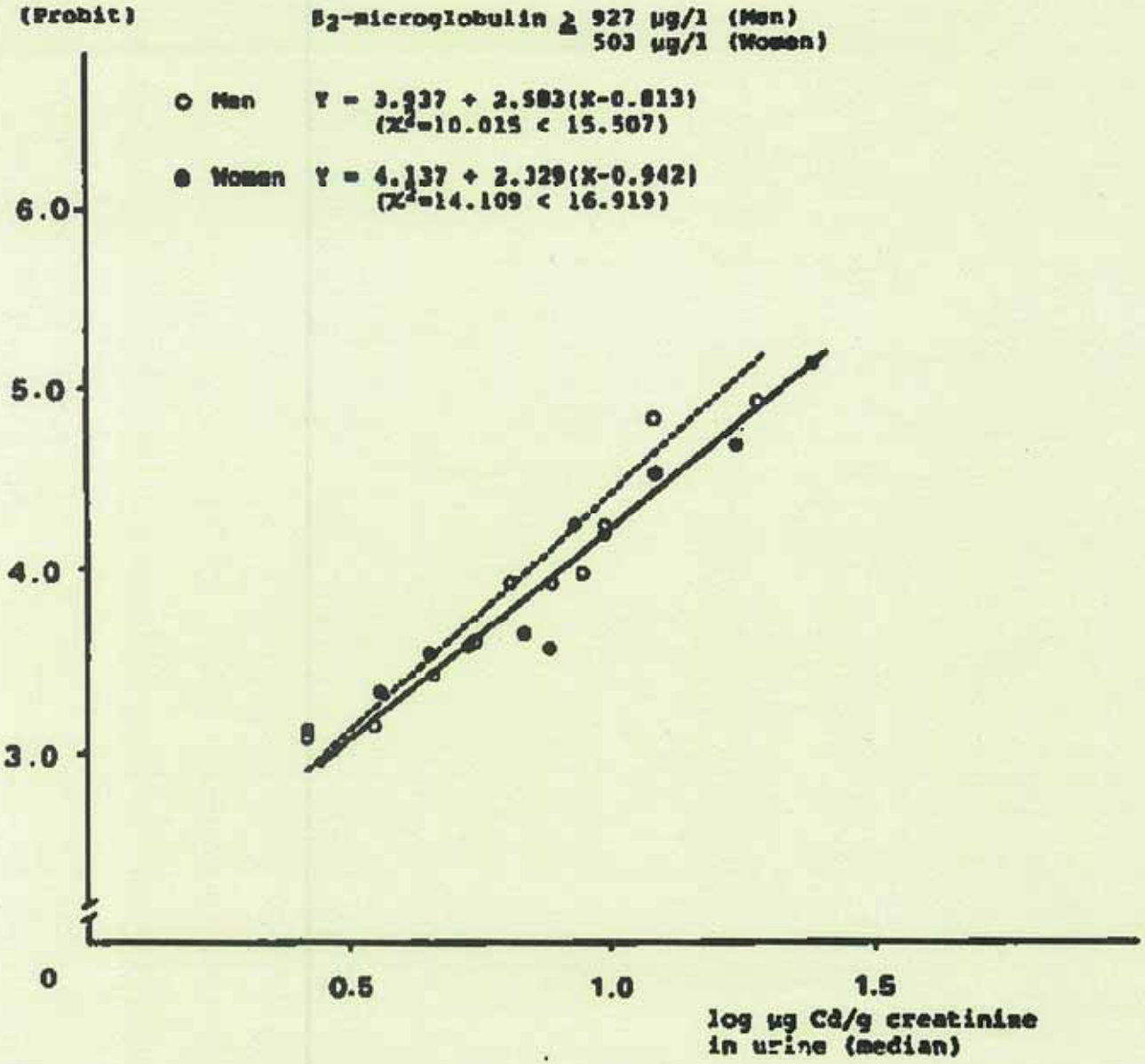


Fig. 1. Probit linear regression line between urinary cadmium concentration and prevalence of β_2-microglobulinuria.

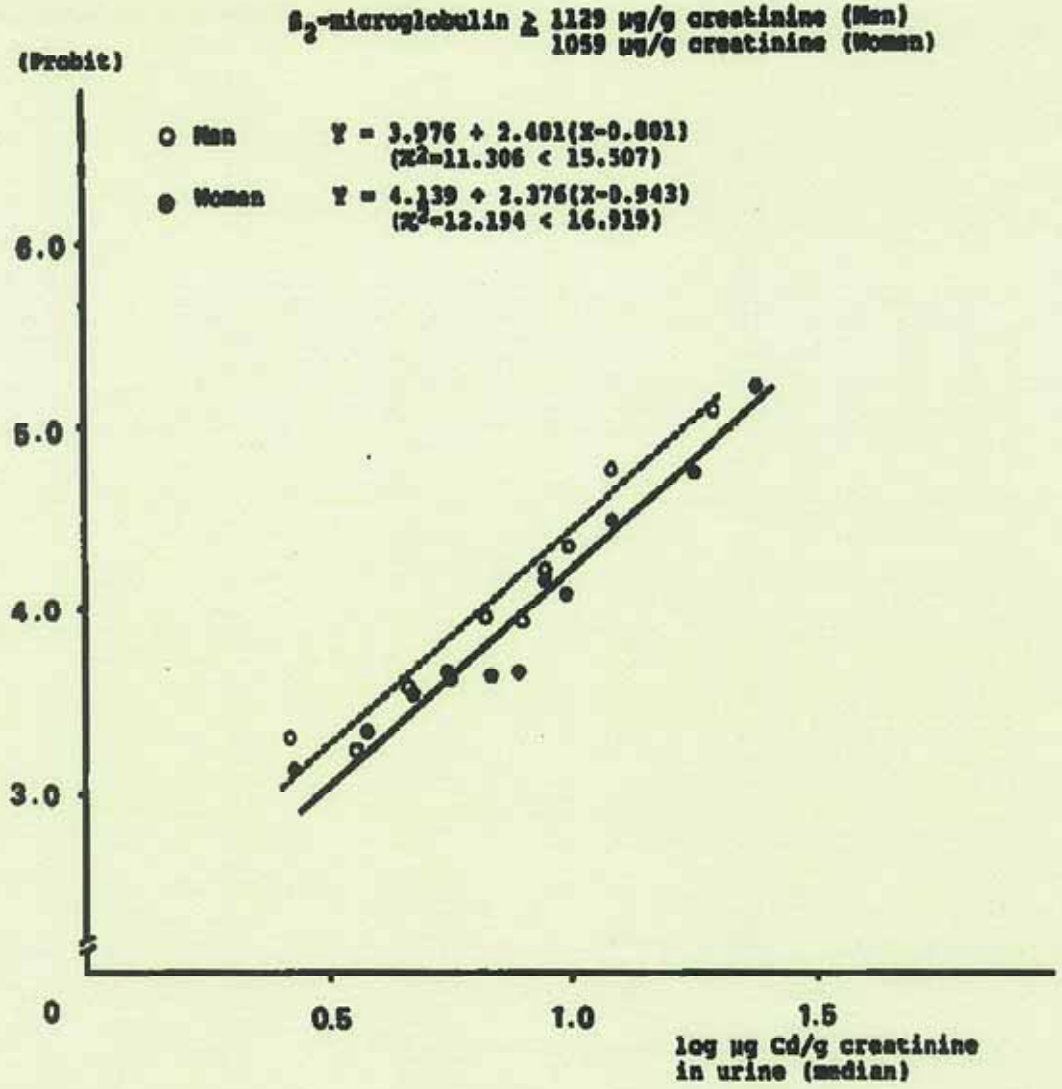
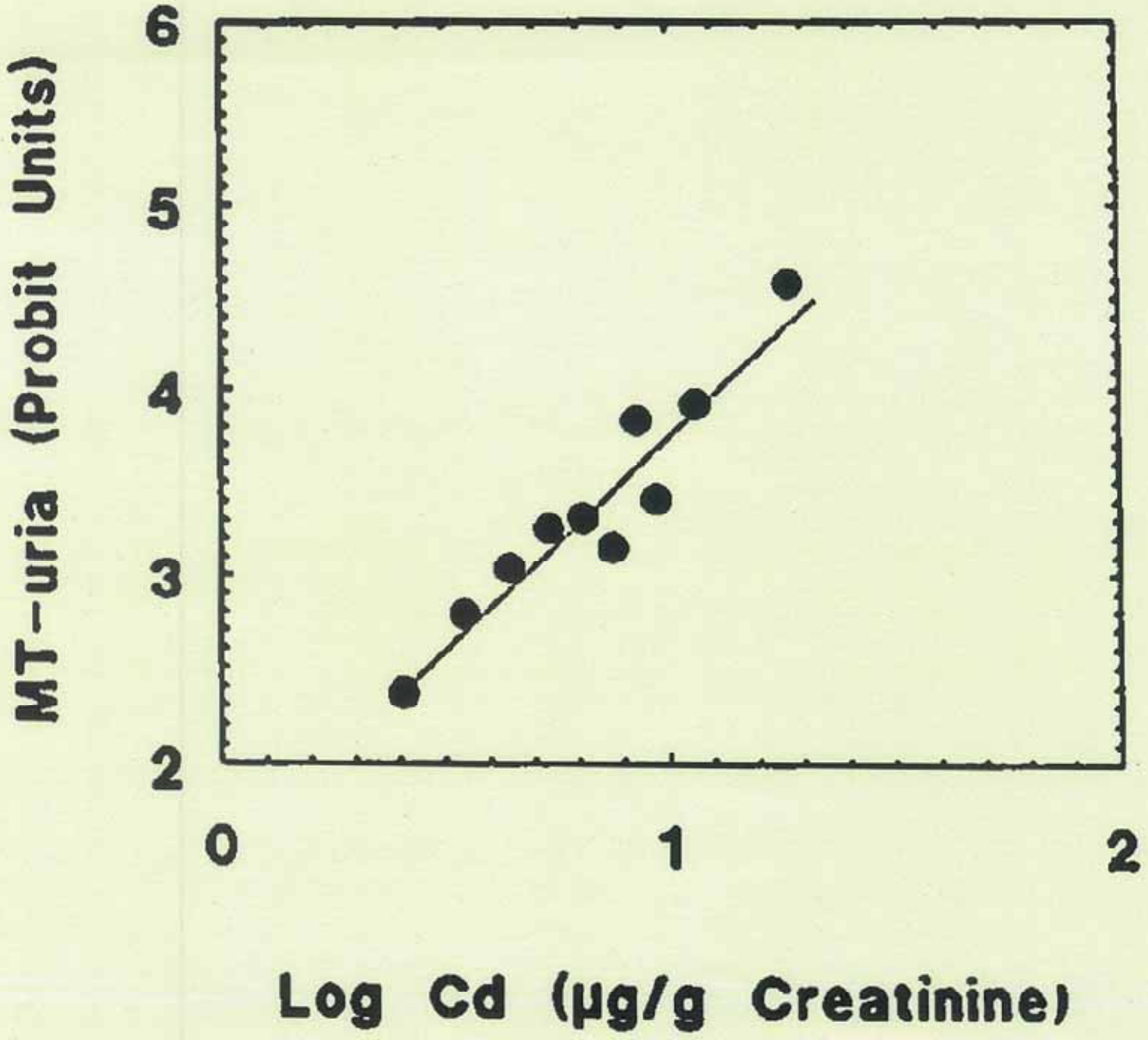
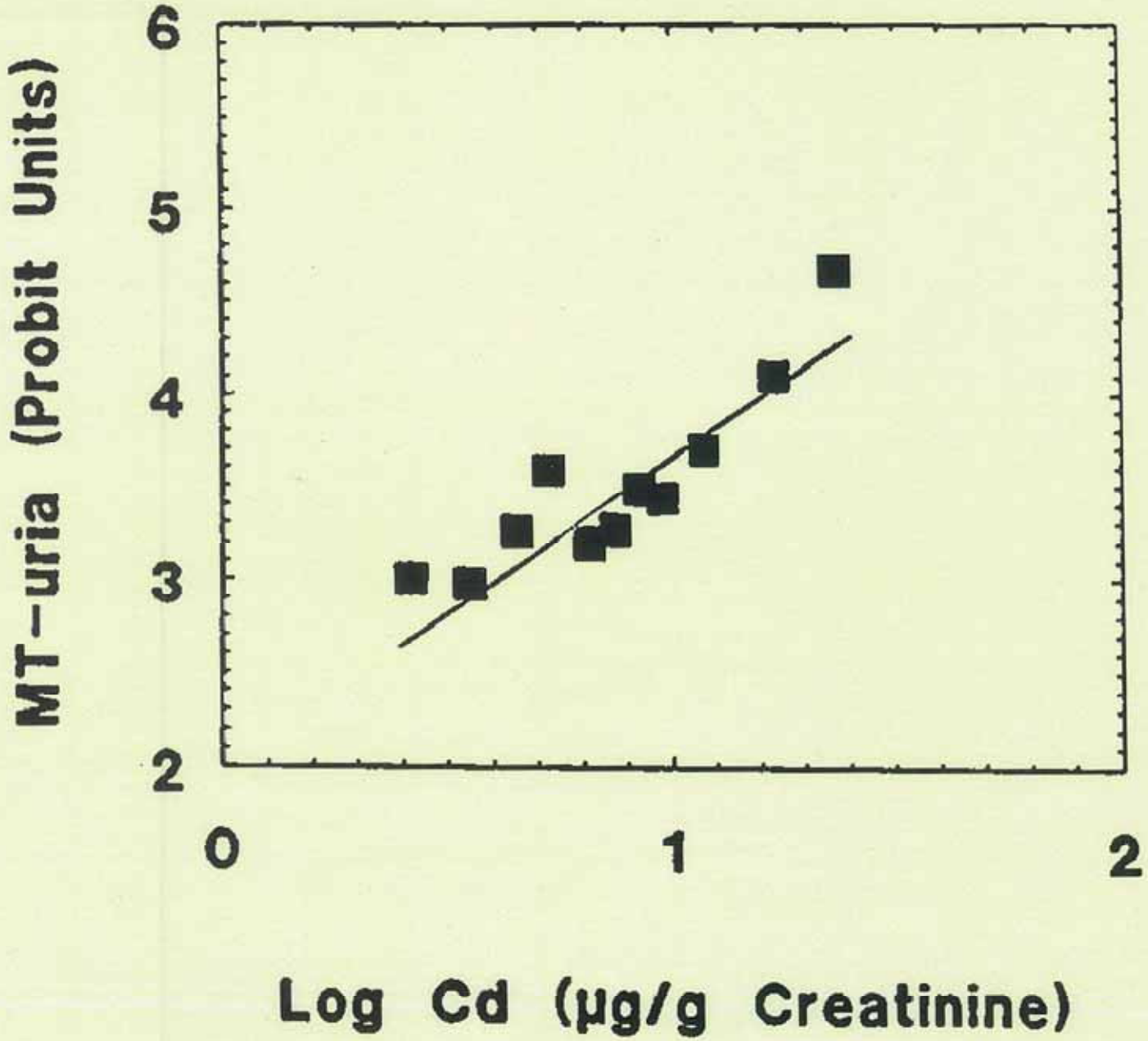


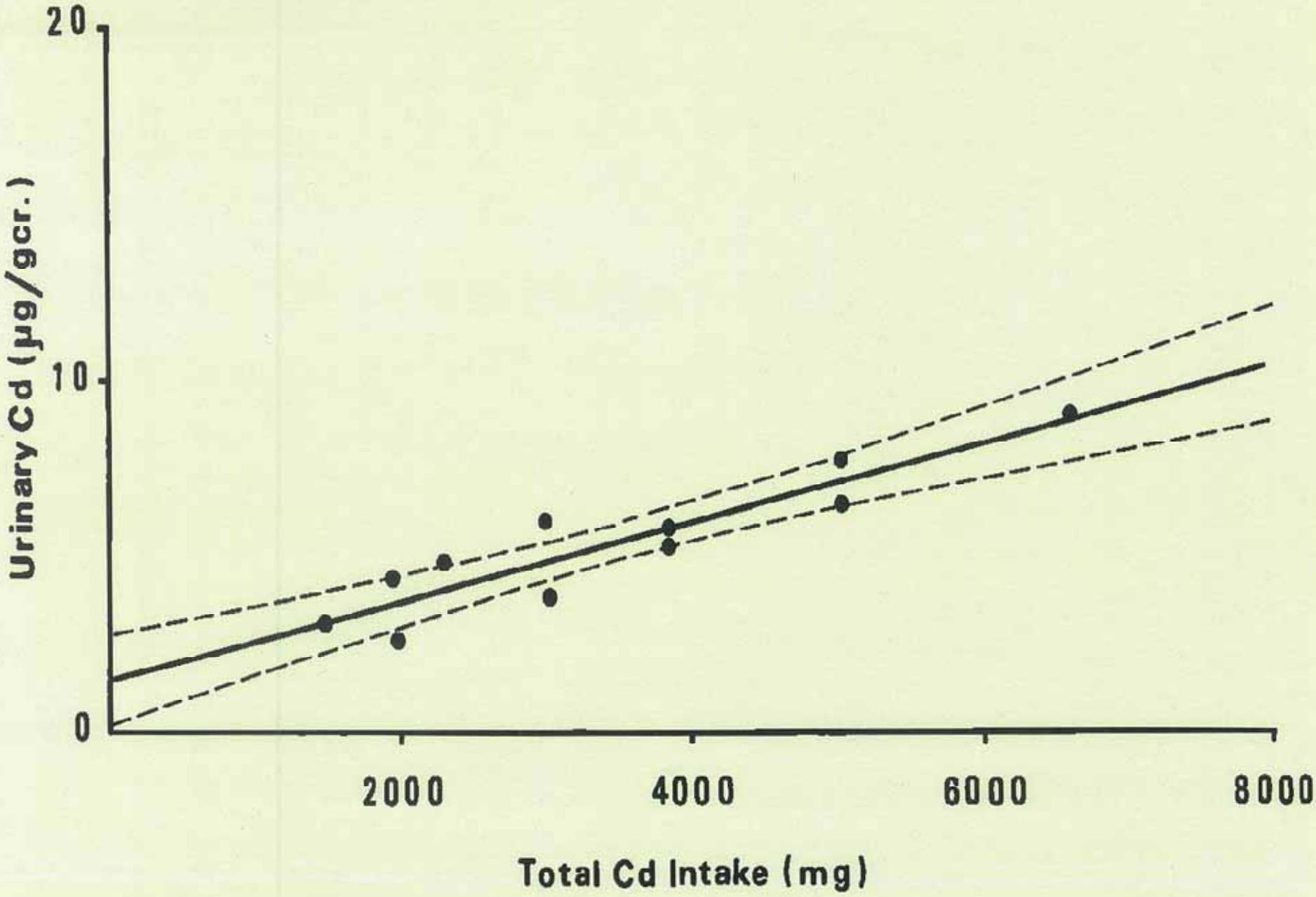
Fig 2. Probit linear regression line between urinary cadmium concentration and prevalence of β_2-microglobulinuria.

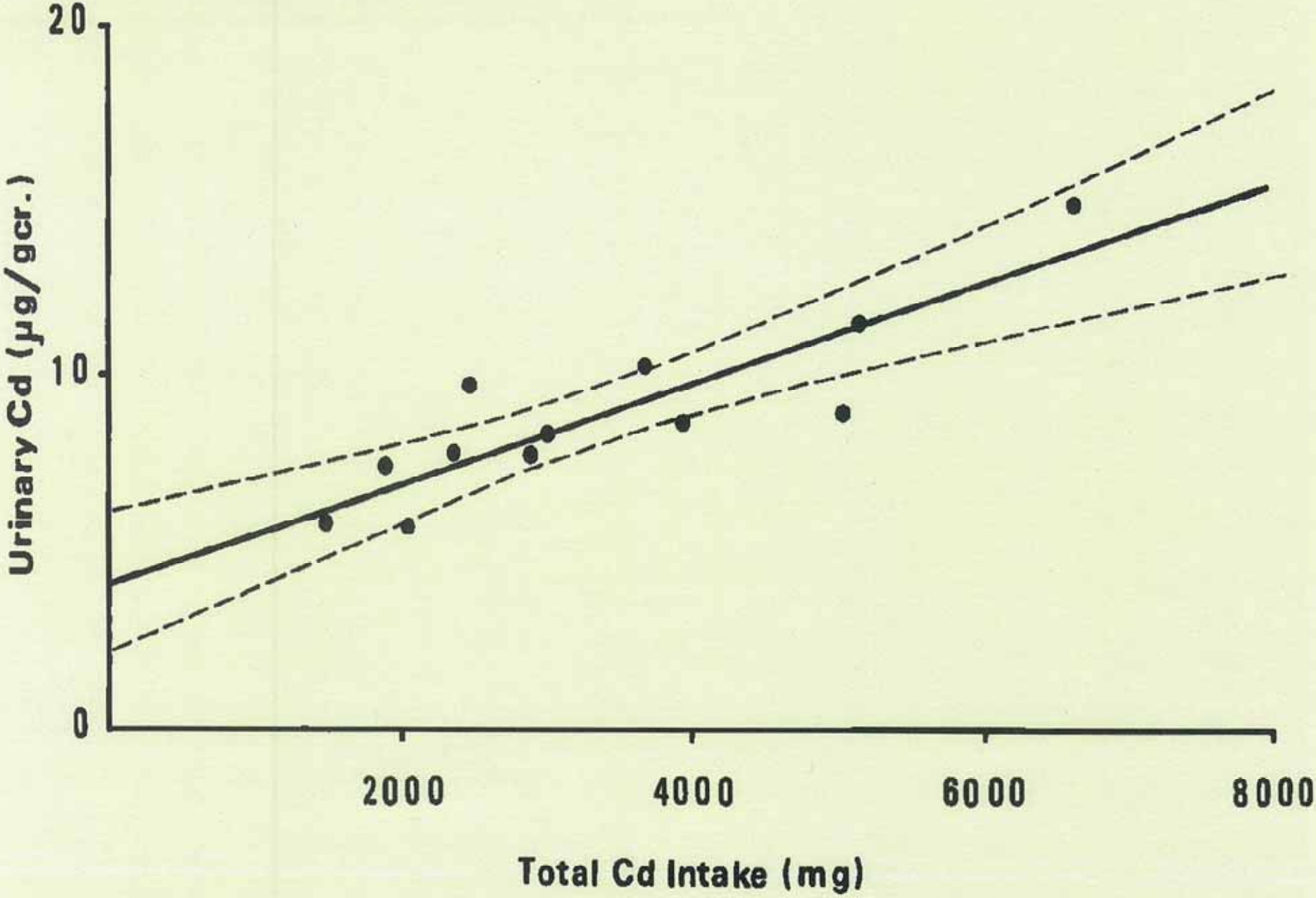

MT-uria (Probit Units)
6
5
4
3
2
0
1
2
Log Cd (µg/g Creatinine)


MT-uria (Probit Units)
6
5
4
3
2
0
1
2
Log Cd (µg/g Creatinine)

Total Cd intake calculated by formula as follows.

([village average Cd concentration in rice] × [the average daily intake of rice] + [daily intake of Cd from foods other than rice]) × [duration of residence in the Cd-polluted areas] + [average daily intake of Cd in non-polluted areas of Japan] × [duration of residence in non-polluted areas].


20
10
0
Urinary Cd (µg/gcr.)
2000
4000
6000
8000
Total Cd Intake (mg)


20
10
0
Urinary Cd (µg/gcr.)
2000
4000
6000
8000
Total Cd Intake (mg)

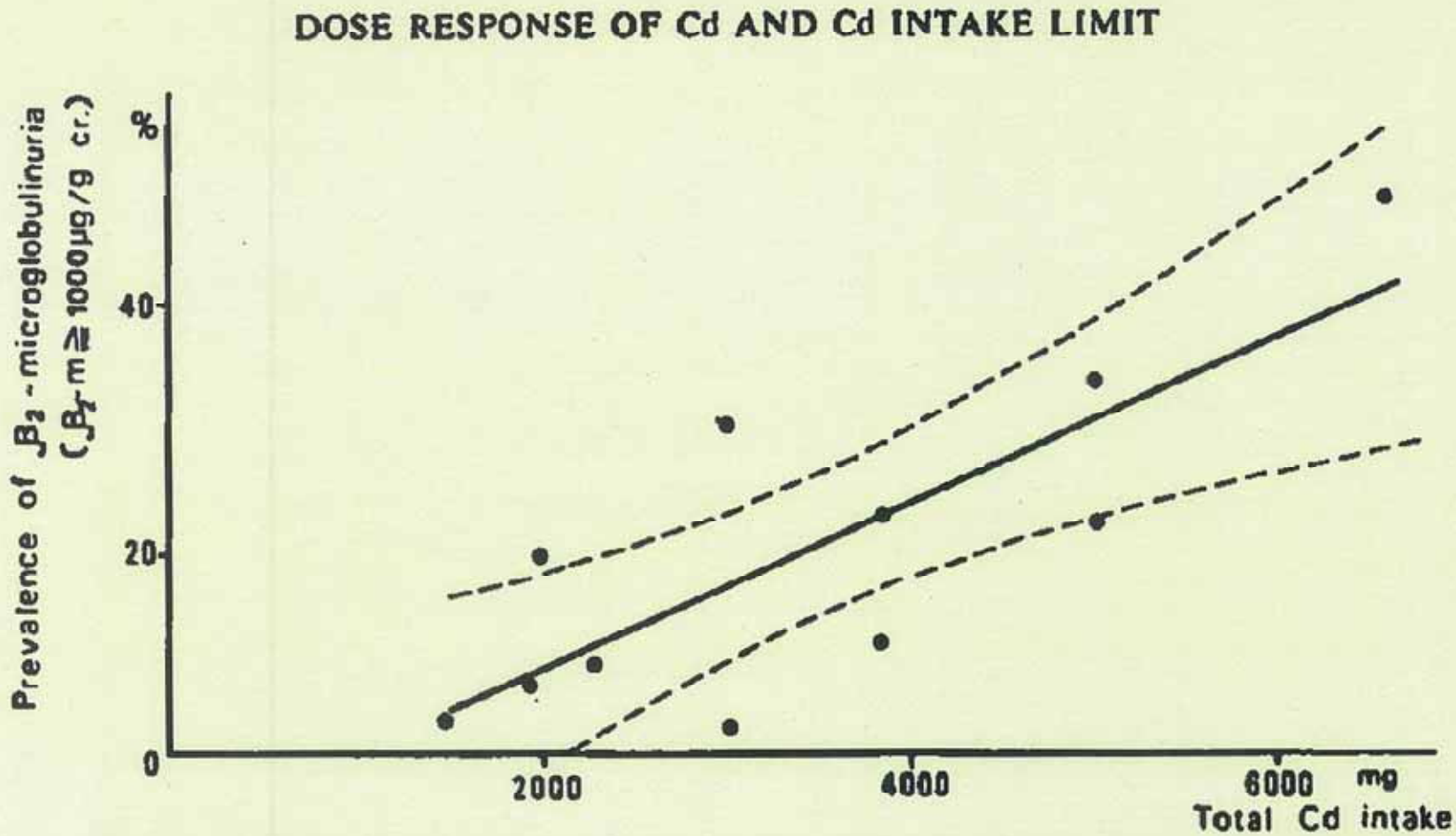


FIG. 2. Correlation between total Cd intake and prevalence of β_2-m-uria (β_2-m $\geq$ 1000 μg/g cr.) for the Cd-exposed male group. The regression line is $Y = 0.0083X - 7.93$ ($r = 0.81$; $P < 0.01$).

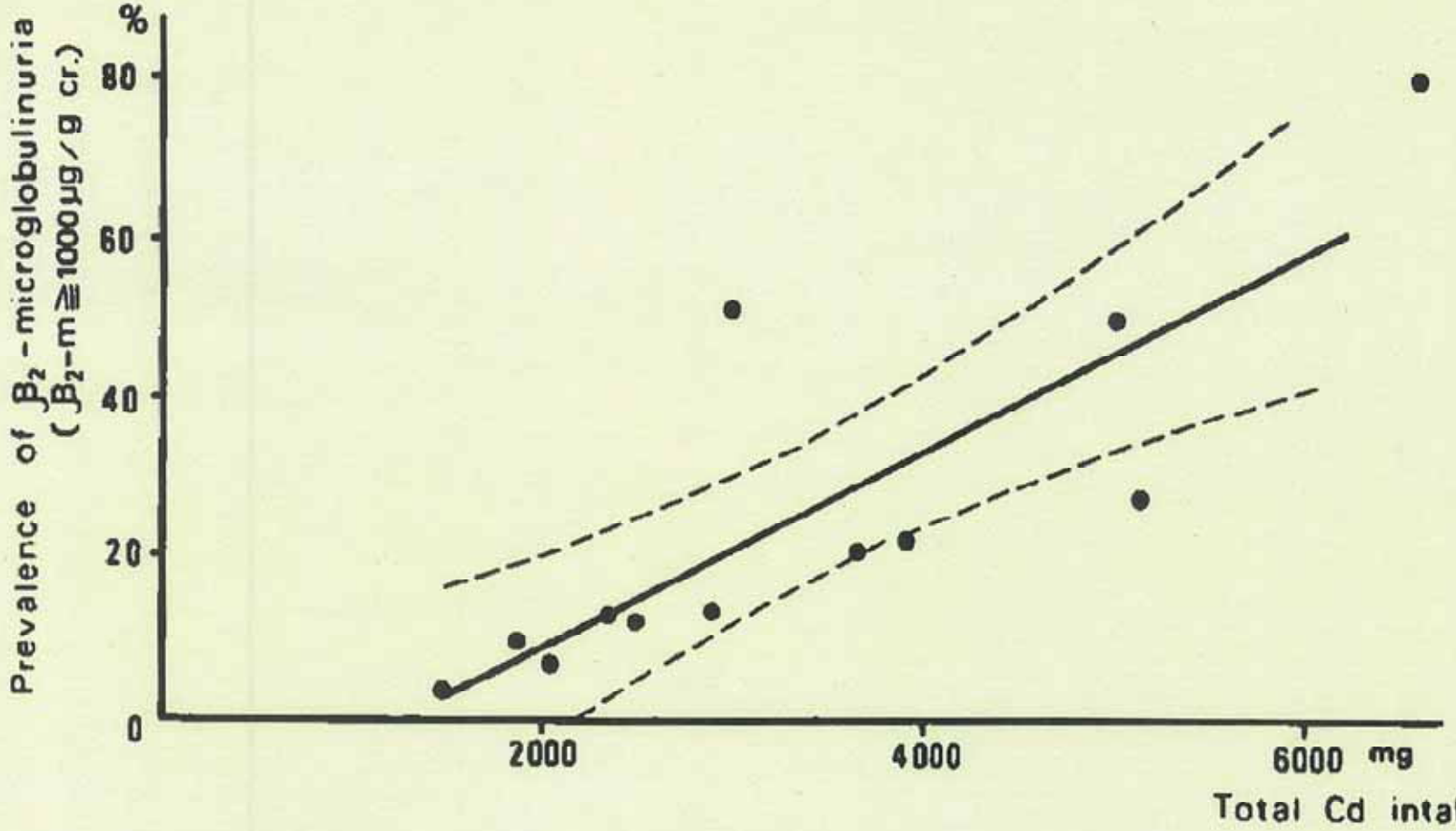
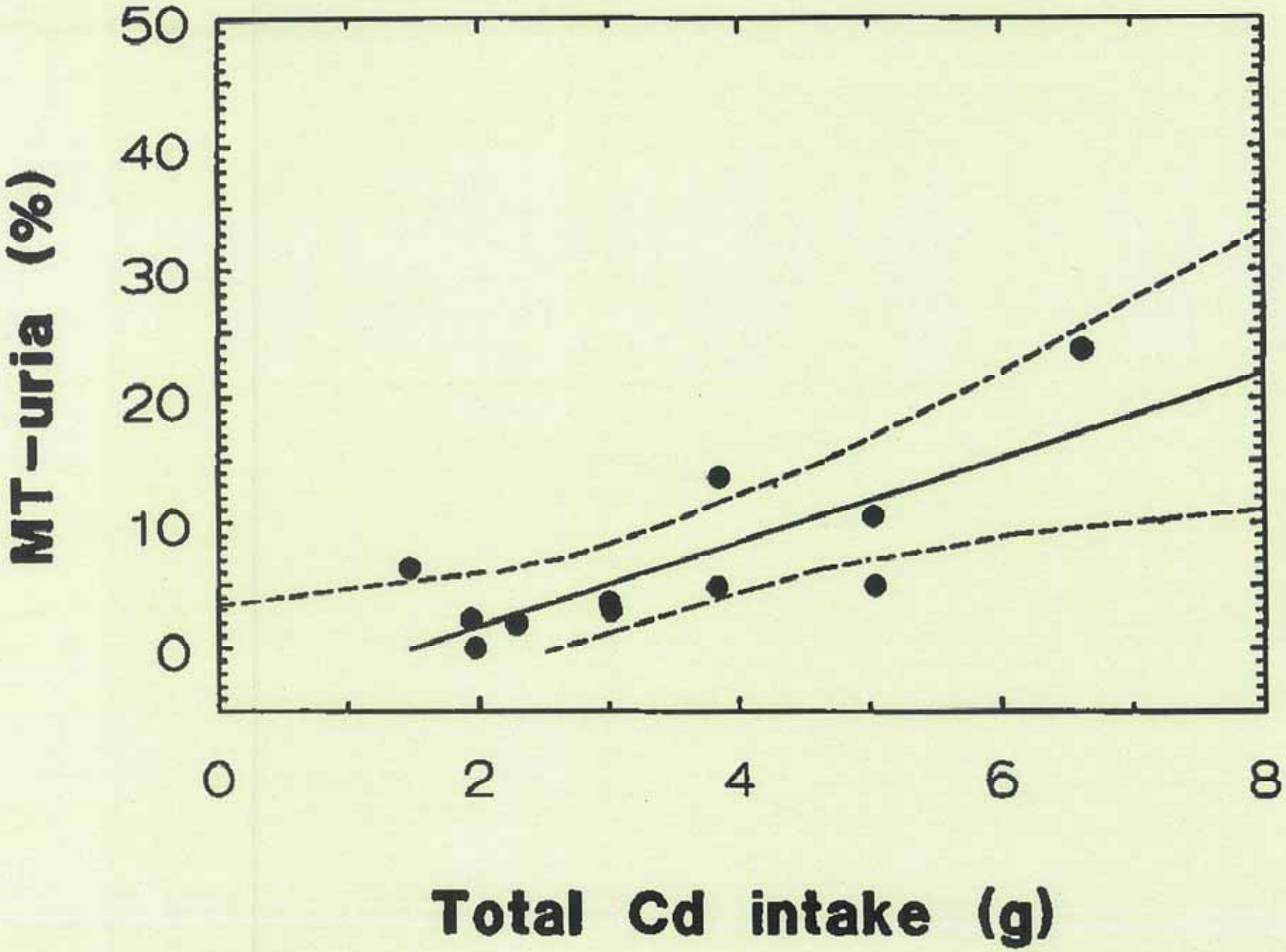
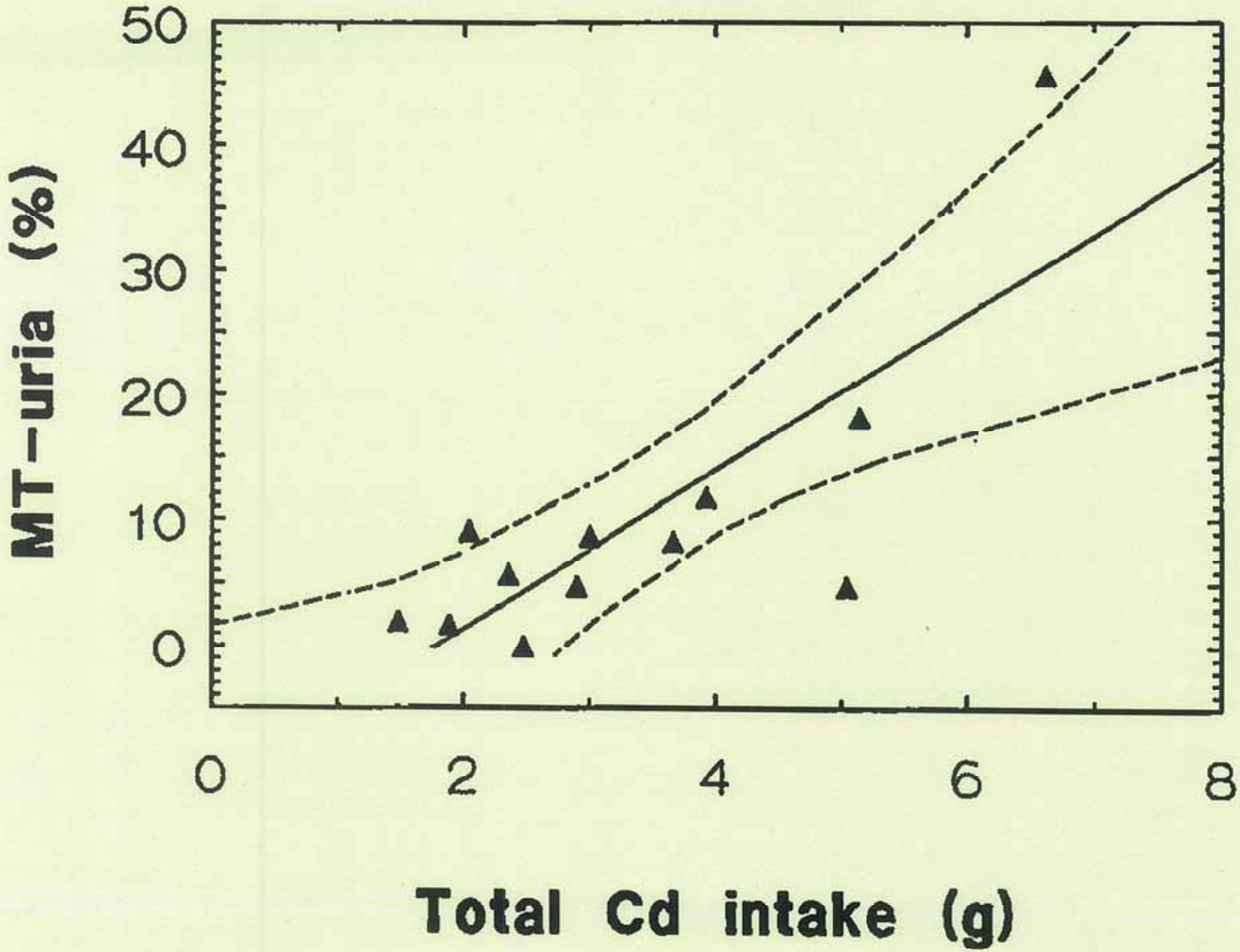


FIG. 4. Correlation between total Cd intake and prevalence of β_2-m-uria (β_2-m $\geq$ 1000 μg/g cr.) for the Cd-exposed female group. The regression line is $Y = 0.012X - 16.16$ ($r = 0.84$; $P < 0.001$).


MT-uria (%)
50
40
30
20
10
0
0
2
4
6
8
Total Cd intake (g)


MT-uria (%)
50
40
30
20
10
0
0
2
4
6
8
Total Cd intake (g)

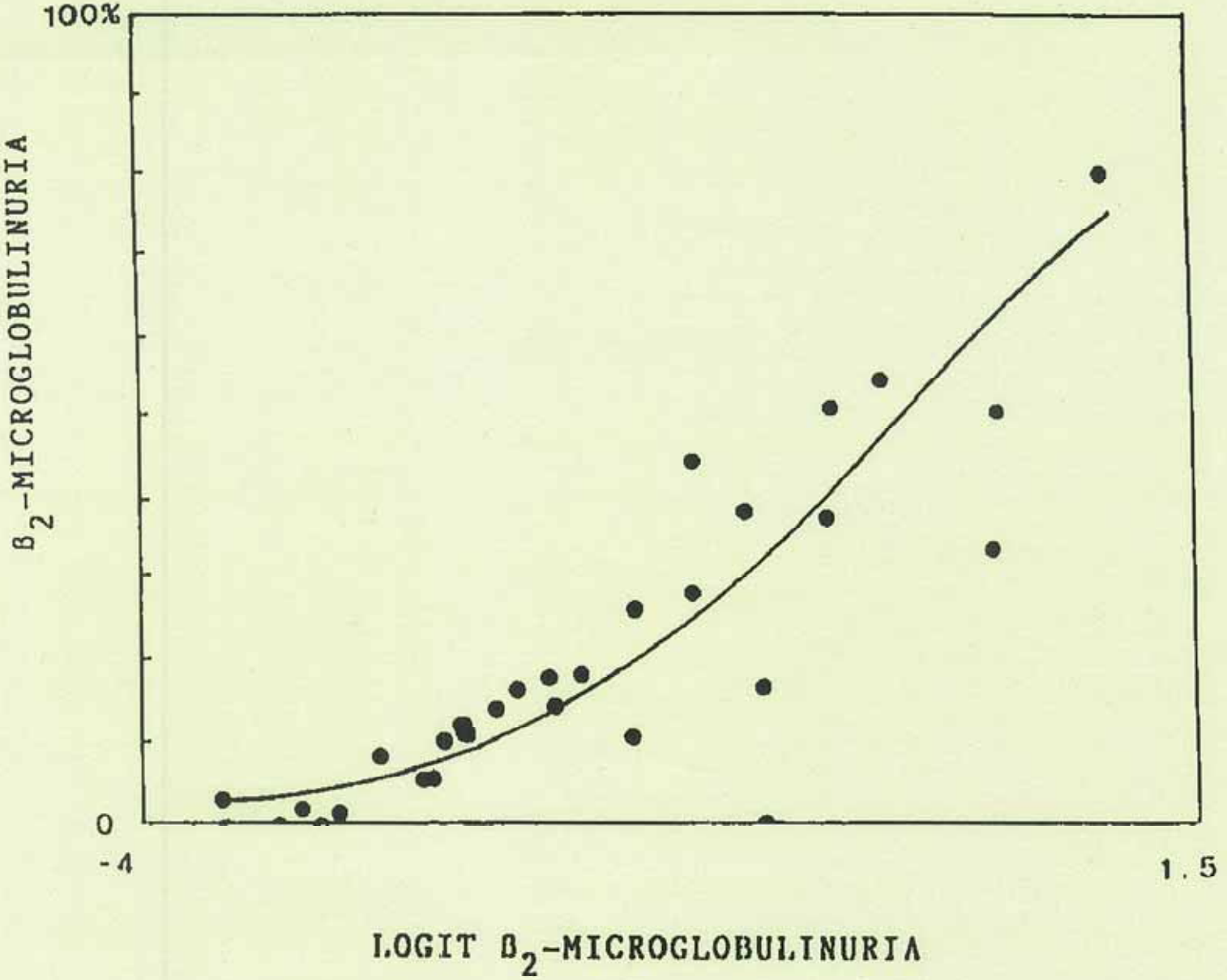


Fig. 1. Prevalence of β_2-MG-uria in the Cd-exposed women and their logistic model in the case of β_2-MG expressed as μg/g·cr.

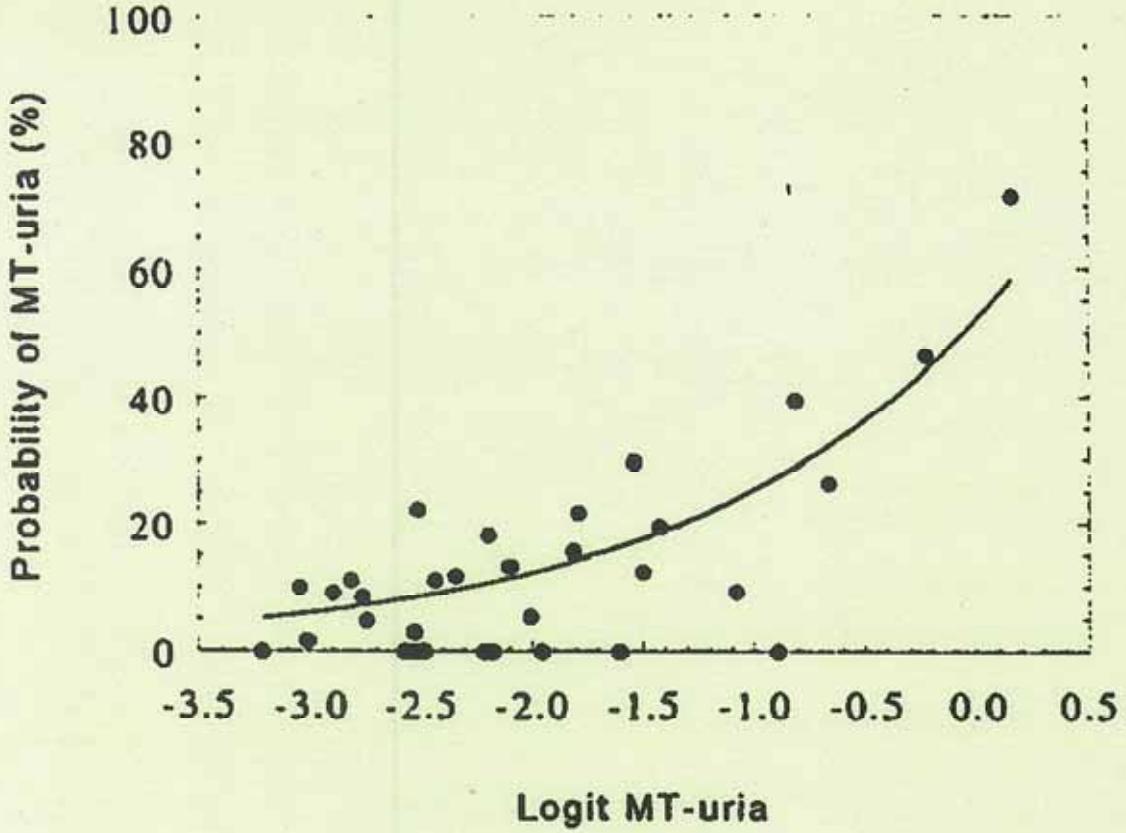


Fig. 1. Logistic regression analysis of the prevalence of MT-uria in the Cd-exposed women. Data are for MT values expressed as μg/g creatinine. The probability of MT-uria (prevalence, %) and ln odds (logit) MT-uria are plotted. Exponential fit, correlation coefficient = 0.75.
Logit MT-uria = –4.6773 + 0.0119 (Age) + 0.000566 (Total Cd intake)

Fig. 7 Prevalence of metallothioneinuria (μg/1) corresponding to each age and total cadmium intake calculated by general linear model

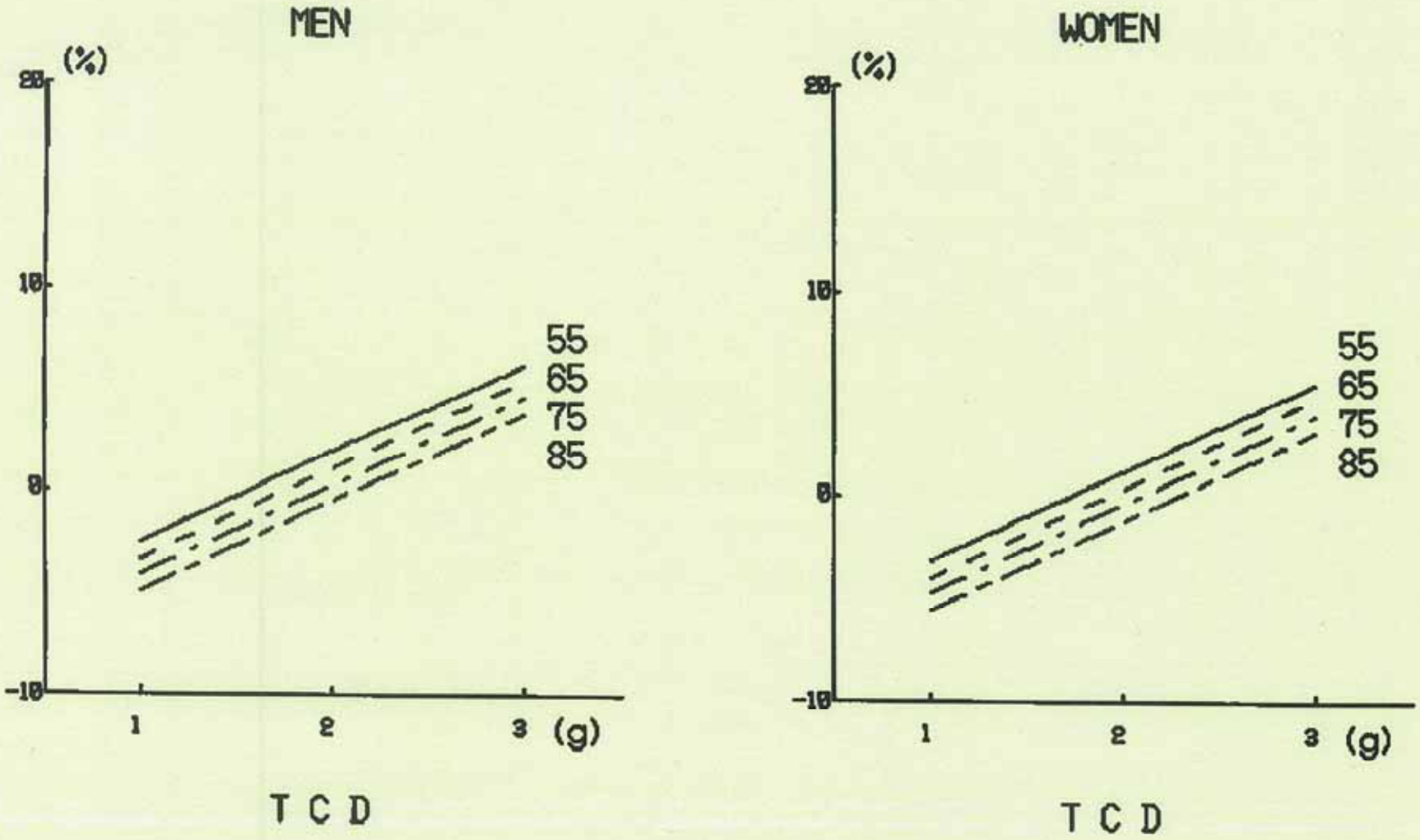
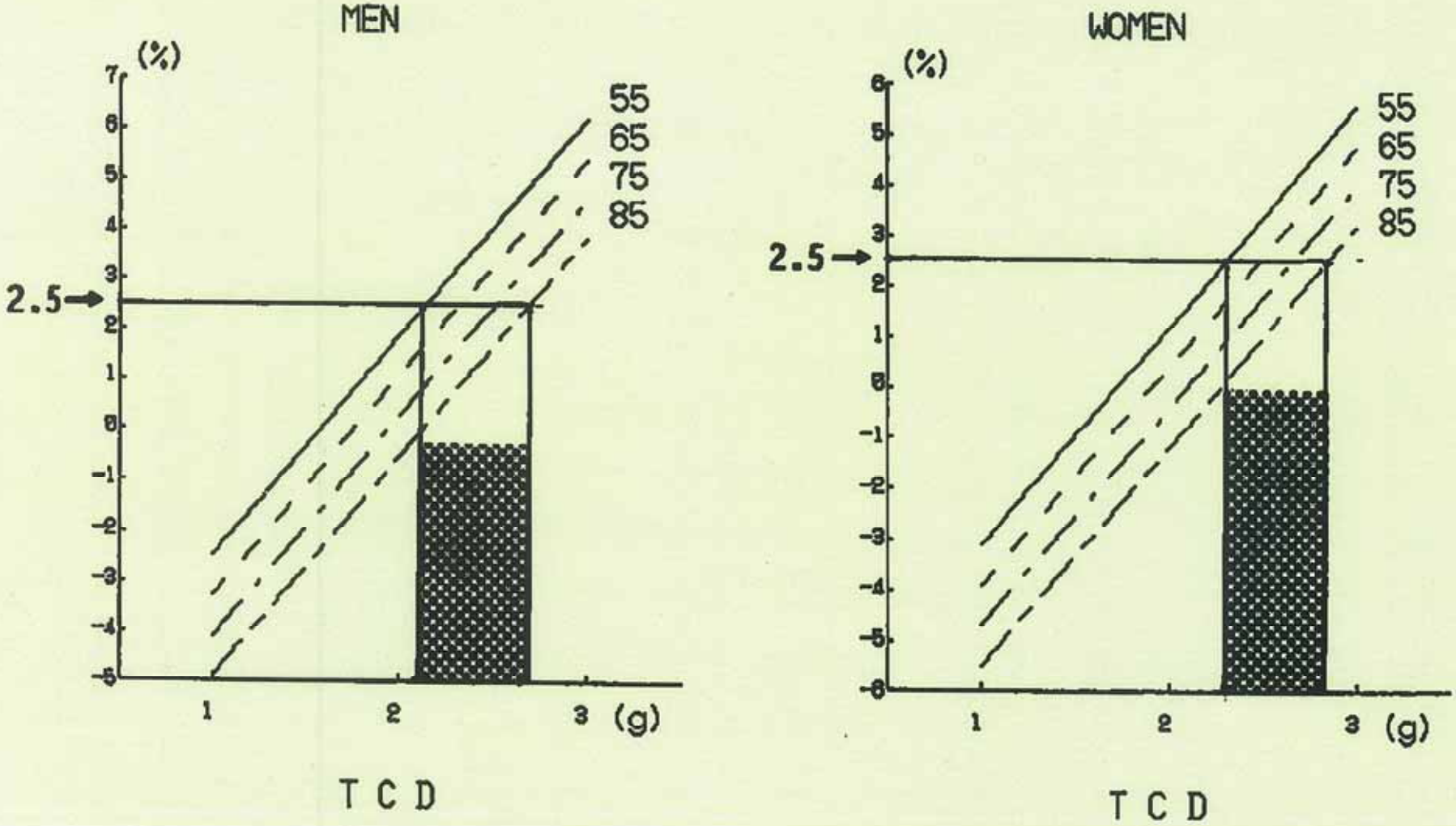


Fig. 10 Ranges of total Cd intakes corresponding to 2.5 % of prevalence of metallothioneinuria in the nonexposed men and women



2g of total Cd intake

[Example]

In case of 80 yr is

= 25 mg / yr (2000 mg / 80 yr)

= 68 μg / day (25,000 μg / 365 days)

< 80 μg (0.4 ppm x 200 g) + α

Cut-off value of rice in Japan

Other foods

Conclusion(1)

- Prevalence of β_2-MG-uria (> 1,000 μ g / g cr.) was 14.3 % in men and 18.7% in women in Cd-polluted areas of Kakehashi River basin, while it was 6.0 % and 5.0 % in men and women in unpolluted areas, respectively.

Conclusion(2)

- Once Cd-induced renal tubular dysfunction occured, it was irreversible even after cessation of Cd-exposure.
- Bone damage such as osteopenia was also found in Cd-exposed subjects with renal tubular dysfunction.

Conclusion(3)

- Total Cd intake corresponding to maximum allowable Cd concentration in urine was calculated as approximately 2 g for both of men and women using linear regression and multivariate analysis.