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A chromosome study among worker groups in the rubber industry

by Marja Sorsa, PhD, Jorma Mäki-Paakkanen, BSc, Harri Vainio, MD¹

SORSA M, MÄKI-PAKKANEN J, VAINIO H. A chromosome study among worker groups in the rubber industry. *Scand j work environ health* 9 (1983): suppl 2, 43-47. Two cytogenetic endpoints, structural chromosome aberrations and sister chromatid exchanges, were analyzed in the blood lymphocytes of several worker groups and referents for an evaluation of possible work-related exposures to chromosome-damaging agents. A total of 35 referents and 55 rubber workers, the latter representing six job categories in two rubber factories, were included in the study. The two job categories frequently revealing increased sister chromatid exchanges or chromosome aberrations were mixers and weighers of chemicals. Statistically significantly increased sister chromatid exchange values were found among the weighers and the mixers. When chromosome aberrations were analyzed, only the group of nonsmoking weighers showed significantly higher values than the reference group. Smoking was found to correlate with increased frequencies of sister chromatid exchanges and chromosome aberrations among both the workers and the referents.

Key terms: biological monitoring, carcinogenicity, chromosome aberrations, genotoxicity, mutagenicity, sister chromatid exchanges.

The strategy of monitoring identified high risk groups for cytogenetic endpoints in somatic cells is becoming an acceptable approach in occupational health practice. Knowledge of the genotoxic characteristics of the huge array of chemicals and mixtures used in the rubber industry is still rather limited, even though outstanding efforts have recently been made to identify their genotoxic properties and to add to a better understanding of them (see the articles in this volume). Because of the multiplicity of the exposure pattern, the idea of the present surveillance approach was not to identify cytogenetic effects caused by exposures to a single known chemical, but rather to try to point out the potentially hazardous job categories among the complex procedure of rubber manufacturing.

The results of this cytogenetic surveillance project in the rubber industry have

been partly discussed earlier for the data on sister chromatid exchanges (8, 10) and for the structural chromosome aberrations (7). In this paper emphasis is placed on the correlation of the results concerning sister chromatid exchanges and chromosome aberrations among the different groups of rubber workers. The detailed results concerning individuals will be reported in a separate paper (Mäki-Paakkanen et al, unpublished).

Subjects and methods

Male (N = 51) and female (N = 4) workers in two rubber factories (A and B) were the subjects of the study, while the reference groups comprised male (N = 31) and female (N = 4) persons working in office occupations either in the rubber factory (reference group for factory B) or in two governmental institutions (reference group for factory A). The possible confounding factors of the cytogenetic analyses were controlled by blood count, interview, and medical records.

The whole blood microculture method with a 50-h culture time for the chromo-

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some aberration analysis and a 68-h culture time for the sister chromatid exchange analysis was used as has been described earlier in detail (5). The culture conditions were kept the same for all the blood samples collected from both the rubber workers and the referents. The total material was analyzed on coded slides by one person, samples from factories A and B separately.

Results and discussion

The results of the cytogenetic analyses among the different worker groups in factory A, manufacturing heavy and light tires, and in factory B, manufacturing various technical rubber products, are given in tables 1 and 2. The worker groups significantly deviating from the respective smoking or nonsmoking reference group with a higher mean frequency of sister chromatid exchanges were the workers (smokers) in the mixing and weighing departments of factory A and workers (nonsmokers) in the weighing department of factory B. Also the vulcanizers in both

factories, the tire builders of factory A, and the mixers of plant B showed elevated frequencies of sister chromatid exchanges when compared with the respective reference group, even though the differences were not statistically significant.

When the mean frequencies of chromosome aberrations were compared, only the group of nonsmoking weighers in factory B differed from the respective group of nonsmoking referents.

Furthermore cigarette smoking was clearly observed to be correlated with an increased frequency of sister chromatid exchanges and chromosome aberrations, both among the groups of rubber workers and among the referents.

The differences between the groups of referents or workers in the two rubber factories were not significant in respect to the frequency of sister chromatid exchanges, except for the nonsmoking workers, for whom the sister chromatid exchanges were slightly lower ($p < 0.05$) in factory A than in factory B (see tables 1 & 2). However the basic level of the frequency of chromosome aberrations was

Table 1. Frequency of structural chromosome aberrations (CA) (100 cells analyzed per subject) and sister chromatid exchanges (SCEs) (30 cells analyzed per subject) among the worker groups of factory A and the reference group.

	Number of subjects	Mean age (years)	Mean length of exposure time (years)	Mean percentage of cells with CA		Frequency of SCEs	
				Including gaps	Excluding gaps ^a	Mean of the mean SCEs/cell	SE
Weighers and mixers							
Smokers	6	36.7	5.5	4.0	6.3	13.7	0.6 ^{b,c}
Nonsmokers	4	47.0	7.0	3.0	3.8	11.5	0.7
Tire builders							
Smokers	4	24.0	1.5	2.0	3.3	13.1	1.5
Nonsmokers	4	32.3	5.8	1.8	2.5	11.3	0.6
Vulcanizers							
Smokers	4	36.3	8.8	2.8	3.8	12.2	0.8
Nonsmokers	6	40.5	11.7	2.8	4.7	11.0	0.5
All exposed workers							
Smokers	14	32.9	5.0	3.1	4.7 (3.1)	13.1	0.5 ^d
Nonsmokers	14	40.0	8.6	2.6	3.8 (1.7)	11.2	0.3 ^e
Referents							
Smokers	5	35.8	—	4.8 ^f	5.6 ^g (3.9)	11.5	0.6
Nonsmokers	12	34.1	—	2.4 [—]	3.4 [—] (1.7)	10.4	0.3

^a Gaps are generally considered insignificant parameters for clastogenicity; the values in parentheses are standard deviations.

^b $p < 0.05$, compared with smoking referents (one-sided t-test).

^c $p < 0.05$, compared with nonsmokers in the same job category (one-sided t-test).

^d $p < 0.01$, compared with nonsmokers in the group (one-sided t-test).

^e $p < 0.05$, compared with nonsmoking referents (one-sided t-test).

^f $p < 0.01$, compared with nonsmoking referents (chi-square test).

^g $p < 0.05$, compared with nonsmoking referents (chi-square test).

significantly ($p < 0.01$) higher among both the smoking and nonsmoking workers of plant B as compared to the workers of plant A, but also among the nonsmoking referents of plant B as compared to the nonsmoking referents of plant A ($p < 0.05$). Because the increase was seen in both the referents and the workers of plant B, the exposure conditions in the two factories, judged on the basis of chromosome aberration frequencies, cannot be considered to be essentially different. However the result points to the absolute necessity of a concurrent reference group in cytogenetic surveillance studies.

The means of the chromosome aberrations between the whole groups of rubber workers and the referents are at almost exactly the same level [3.7 (SD 2.4) for workers, 3.9 (SD 2.3) for referents – gaps excluded]. Among the individual results the tendency towards an increased chromosome aberration frequency for smoking individuals can be noticed.

Even though the sensitivity of the structural chromosome aberrations in identifying individuals potentially at risk in the rubber industry seems to be lower than with the sister chromosome exchange method, a positive correlation ($r = 0.32$; $t = 3.2$; $p < 0.01$) existed between the individual sister chromosome exchange values and the chromosome aberration frequencies (fig 1). Although the variation between individual results is wide, the group showing the most deviant high values for both chromosome aberrations and sister chromatid exchanges are the smoking rubber workers. Respectively, the individuals most frequently with low values for both parameters are the nonsmoking referents.

On the basis of the present study the sister chromosome exchange analysis seems to be a more sensitive indicator of exposure to genotoxic chemicals in the rubber factory; the slight increase of chromosome aberrations is generally left

Table 2. Frequency of structural chromosome aberrations (CA) (100 cells analyzed per subject) and sister chromatid exchanges (SCEs) (30 cells analyzed per subject) among the worker groups of factory B and the reference group.

	Number of subjects	Mean age (years)	Mean length of exposure time (years)	Mean percentage of cells with CA		Frequency of SCEs	
				Including gaps	Excluding gaps ^a	Mean of the mean SCEs/cell	SE
Weighers							
Smokers	6	38.2	8.0	4.7	4.7	12.6	1.0
Nonsmokers	3	35.3	5.0	5.7	8.3 ^b	12.0	0.8 ^c
Mixers							
Smokers	7	39.9	8.3	5.1	6.6	13.7	0.6 ^d
Nonsmokers	3	43.0	14.5	4.0	6.0	11.5	0.7
Cleaners							
Nonsmokers	1	63	4.0	1.0	2.0	11.3	
Vulcanizers							
Smokers	2	39.5	1.0	9.0	10.5	12.8	1.5
Nonsmokers	2	36.5	1.0	2.0	4.5	13.9	1.7
Molders							
Smokers	2	30.0	1.5	3.0	5.5	12.0	1.2
Nonsmokers	1	29	3.0	4.0	9.0	12.5	
All exposed workers							
Smokers	17	38.1	6.5	5.2	7.0 (2.9)	13.0	0.5
Nonsmokers	10	39.7	5.9	3.8	6.3 (3.4)	12.2	0.5 ^e
Referents							
Smokers	9	38.2	–	5.7 ^b	7.2 (1.9)	12.6	0.4 ^f
Nonsmokers	9	40.3	–	3.7	5.2 (1.3)	10.7	0.3

^a Gaps are generally considered insignificant parameters for clastogenicity, the values in parentheses are standard deviations.

^b $p < 0.05$, compared with nonsmoking referents (chi-square test).

^c $p < 0.05$, compared with nonsmoking referents (one-sided t-test).

^d $p < 0.05$, compared with nonsmokers in the group (one-sided t-test).

^e $p < 0.01$, compared with nonsmoking referents (one-sided t-test).

^f $p < 0.001$, compared with nonsmoking referents (one-sided t-test).

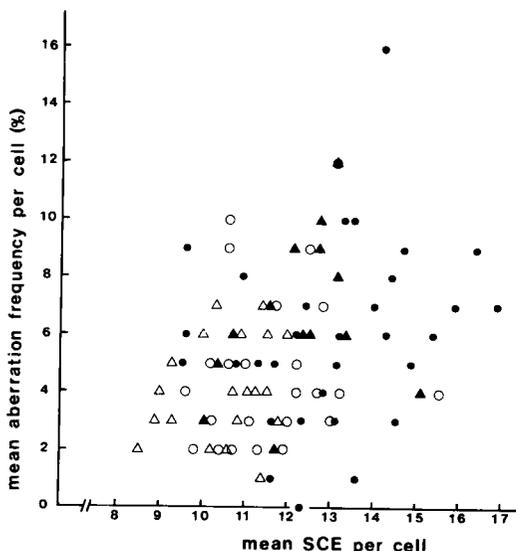


Fig 1. Correlation of the individual frequencies of structural chromosome aberrations and sister chromatid exchanges (SCE) in the blood lymphocytes of rubber workers and referents (○ = non-smoking rubber worker, ● = smoking rubber worker, △ = nonsmoking referent, ▲ = smoking referent)

statistically nonsignificant because of the small number of individuals (and cells analyzed) in the smoking and nonsmoking subgroups.

Experience and viewpoints from other occupational or environmental monitoring studies vary in respect to which of the two methodologies has the better sensitivity. For example, for vinyl chloride workers chromosome aberrations were considered a better parameter of exposure (1), while among cigarette smokers, the sister chromatid exchange response seems to be a more sensitive indicator of exposure (4).

The exact molecular mechanism and the nature of lesions leading to sister chromatid exchanges has not yet been established, but it is generally considered that these exchanges can be a manifestation of a slightly different type of damage in the deoxyribonucleic acid than what is necessary for structural chromosome aberrations [see, eg, the report of Carrano & Moore (2)]. Consequently different types of mutagenic agents specifically induce sister chromosome exchanges or chromosome aberrations; thus the importance of including both of these methods in cytogenetic monitoring programs should

be stressed (6, 9), especially when exact information on exposure and its characteristics is unavailable.

The results of the present chromosome study, well in accordance with the biological monitoring data obtained by the urine mutagenicity assay of the same worker groups [see the report by Falck in this volume (3)], thus identify the chemical weighing and mixing departments in the processing of rubber as sites where potentially hazardous exposures may occur.

At the present state of the art, cytogenetic surveillance data can be used for qualitative risk estimation. The rationale includes that any exposure capable of producing genetic damage, detectable with cytogenetic analyses, must be considered undesirable.

The data from the present study suggest that within the rubber industry a few job categories may involve higher risks than others. Hygienic improvements focused towards minimizing exposures in the mixing and weighing operations are thus necessary. In fact, actions towards this end have already been taken in the two rubber factories concerned. Prospective and intervention types of studies would be necessary to show the efficiency of the hygienic improvements.

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