ECOLOGY

Mutagenic Effect of Vibration in Combination with Some Chemical Mutagens

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 125, No. 4, pp. 454-456, April, 1997
Original article submitted January 27, 1997

The effect of vibration on the occurrence of micronuclei in bone marrow polychromatophile erythrocytes is examined in combination with the standard mutagens benzene, orthoaminoazotoluol, quinoline, benzpyrene, and 2-acetaminofluorene. Mutagenic effect of benzpyrene was studied against the background of long-term (3 days or 2 months) vibration. Reduction in mutagenicity was observed with all studied agents. It was demonstrated that vibration modifies the effects of some mutagens and elicits effects opposite to those of the mutagens in the micronuclear test.

Key Words: *vibration; mutagenicity; micronuclear test; modification of mutagenic effect*

So far, it remains unclear whether vibration produces mutagenic or antimutagenic effects. In the present study we examined the effect of vibration in combination with mutagens in the micronuclear test.

MATERIALS AND METHODS

Experiments were performed on 180 male albino mice of the same age and body weight. In the first series of experiments, the effect of a single exposure to vibration (equivalent corrected level of vibration rate 117 dB) on the mutagenicity of standard mutagens was examined in the micronuclear test. The following mutagens were used: benzene (purified from thiophene, 1600 mg/kg) orthoaminoazotoluol (0.25 mg/kg, Serva), benzpyrene (BP, 100 mg/kg, Merck), quinoline (100 mg/kg), and 2-acetaminofluorene (2-AAF, 0.6 mg/kg, Serva). The mutagens were injected intraperitoneally in a single dose immediately after vibration. Micronuclei in the brain marrow polychromatophile erythrocytes were counted after 72 h by the standard method [12]. The terms and doses were defined as suboptimal in preliminary experiments. In the second series of experiments the effect of vibration applied during a 3-day or 2-month period on the mutagenicity of BP was investigated. The data were processed using the exact method of Fisher and double-factor analysis of variance.

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RESULTS

All studied agents significantly increased the number of micronuclei of polychromatophile erythrocytes. The significance of the effect was also confirmed by analysis of variance. Vibration reduced the effects of all mutagens by 1.5-fold (Table 1). Similar results were obtained in experiments with BP and long-term vibration: for instance, vibration applied for 3 months decreased the mutagenic effect (ME) of BP by more than 3 times (Table 2). This change in ME is referred to as modification of ME. Modification is often regarded from the phenomenological viewpoint, without taking into consideration the nature and mechanisms of combined action [4,6,9,11]. However, the use of double-factor analysis of variance revealed new aspects in this problem, namely, the gradation of factors (vibration and mutagenesis) in

0007-4888/98/0004-0402$20.00

TABLE 1. Modification of the Effects of Mutagens by Vibration

Experimental conditions	Number of animals	Data obtained in the test ($\bar{X}$), %	Influence of the factors			
			vibration	mutagen	vibration+ mutagen	factors of experiment
Control	10	0.50 (60.0-160)				
Vibration	9	0.34 (29.4-147)				
2-AAF	7	1.56 (70.5-154)**				
Vibration+2-AAF	10	1.09 (55.0-147)*	0.11***	0.623*	0.031***	0.76*
BP	8	1.86 (69.9-140)**				
Vibration+BP	10	1.29 (62.0-140)*	0.032*	0.32	0.01	0.36***
Benzene	8	2.04 (53.8-295)**				
Vibration+benzene	9	1.43 (55.9-175)*	0.045***	0.607*	0.026	0.68*
Quinoline	6	1.83 (54.6-219)**				
Vibration+quinoline	7	1.19 (42.0-151)*	0.071	0.521	0.026	0.61*
Orthoaminoazotoluol	8	1.53 (52.8-157)**				
Vibration+orthoaminoazotoluol	10	1.09 (64.2-156)*	0.07**	0.62**	0.015	0.705*

Note. Here and in Table 2: the interval (% of X) between minimal and maximum value of the sample is given in parentheses; $p<0.025$: *compared with isolated influence, **compared with the control. Here and in Table 3: the intensity of influence: *0.999, **0.99, ***0.95.

the first series of experiments was significant only for the vibration+2-AAF combination (Table 1). Therefore, modification of ME was relevant only with 2-AAF, but not with benzene, orthoaminoazotoluol, quinoline, and BP [7,10]. The approach when the effect of interaction in a two-component complex is confirmed by a double-factor analysis of variance has been employed by several researchers and by WHO [2,3,5,7,13]. In our classification, modification of ME differ both in the result, i.e., the effect intensity, and in the mechanism. Only the interaction between a mutagen and the agent that modifies ME but possesses no mutagenic activity is regarded as a true modification [8]. In our experiments, vibration displayed no mutagenic activity in the micronuclear test, but markedly changed effects of other mutagens, i.e., ME modification is relevant. Thus, the vibration+2-AAF combination can be regarded as a true modification. However, changes in experimental conditions may change the characteristics of modification. For instance, when the period during which vibration has been applied was prolonged to 2 months, the interaction between vibration and mutagen becomes statistically significant (Table 3); hence, BP and prolonged preliminary vibration can be referred to as true modification. The influence of the original background reactivity on ME has been demonstrated [4].

Presumably, the mechanism of the modifying influence of vibration on the effects of mutagens with different mechanisms of action is nonspecific. It may be associated with increased rate of mutagen clearance [8]. This suggestion is consistent with a decrease in the arsenic content in the gonads of animals with a simultaneous suppression of ME of this agent in the dominant lethal allele test [6]. It is indirectly confirmed by the effects of vibration. The number of micronuclei decreases under the action of vibration below the background level, the decrease being statistically significant with prolonged (2 months) vibration (Tables 1 and 2). This "antimutagenic effect" of vibrations in the absence of mutagen, i.e., a specific variant of modification may be associated with increased clearance of endogenous or exogenous (food) mutagens, which is consistent with the data

TABLE 2. Modification of the Mutagenic Effect of BP by Long-Term Vibration

Experimental conditions	Vibration 3 days ($\bar{X}$)	Number of animals	Vibration 2 days ($\bar{X}$)	Number of animals
Control	0.605 (54.5-165)	6	0.605 (54.5-165)	6
Vibration	0.33 (0-303)	6	0.23 (0-217)	8
BP	1.48 (54.0-176)**	6	2.32 (28.6-162)**	7
Вибрация+БП	1.26 (0-195)	6	0.36 (0-361)*	9

Note. Data obtained with 2-month vibration served as the control.

TABLE 3. Modification of Mutagenic Effect of BP by Vibration (Double-Factor Analysis of Variance)

Parameter	Vibration								
	1 day			3 days			2 months		
	vibration	mutagen	vibration+ mutagen	vibration	mutagen	vibration+ mutagen	vibration	mutagen	vibration+ mutagen
η^2	0.033	0.32	0.01	0.21	0.4	0.24	0.29	0.18	0.24
F	1.53	15.1^{+}	0.48	7.49^{+++}	14.2^{++}	8.54^{++}	17.7^{++}	10.9^{++}	7.92^{++}

obtained in experiments with arsenic [6]. This is also confirmed by contralateral effects of vibration and mutagens.

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