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Short Note

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Susceptibility to Motion Sickness

Krishan Sharma

Department of Anthropology, Panjab University, Chandigarh, India

A sample of 119 pairs of twins, together with their 87 siblings and 100 pairs of parents, were examined with respect to susceptibility to the motion sickness syndrome. Children were found to exhibit resistance to the syndrome below two years of age, and females were more susceptible than males. The incidence appeared to be highest in families with both parents affected. Concordance rates were much higher in MZ (100%) than in DZ pairs (27.6%). Genetic effects are likely, but cultural factors should not be ignored.

Key words: **Motion sickness, Concordance, Children resistance, Female susceptibility, Cultural Factors, Twins**

INTRODUCTION

The term "motion sickness" was recorded by Irwin in 1881 [10], but was popularized by Sir Frederick Banting during the Second World War when sea and air sickness were studied together. Since then, much knowledge about motion sickness has accumulated. The literature is voluminous, and many reviews have been published [cf, eg: 3, 15, 24]. The disorder can be defined as a syndrome characterized by anorexia, nausea, dizziness, and vomiting in response to certain kinds of motion. The principal causes are visual, kinesthetic (ie, related to the sense of perception of movement), and psychologic; the vestibular apparatus is said to be involved [16]. Further details are given by Money [15].

Motion sickness is a general term that includes not only air and sea sickness but also the sickness caused by a variety of vehicles and devices (automobiles, buses, trains, swings, etc). Susceptibility to this disorder presents considerable variation [9]. It would appear [22] that 1–2% of the population is susceptible to all kinds of moving vehicles from early childhood and that 30% show symptoms of motion sickness when the motion is quite rough. Children have been found to be relatively resistant before the age of six years [5]. A genetic factor for excessive susceptibility [12] and an association, possibly of a genetic nature, of Heberden's arthritis, migraine headache, and motion sickness [11] have been suggested. Females have been reported to be more prone than males, and polygenic inheritance has also been advocated [1]. Dogs appear to have roughly the same susceptibility as humans [17, 18], while a lesser but unambiguous susceptibility has been found in many other species (eg, horses, cows, monkeys various kinds of birds) [3, 13], chimpanzees [7], and seals [3, 4]. Still, very little is known of the factors that underlie susceptibility to motion sickness. The present twin and family study has therefore been undertaken.

TABLE 1. The Twin Sample by Age, Sex, and Concordance for Motion Sickness

Age (years)	Sex	Number of pairs	Motion sickness		
			++	+ –	– –
2	MM	3	...	...	3
	FF	1	...	...	1
	MF	2	...	1	1
3	MM	3	...	...	3
	FF	1	...	...	1
	MF	1	...	...	1
4	MM	5	...	...	5
	FF	5	...	2	3
	MF	3	...	2	1
5	MM	1	1	...	...
	FF	1	...	...	1
	MF	3	...	1	2
6	MM	6	...	...	6
	FF	...	...	...	...
	MF	5	1	...	4
7	MM	1	...	...	1
	FF	3	1	1	1
	MF	2	...	1	1
8	MM	4	...	1	3
	FF	1	...	...	1
	MF	...	...	...	...
9	MM	2	1	1	...
	FF	2	...	...	2
	MF	1	...	...	1
10	MM	1	...	...	1
	FF	...	...	...	...
	MF	1	...	1	...
11	MM	2	...	...	2
	FF	4	2	...	2
	MF	1	...	1	...
12	MM	1	...	...	1
	FF	1	...	...	1
	MF	2	...	1	1
13	MM	2	1	...	1
	FF	2	...	...	2
	MF	...	...	...	...
14	MM	3	1	...	2
	FF	3	1	1	1
	MF	2	...	1	1
15	MM	3	1	...	2
	FF	...	...	...	...
	MF	1	...	...	1
16	MM	5	1	1	3
	FF	2	...	1	1
	MF	1	...	...	1
17	MM	3	...	...	3
	FF	4	2	1	1
	MF	...	...	...	...
18 and more	MM	5	1	1	3
	FF	11	...	2	8
	MF	3	1	...	2
Total		119	16	21	82

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MATERIAL AND METHODS

A sample of 119 twin pairs, with their 87 siblings and 100 pairs of parents, was ascertained through inquiries at Chandigarh schools and hospitals. Zygosity determination, based on blood groups (A_1A_2BO, Rh, MN), ABH secretion, GPD, PTC, dermatoglyphics, and anthropometry, resulted in 28 MZ and 91 DZ pairs.

Two types of techniques are generally employed in assessing susceptibility to motion sickness. In the first, (swing test, "Roll Rocker" machine, etc) subjects are exposed to a rapid change in acceleration and then are graded in terms of number of symptoms manifested [2, 8, 20, 23]. The second type of technique involves a personal history questionnaire [14, 19, 21]. Both approaches are reasonably valid and correlated well [2, 20]. The questionnaire technique appears to be somewhat more valid, in that it covers a wider variety of types and conditions of motion sickness than does the exposure technique. Hence, the questionnaire approach was used for the present study. Each subject was asked to indicate how often he or she had felt nauseated and/or vomited while travelling on various types of vehicles (cars, buses, trains, aeroplanes). Only those subjects were earmarked as susceptibles who had travelled in any of these vehicles more than five times and had manifested the symptoms of motion sickness. Twins below two years of age were not included in the genetic analysis, because none of 11 such twin pairs manifested any symptom of the syndrome.

Table 1 shows the distribution of the twin sample by age, sex, and presence/absence of motion sickness in the cotwins.

RESULTS

Incidence of motion sickness in the sample is presented in Table 2. In the calculations, all like-sexed concordant twin pairs were treated as single observations. The table shows that females (29.27%) are more susceptible than males (16.6%), the difference being highly significant ($P < 0.001$).

Table 3 shows concordance for susceptibility to motion sickness to be as high as 100% in MZ twins vs only 27.6% in DZ twins. However, when concordant MZ twins were compared by Gedda's clinical cotwin method [6], three of eight MZ pairs showed differences between cotwins in degree of severity and susceptibility. In one MZ concordant pair, one twin suffered from motion sickness when he travelled on hills, but not on plains, whereas his cotwin suffered both on hills and on plains. Similarly, the other two concordant pairs showed quantitative differences in the severity of manifestation and susceptibility to the disorder. Among DZs, the highest discordance rate (81.82%) was shown by opposite-sex pairs (MF), which can be attributed to the higher incidence of motion sickness among females as compared to males: In the nine discordant pairs, six were susceptible females and three were susceptible males, thus forming the ratio of 2:1.

TABLE 2. Incidence of Motion Sickness in the Pooled Sample of Twin Subjects by Sex

	Symptoms of motion sickness		Total number observed
	+	−	
Males	44 (16.6%)	221 (83.4%)	265
Females	72 (29.27%)	174 (70.73%)	246
Total	116 (22.7%)	395 (77.3%)	511
	$\chi^2 = 11.66$	$P < 0.001$	

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TABLE 3. Twin Concordance Rates for Motion Sickness

Zygosity	Sex	Number of pairs	Motion sickness ++	Motion sickness +–	Motion sickness ––	Concordance (%)	Discordance (%)
MZ	MM	15	5	...	10	100	...
	FF	13	3	...	10	100	...
	Total	28	8	...	20	100	...
DZ	MM	35	2	4	29	33.33	66.67
	FF	28	4	8	16	33.33	66.67
	MF	28	2	9	17	18.18	81.82
	Total	91	8	21	62	27.60	72.40

TABLE 4. Motion Sickness in Families: Parents vs Children

Motion sickness in parents	Motion sickness in the children N	+	–	Total number of children
Both parents	8	9 (42.86%)	12 (57.14%)	21
One parent	40	25 (21.19%)	93 (78.81%)	118
Neither parent	52	20 (14.39%)	119 (85.61%)	139
	$\chi^2 = 9.85$		$0.01 > P > 0.005$	

TABLE 5. Acclimatization to Motion Sickness in the Parents

Incidence of acclimatization +	–	Mean age at acclimatization (years)	SD	Range (years)
11 (19.6%)	45 (80.4%)	22.3	4.88	12–28

When the parents are subdivided into three groups, according to whether both, one, or none had suffered from motion sickness, it is observed that children of the last group have the lowest incidence, and children of the first group have the highest incidence of motion sickness (Table 4), the difference being significant ($P < 0.01$). For calculating the incidence and chi-square values, each concordant MZ pair was counted as a single observation.

As shown in Table 5, 19.6% of the parents who suffered from motion sickness during childhood, adolescence, or later had become acclimatized against motion sickness, in a few cases as early as at 12 years of age.

DISCUSSION

The results indicate higher susceptibility to motion sickness in females than males. Second, children are found to be "relatively resistant" before the age of two years: None of the 11 pairs below two years of age manifested symptoms of motion sickness, although some of their parents were prone to the syndrome. Dylong's finding indicating resistance below six years of age [5] can therefore not be confirmed, although the condition was relatively less frequent in the age range 2–5 than in older groups (cf Table 1). Third, the data show a very significant association ($P < 0.01$) between parents and children in susceptibility to motion sickness. The incidence of susceptible children is highest when both parents manifest symptoms of the disorder.

The comparison of concordance rates in MZ (100%) and DZ twins (27.6%), together with the association between parents and children in susceptibility to motion sickness, clearly point to the existence of a genetic component, although cultural factors may obviously play a role. The latter might also partly explain the greater susceptibility of females to motion sickness. If a culture involved a lot of camel riding, sailing in small boats, extensive participation in sports, etc, then one might expect a decreased susceptibility from habituation in the more exposed male population. However, no study of cultural effects on the incidence of susceptibility to motion sickness has been done to date [Money, personal communication].

As regards the inheritance of the syndrome, the findings are in agreement with Abe et al [1] and do not favour simple models, not even assuming incomplete penetrance. The sex distribution of the syndrome might suggest partial sex-limited inheritance, but sex-linked inheritance is unlikely in view of the frequent occurence of father-to-son transmission of the syndrome. The variability in the degree of the susceptibility and manifestations of the syndrome in MZ twins may also suggest polygenic inheritance; however, the possibility of a single major locus for susceptibility to motion sickness cannot be ruled out, as in most of the families the syndrome is inherited as a typical dominant trait. The influence of environmental factors in precipitating the syndrome should not, however, be ignored.

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Correspondence: Krishan Sharma, H. No. 3276, Sector 21-D, Chandigarh-160022, India