Train Passengers Comfort with regard to Whole-Body Vibration

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A case study was conducted to evaluate passengers' comfort on the Tehran-Andimeshk train in Iran. Hence, based on *a*=0.05, 91 passengers were selected. Whole-body vibration transmitted to the passengers was measured according to ISO 2631-1-1997. The crest factors in the the majority of wagons were below the 19 dB according to ISO 2631-1-1997 hence, the equal acceleration levels of the wagons were taken into consideration. The statistical relationships between 15 psychological and physiological disorders with age, gender, number of the trips and A_{eq} (equivalent acceleration level) were studied based on the questionnaires. The results revealed no statistical relationships between the health symptoms and age. Conversely, there was a significant statistical relationship between fatigue and gender. Also, sleeplessness and hearing disorders bother the passengers during the trips based on statistical analysis. Moreover, there were statistical relationships between studying with headache and nausea with eating. In addition, despite all 15 symptoms bothering the passengers during the trips, there was only a significant statistical relationship between A_{eq} (equivalent acceleration level) and anger. Hence, more factors must be taken into consideration to find the other reasons of passengers discomfort during the trips.

Keywords: Whole-body vibration, Health symptoms, Passengers, Train, Iran

1. INTRODUCTION

Vibration can cause discomfort and annoyance, interfere with activities and present a risk to health. The minimization of vehicle vibration has been called the 'improvement of ride quality' a term which refers to some unspecified collection of effects of vibration. However, the effects of vibration on the body are numerous and cannot all be predicted with accuracy using any single simple procedure [1].

Discomfort or annoyance can arise from vibration occurring at any location in the body (e g the feet, abdomen, thorax, head or hands) [1].

It is believed that daily exposure to whole-body vibration over a number of years causes physiological and psychological disturbances of varying magnitude. Many experimental, mathematical modeling and epidemiological studies were conducted to determine possible adverse effects of whole-body vibration on human performance, safety and health [2].

Kjellberg and Wikstrom implied that stomach motility can be affected by whole-body vibration in certain frequency ranges and that low frequency random vibration exposure had no effect on postural control [3].

Low frequency vibration (less than about 0.5 Hz) can cause the motion sickness syndrome characterized by pallor, sweating, nausea and vomiting [4].

Scutter et al reported headache and

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neck pain among farmers exposed to whole body vibration while driving tractor [5].

Sevencan et al investigated whole body vibration among bus drivers and their results demonstrated a significant statistical relation between whole body vibration level and suffering from sleeplessness and fatigue ($p<0.05$) [6].

Also, sciatica, digestive disorders, genitourinary problems and hearing damage have been observed due to whole-body vibration [7].

In addition, vision is easily disturbed by some motions of the body. Most reported effects of whole-body vibration on vision arise from the reduced clarity of images on the retina of the eye due to eye movement [7].

Vibration might cause many types of health disorders –depending on its magnitude and location-but disorders of the back often been of greatest interest [1].

Therefore, the goal of this cross-sectional descriptive case study is to evaluate passenger comfort with regard to whole-body vibration as well as investigation of the prevalence and distribution of some vibration disorders in the Tehran-Andimeshk train. Moreover, it is the oldest train in Iran and the passengers are always dissatisfied during trips.

2. MATERIALS & METHODS

In this study data and information are obtained by different methods.

2.1. QUESTIONNAIRE SURVEY

To study the health effects of whole-body vibration and assessment of the relationship between these effects and age, gender and number of the trips on the Tehran-Andimeshk train, questionnaires were prepared using literature and consulting specialists, see references [2, 8-23]. These were completed during the trips by the passengers. Meanwhile, the questionnaires were validated by validity content and test-retest procedures. The questionnaires consisted of 9 questions, questions 1-4 were about demographic information and question No.9 was about health symptoms.

These questionnaires consist of two different parts:

2.1.1. Descriptive data

In this section variables such as: age, gender, number of trips and passengers activity were taken into consideration.

2.1.2. Investigation of the health symptoms due to exposure to vibration

Here, symptoms such as: headache, nausea, vision disorders, becoming cold and warm, aggression, vertigo, vomiting, digestive disorders, hearing disorders, loss of appetite, agitation, sleeplessness, urinary incontinence, anger, lack of concentration and fatigue have been considered during the trips.

It must be stated that in order to increase the confidence level of the questionnaires some interfering variables were taken into account as follows:

A. The researcher had explained the goals of the study to the passengers before the questionnaires had been completed.
B. All passengers who had chronic disorders such as: digestive disorders, vision disorders, chronic headache, migraine, motion disorders and nervous disorders were removed from the study. In addition, all passengers who take a trip less than 10 times a month are removed from the questionnaire.
C. The researcher had wanted the passengers to comment on health symptoms when the train is in motion compared with normal living routines.
D. The researcher had wanted the passengers to mention only the

Table 1. Number of the passengers in each line

Line	Number of passengers
1	20
2	21
3	28
4	22
Total	91

symptoms which cause disorders during the trips.

E. Passengers older than 15 years old were taken into consideration (Table II).

Based on $\alpha=0.05$, 91 passengers participated in this study. According to Table I line No.1 is representative for Tehran to Andimeshk for the first time, line No.2 is representative for Andimeshk to Tehran for the first time, line No.3 is representative for Tehran to Andimeshk for the second time and line No.4 is representative for Andimeshk to Tehran for the second time.

To measure vibration exposure level, different wagons of the train were selected. Vibration level of the wagon floor was measured. To analyze questionnaires, SPSS software and for graphs, excel software have been used.

Hence, a Brüel & Kjær human response vibration meter model 2512 was used. A whole-body vibration transducer formed in the shape of a pad of small diameter and covered with rubber material which is put between body and instrument. In this study a triaxial seat accelerometer model 4322 for determination of vibration motion with regard to whole-body vibration exposure was used. This accelerometer has triaxial transducers that are able to assess vibration in three directions (X,Y,Z).Aforesaid accelerometer consisted of a semi rigid rubber disk with diameter 250mm and in the middle of that, the triaxial accelerometer is housed on the rigid metal disk with diameter 75mm.

Therefore whole-body vibration transmitted to the passengers was measured according to ISO 2631-1-1997 [25].

3. RESULTS & DISCUSSION

According to Table II most of the passengers were between 20-25y.

Table II. Frequency distribution of the age of the passengers on the Tehran-Andimeshk train, Iran

Age		15-19	20-25		26-31		32-37		38-43		44-49		50-55		>56	
Number& Percent		N	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	20	0	0	0	7	35	2	10	7	35	2	10	0	0	2	10
2	21	1	5	8	38	3	14	1	5	5	23	1	5	1	5	1	5
3	28	1	4	9	32	3	11	1	4	3	10	4	14	2	7	5	18
4	22	2	9	6	27	4	18	2	9	5	23	2	9	1	5	0	0
Total	91	4	4	23	25	17	18	6	7	20	22	9	10	4	4	8	10

Table III. Frequency distribution of the gender of the passengers on the Tehran-Andimeshk train, Iran

Line	Gender	Male		Female	
	Number & Percent	N	%	N	%
1	20	18	90	2	10
2	21	17	81	4	19
3	28	17	61	11	39
4	22	17	77	5	23
Total	91	69	76	22	24

Table IV. Frequency distribution of number of the trips per month among the passengers of Tehran-Andimeshk train ,Iran

Number of the trips		1		2		3		4		5		6		7		8	
Number& Percent		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	20	3	15	2	10	1	5	-	-	4	20	6	30	-	-	4	20
2	21	2	9	3	15	2	9	-	-	6	29	4	19	-	-	4	19
3	28	1	4	-	-	5	18	-	-	7	25	-	-	-	-	15	53
4	22	-	-	-	-	3	14	6	27	5	23	2	9	-	-	6	27
Total	91	6	7	5	5	11	12	6	7	22	24	12	13	-	-	29	32

Table V. Frequency distribution of the train passengers' activity during the trips

Activity		Studying				Eating			
		Yes		No		Yes		No	
Number& Percent		N	%	N	%	N	%	N	%
1	20	7	35	13	65	13	65	7	35
2	21	14	66	7	34	14	66	7	34
3	28	18	64	10	36	24	86	4	14
4	22	13	60	9	40	14	64	8	36
Total	91	52	57	39	43	65	71	26	29

As shown in Table III most of the passengers were male (76%).

According to Table IV most of the passengers take a trip 8 times a month.

71%of the passengers eat and 57% of them study during the trips (see Table V).

As shown in Table VI, 58 % of the passengers lie during the trips. Hence, the beds of the passengers must be considered.

Tables VII-XIV show the neasurement results of whole-body vibration transmitted to the passengers of Tehran-Andimeshk train.

Table VI. Position of the train passengers during the trips

Posture	Time (hour)	Percent
Sitting	4.5	38
Lying	7	58
Standing	0.5	4
Total	12	100

Table VII. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the sitting position (Line 1)

Posture		Sitting									
Parameter		A_{peak} (dB)			A_{rms} (dB)			A_{eq} (dB)	CF(dB)		
Axis		X	Y	Z	X	Y	Z		X	Y	Z
Wagon	Compartment										
First	5	116	130	130	107	115	114.5	119	9	15	15.5
	7	138	135	130	132.5	131	129	136	5.5	4	1
	10	116.5	131	135	109	120	119	124	7.5	11	16
	11	121.5	132.5	137.5	111.5	120	123	124	10	12.5	14.5
Middle	3	118	118	121.5	107	106	108.5	111	11	12	13
	7	118.5	120	123	104	103	105	108	14.5	17	18
	10	117	127	127	106	108	108	112	11	19	19
	11	109	119	125	104	105	108	110	5	14	17
End	7	125	122	126	105	105	108	100	20	17	18
	9	125	120	116.5	106	103	106.5	108	19	17	10
								128			

Table VIII. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the lying position (Line 1)

Posture		Lying									
Parameter		A_{peak} (dB)			A_{rms} (dB)			A_{eq} (dB)	CF(dB)		
Axis		X	Y	Z	X	Y	Z				
Wagon	Compartment								X	Y	Z
First	5	114.5	114.5	114.5	100	100	100	105	14.5	14.5	14.5
	7	125	125	125	110.5	108	108	113	14.5	17	17
	10	117	118.5	121.5	103	103	105	108	14	15.5	16.5
	11	118.5	122.5	119	100	103	103	107	18.5	19.5	16
Middle	3	117	116.5	119.5	105	105	108	100	12	11.5	11.5
	7	128.5	128.5	125	112.5	111	110.5	116	16	17.5	14.5
	10	117.5	117.5	121	108.5	107.5	110	113	9	10	11
	11	115	116	120	106.5	106.5	107	111	8.5	9.5	13
End	7	117	124	126	109	108	108	113	8	16	18
	9	114.5	121	121	106.5	107	106.5	112	8	14	14.5
								122			

Table IX. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the sitting position (Line 2)

Posture		Sitting									
Parameter		A_{peak} (dB)			A_{rms} (dB)			A_{eq} (dB)	CF(dB)		
Axis		X	Y	Z	X	Y	Z				
Wagon	Compartment								X	Y	Z
First	2	111	119	130	103	104	110	109	8	15	20
	4	130	130	130	114.5	113.5	113	118	15.5	16.5	17
	6	130	126	126	112.5	108	107	114	17.5	18	19
	8	132.5	133.5	134	117.5	115.5	113	121	15	18	21
Middle	3	116	120	120	107.5	107.5	107.5	112	8.5	12.5	12.5
	5	119	119	119	104	103	106.5	108	15	16	12.5
	7	128	128	128	116	114	112	119	12	14	16
	9	128	125	118.5	117	116	115	121	11	9	3.5
End	2	126	127	125	108	114	105	118	18	13	20
	8	139	127	126	121	118	114	122	18	9	12
	10	111	115	119	101	103	105	108	10	12	14
								127			

Table X. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the lying position (Line 2)

Posture		Lying									
Parameter		A_{peak} (dB)			A_{rms}(dB)			A_{eq} (dB)	CF (dB)		
Axis		X	Y	Z	X	Y	Z				
Wagon	Compartment								X	Y	Z
First	2	118	118	118	103	103	105	108	15	15	13
	4	111	115	120	104	104	108	109	7	11	12
	6	122	122	122	104	106	106.5	110	18	16	15.5
	8	120	120	120	103	104	104	109	17	16	16
Middle	3	117	117	117	100	100	100	105	17	17	17
	5	122	122	122	112	111	110	116	10	11	12
	7	120	120	120	107	103	103	107	13	17	17
	9	117	118	126	106	106	107	111	11	12	19
End	2	129	129	129	111	111	112	116	18	18	17
	8	127	127	127	111	107	107	113	16	20	20
								123			

Table XI. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the sitting position (Line 3)

Posture		Sitting									
Parameter		A_{peak} (dB)			A_{rms}(dB)			A_{eq} (dB)	CF (dB)		
Axis		X	Y	Z	X	Y	Z		X	Y	Z
Wagon	Compartment										
First	2	117.5	139	140	107	123	122	128	10.5	16	18
	4	112	119	126	104	105	108	110	8	14	18
	6	119	119	119	106	106	106	111	13	13	13
	7	125.5	136	135	111	120	119	124	14.5	16	16
	9	120	118	119.5	117	116	115	121	3	2	4.5
	11	116.5	118.5	126.5	106	107	111.5	112	10.5	11.5	15
Middle	3	112	119	135	103	104	118	112	9	15	17
	5	111.5	146.5	144	101	128	125	132	10.5	18.5	19
	7	117	114.5	117	103	104	104	109	14	10.5	13
	10	115	124.5	124.5	106	108	108	112	9	16.5	16.5
End	1	110	127.5	127.5	104	109	109	113	6	18.5	18.5
	3	114.5	143	140	107.5	124.5	123	127	7	18.5	17
	5	118	138	139	108.5	123	120	125	9.5	15	19
	7	111	143	143	103	124	125	128	8	19	18
								128			

Table XII. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the lying position (Line 3)

Posture		Lying									
Parameter		A_{peak} (dB)			A_{rms}(dB)			A_{eq} (dB)	CF (dB)		
Axis		X	Y	Z	X	Y	Z		X	Y	Z
Wagon	Compartment										
First	2	110.5	119	119	100	103	103	107	10.5	16	16
	4	112	112	121	103	103	105	108	9	9	16
	6	118	124	125	109	107	107	112	9	17	18
	7	122.5	122.5	122.5	108	109	108	114	14.5	13.5	14.5
	9	117	117	120	103	103	105	108	14	14	15
	11	120	120	125	110.5	109.5	111	115	9.5	10.5	14
Middle	3	125.5	125.5	125.5	108	107	107	112	17.5	18.5	18.5
	5	119	119	119	106.5	107	106.5	112	12.5	12	12.5
	7	116.5	116.5	120	104	106	106.5	110	12.5	10.5	13.5
	10	145.5	145.5	145.5	126.5	127.5	126.5	131	19	18	19
End	1	126	128	125	116	115	115	120	10	13	10
	3	131	131	138	118	117	119.5	122	13	14	18.5
	5	140	138	139	130	125	125	131	10	13	14
	7	124	123	123	109	107	107	112	15	16	16
								124			

Table XIII. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the sitting position (Line 4)

Posture		Sitting									
Parameter		A_{peak} (dB)			A_{rms} (dB)			A_{eq} (dB)	CF(dB)		
Axis		X	Y	Z	X	Y	Z		X	Y	Z
Wagon	Compartment										
First	1	125	126	128	117	114	113	120	8	12	15
	3	120	123	122	106	104	104	109	14	19	18
	5	124	125	125	109	108	108	113	15	17	17
	7	118	132	132	117	116	114	120	1	16	18
Middle	3	121	124	124	110	109	109	114	11	15	15
	5	124	127	127	115	109	116	119	9	18	11
	7	131	131	131	113	111	108	116	18	20	23
	9	126	126	126	115	117	113	121	11	9	13
End	2	126	116	118	115	114	116	122	11	2	2
	4	124	120	124	109	108	107	112	15	12	17
	6	125	127	123	117	120	122	124	8	7	1
								129			

Table XIV. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train in the lying position (Line 4)

Posture		Lying									
Parameter		A_{peak} (dB)			A_{rms} (dB)			A_{eq} (dB)	CF(dB)		
Axis		X	Y	Z	X	Y	Z		X	Y	Z
Wagon	Compartment										
First	1	129	129	129	112	111	111	116	17	18	18
	3	124	124	124	108	107	107	112	16	17	17
	5	126	126	122	108	106	105	110	18	20	17
	7	118	117	116	103	103	105	108	15	14	11
Middle	3	128	125	120	116	110	109	117	12	15	11
	5	116	121	121	108	109	108	114	8	12	13
	7	126	125	116	109	107	107	112	17	18	9
	9	128	128	128	112	111	110	116	16	17	18
End	2	114	125	125	108	109	108	114	6	16	17
	4	121	122	125	111	107	107	113	10	15	18
	6	127	125	125	108	107	107	112	19	18	18
								124			

Table XV. The measurement results of whole-body vibration transmitted to passengers on the Tehran-Andimeshk train based A_{eq} (equal acceleration level) (dB)

Posture / Line	Sitting (dB)	Lying (dB)
1	128	122
2	127	123
3	128	123
4	129	124

As shown in Tables VII-VIX crest factors in the majority of wagons are below 19dB according to ISO 2631-1-1997 [25]. Hence, the A_{eq} (equivalent acceleration level) of the wagons in three directions (X, Y and Z) was taken in to consideration. In addition, Tables VII-XIV confirm that WBV transmitted to the passengers is due to the wagons rather than the train route.

According to Table XV, the passengers' seats were extremely uncomfortable and their beds were very uncomfortable according to ISO-2631-1-1997 [25].

According to Table XVII fatigue bothers passengers more than the other factors (57 %) conversely, vomiting occurred least (4%) and this meets the findings obtained by Nassiri et al [8].

According to Table XVIII there is no significant relationship between the health symptoms and the passengers' age on the Tehran–Andimeshk trains and this is in agreement with Nassiri et al's [8] results except lack of concentration.

Table XVI. Whole-body vibration standard, (dB) [25]

Acceleration (db)	Condition
<110	not uncomfortable
110-116	a little uncomfortable
114-120	fairly uncomfortable
118-124	uncomfortable
122-128	very uncomfortable
>126	extremely uncomfortable

Table XVII. Frequency distribution of health symptoms among passengers on the Tehran-Andimeshk train

Condition Disorder	Yes		No		Condition Disorder	Yes		No	
	N	%	N	%		N	%	N	%
Headache	28	31	63	69	Anger	20	22	71	78
Vertigo	17	19	74	81	Becoming cold and warm	33	36	58	64
Sleeplessness	42	46	49	54	Loss of appetite	8	9	83	91
Nausea	17	19	74	81	Lack of concentration	24	26	67	74
Vomiting	4	4	87	96	Aggression	8	9	83	91
Urinary incontinence	7	8	84	92	Agitation	46	51	45	49
Vision disorders	13	14	78	86	Fatigue	52	57	39	43
Hearing disorders	36	40	55	60					

Table XVIII. Statistical relationship between age and health symptoms among the passengers on the Tehran-Andimeshk train

Health Symptom	P_{value}	Health Symptom	P_{value}	Health Symptom	P_{value}
Loss of appetite	0.503	Urinary incontinence	0.508	Headache	0.67
Lack of concentration	0.075	Vision disorders	0.129	Vertigo	0.397
Aggression	0.207	Hearing disorders	0.817	Sleeplessness	0.767
Agitation	0.114	Anger	0.578	Nausea	0.801
Fatigue	0.979	Becoming cold and warm	0.334	Vomiting	0.839

Table XIX. Statistical relationship between gender and health symptoms among the passengers of Tehran – Andimeshk train

Health Symptom	P_{value}	Health Symptom	P_{value}	Health Symptom	P_{value}
Loss of appetite	0.955	Urinary incontinence	0.525	Headache	0.903
Lack of concentration	0.119	Vision disorders	0.549	Vertigo	0.945
Aggression	0.419	Hearing disorders	0.516	Sleeplessness	0.059
Agitation	0.299	Anger	0.061	Nausea	0.945
Fatigue	0.028	Becoming cold and warm	0.303	Vomiting	0.217

Based on Table XIX, of 15 health symptoms, there is only a significant statistical relationship between fatigue and gender among passengers on the Tehran – Andimeshk train.

Sleeplessness and hearing disorders bother the passengers during the trips based on statistical analysis (see Table XX).

Table XX. Statistical relationship between number of the trips per month and health symptoms among the passengers on the Tehran – Andimeshk train

Health Symptom	P_{value}	Health Symptom	P_{value}	Health Symptom	P_{value}
Loss of appetite	0.082	Urinary incontinence	0.893	Headache	0.516
Lack of concentration	0.101	Vision disorders	0.083	Vertigo	0.508
Aggression	0.928	Hearing disorders	0.002	Sleeplessness	0.032
Agitation	0.9	Anger	0.661	Nausea	0.596
Fatigue	0.736	Becoming cold and warm	0.661	Vomiting	0.95

Table XXI. Statistical relationship between studying and health symptoms among train passengers

Health Symptom	P_{value}
Headache	0.000
Vertigo	0.485
Vision disorders	0.387
Fatigue	0.245

Table XXII. Statistical relationship between eating with nausea and vomiting among train passengers

Health Symptom	P_{value}
Nausea	0.005
Vomiting	0.208

According to Table XXI there is a significant statistical relationship between studying and headache among train passengers.

Based on Table XXII nausea has a statistical relationship with eating among passengers.

Although all passengers feel some psychological and physiological disorders during the trips according to Table IX, there is only a significant statistical relationship between A_{eq} and anger (Table XXIII).

According to the results of the present study there was no statistical relationship between A_{eq} and fatigue. However, based on the results there was a significant statistical relationship between gender and fatigue. Therefore, the reason may be due to the long distance between Tehran to Andimeshk on the other hand, the effect of long distance on fatigue must not be ignored. In contrast, Kamenskiĭ et al's [12] results revealed statistical relationships between fatigue and gender among train passengers. On the other hand, according to their results females were more vulnerable with regard to fatigue caused by WBV.

In addition, according to the results headache had a statistical relationship with studying among passengers but there was no statistical relationship between headache and A_{eq}. In contrast, Shafiquzzaman Khan and Sundstroms

Table XXIII. Statistical relationship between A_{eq} and health symptoms among train passengers

Index	Health symptom	P_{value}
A_{eq}	Furiousness	0.01

[26] results revealed that two-thirds of the train passengers reported difficulties in performing sedentary activities such as reading and writing due to vibration and shocks. However, their results showed that the standardized measurements did not reveal any severe discomfort values due to vibration.

With regard to nausea, despite the results revealing a statistical relationship between eating and nausea, there was no significant statistical relationship between nausea and A_{eq}. In addition, the results revealed statistical relationships between sleeplessness and hearing disorders with number of the trips conversely, there were no statistical relationships between these symptoms with A_{eq} too.

Finally, among 15 health symptoms only anger had a statistical relationship with A_{eq}. On the other hand, anger bothers the passengers during the trips because of WBV.

4. CONCLUSIONS

Although the results revealed statistical relationships between some of the health symptoms with gender, number of the trips, studying and eating but there was only significant statistical relationship between A_{eq} (equivalent acceleration level) and anger. Hence, it can be stated that WBV was not the main reason on passengers discomfort during the trips.

On the other hand, vibration can be a principle cause of discomfort in vehicles but it is not the only factor responsible for discomfort, or poor ride quality [1]. Therefore, more factors must be taken into consideration to find the other reasons for passengers discomfort during the trips.

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REFERENCES

1. Griffin, M.J., Evaluation of vibration with respect to human response, Technical Paper #860047, *Society of Automotive Engineers*, Warrendale, PA, USA, 1986.

2. Ozkaya. N., Willems. B. and Goldsheyder. D., Whole-body vibration exposure: a comprehensive field study. *American Industrial Hygiene Association Journal*, 1994, 55(12), 1164-1171.

3. Kjellberg, A. and Wikstrom, B.O., Acute effects of whole-body vibration, Scand. J. Work Environ. Health, 1987, 3, 243-246.

4. Barber, A., *Handbook of noise and vibration control*, Elsevier Science, 1993.

5. Scutter, S., Türker, K.S. and Hall, R., Headaches and neck pain in farmers, *Australian Journal of Rural Health*, 1997, 5(1), 2-5.

6. Sevencan, F. et al, The measurement of whole body vibration levels to which shuttle bus drivers, *12th World Congress on Public Health*, Istanbul, Turkey, 2009.

7. Griffin, M.J., *Handbook of human vibration*, London: Academic Press, 1990.

8. Nassiri, P., Koohpaei, A.R., Zeaati, H., Shalkouhi, P.J. Evaluation of exposure to whole-body vibration and its health effects on train operators in Tehran-Andimeshk line, Iran, *Journal of Low Frequency Noise, Vibration and Active Control*, 2009, 28(4), 285-294.

9. Barbaso, E., On the incidence of vertebral column changes in traveling personnel of a transport company, *Medicina de Lavora*, 1958, 49,630-634.

10. Barsukova, O., Effects of vibration on the morbidity of female train-staff and prophylactic measures, *Gig Tr Prof Zabol*, 1961, 32, 45-46 (på ryska).

11. Guignard, J.C., *Evaluation of exposure to vibration*, In: Cralley LV, Cralley LJ (eds) Patty's industrial Hygiene & Toxicology (Theory and rational of industrial hygiene practice, vol.3), Wiley Interscience, New York, 1979.

12. Bembnowski, B. and Miszczak, J., Analysis of changes in the musculoskeletal system in helicopter pilots, *Med Pr*, 1967, 18(2), 151-157.

13. Kamenskiĭ, IuN., Iushkova, O.I. and Kiseleva A.A., Effects of noise and vibration in the conditions of high-stress work, *Gig Tr Prof Zabol*, 1988, Apr; (4) 50-51.

14. Moseley, M. and Griffin M.J., Effects of display vibration and whole-body vibration on visual performance, *Ergonomics*, 1986, 29, 977-983.

15. Boshuizen, H.C., Hulshof, C.T.J. and Bongers, P.M., Long-term sick leave and disability pensioning due to back disorders of tractor drivers exposed to whole-body vibration, *International archives of occupational and environmental health*, 1990, Vol.62, No.2, 117-122.

16. Yonekawa, Y., Evaluation of bullet train vibration for residents near railways, *Industrial Health*, 1977, 15, 23-32.

17. Medvedovskaya, Ts. P. and Parlyuk, A. F., The functional state of the visual analyser in persons subjectd to the action of general low frequency jerking vibration, *Gig. i Sanitaria* , 1973 (11), 42-46.

18. Arnautova-Bulat, S., O mogucem djelovanju vibracija na kraljesnicu u zeljeznicara (On the possible effect of vibrations on the spine of railwaymen), *Arhiv za Higijenu Rada i Toksikologiju*, 1979,30, 259-266

19. Suvorov, GA., Denisov, EI., Ovakimov, VG. and Syromiatnikov, IuP., Dynamics of the length of work service in specific and nonspecific disorders from noise and vibration body exposure of weavers, *Gig Tr Prof Zabol*, 1979,Nov,(11) ,28-32

20. Issever, H., Aksoy, C., Sabuncu, H. and Karan A., Vibration and its effects on the body, *Med Princ Pract*, 2003 ,12(1) , 34-38.

21. Johanning, E., Back disorders and health problems among subway train operators exposed to whole-body vibration, *Scand J Work Environ Health*, 1991, 17(6), 414-9.

22. Suzuki, H., Comparison of railway employees and college students as evaluator of vibration discomfort, *Shinrigaku Kenkyu*, 2002, Jun; 73(2), 166-171.

23. Battié, M., Videman, T., Gibbons, L., Manninen, H., Gill, K., Pope, M. and Kaprio, J., Occupational driving and lumbar disc degeneration: a case-control study, *The Lancet*, 2002, Vol. 360, Issue 9343, 1369-1374.

24. Bonney, R.A. and Corlett, E.N., Vibration and spinal lengthening in simulated vehicle driving, *Applied Ergonomics*, 2003, 34 (2), 195-200.

25. International Organization for Standardization: *ISO 2631/1-Evaluation of human exposure to whole-body vibration*, Geneva: International Organization for Standardization, 1985.

26. Shafiquzzaman Khan, M., Sundstrom, J. Effects of vibration on sedentary activities in passenger trains, *Journal of Low Frequency Noise, Vibration and Active Control*, 2007, 26(1), 43-55.

NATIONAL NOISE BARRIER BILL

From the 1970s to 2007, in the USA, about 2500 miles of highway noise barriers were built at a cost of approximately $3.3 billion.

NEW AIRPORT NECESSARY, BUT NOT PRACTIBLE

Public opposition to increased noise and activity; huge pricetags for site work and buyouts of surrounding properties; conflicts with existing airspace corridors over North Georgia: those are the obstacles standing between Atlanta and a second commercial airport. And they are big obstacles, according to a recent federally funded study of potential sites. The FAA examined 29 candidates, narrowed them to eight finalists spanning the metro area's northern arc — and deemed none of them feasible. Estimated development costs topped $2 billion for seven of the eight.

MP THINKS ENFORCEMENT INADEQUATE

A Gloucestershire MP has said the problem of noise pollution is not being dealt with properly in the county. Martin Horwood, the Liberal Democrat MP for Cheltenham, wants councils to be more proactive. New figures show that noise complaints have gone up in the town by 6% in the last year. Cheltenham Borough Council said the figures showed no "significant" increase and prompted "no immediate cause for concern." Mr Horwood said: "I found there was literally nobody to call about a noisy party or a noisy disturbance during the night. I don't think our councils are using the powers they could use and I think they're underestimating the seriousness of the problem."