

An investigation on the physiological and psychological effects of infrasound on persons

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INTRODUCTION

In order to study the physiological and psychological effects of infrasound on person, we have measured the changes of blood pressure and heart rate and also investigated subjective feelings of subjects exposed to infrasound. Hood et al and Evans and Tempest the subjective reaction and the hearing threshold etc Mfiller reported the physiological and psychological effects of infrasound (with frequency bandwidth of from 6.3 Hz to 31.5 Hz) on persons. Considering that the main resonant frequency of person's internal organs is below 5 Hz, the study has adopted two different infrasonic conditions, about 2 Hz 110 dB (A) and 4 Hz 120 dB (A). Two groups of subjects were used in the experiment—Group A and Group B. Group A were exposed to infrasound with about 2 Hz 110 dB for 1 hour Group B were exposed to infrasound with about 4 Hz 120 dB for 1 hour. During the experiment, noise with frequency of over 20 Hz was minimized. The physiological and psychological effects of infrasound on persons have been objectively demonstrated.

METHODS

The experiment was arranged in a large room ($L \times W \times H = 7.3 \times 6.9 \times 3.6 \text{ m}^3$). To acquire experimental data, a B&K4155 microphone and B&K2231 sound level meter were used. we also used a frequency spectrum analyser to analyze infrasonic conditions and a blood-pressure meter and cardiometer to measure the changes of the subjects blood pressure and heart rat. At the same time we provided the subjects with pure water and requested them to remain calm. By a previous experiment, we found that the sound level was approximately uniform in this room. The microphone and sound level meter are fixed on a tripod and located on the centre of the room as shown in Figure 1. Figures 2 and 3 show the frequency spectrum characteristic of the two different infrasound signals—2.14 Hz 110 dB (A) and 4.10 Hz 120 dB (A).

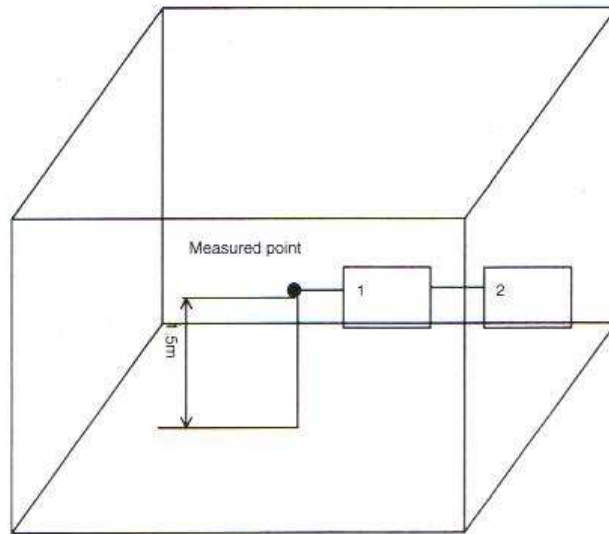


Figure 1. Infrasound measuring and signal analysis system 1. B&K4155 microphone and B&K2231 sound level meter 2. Signal analysis system.

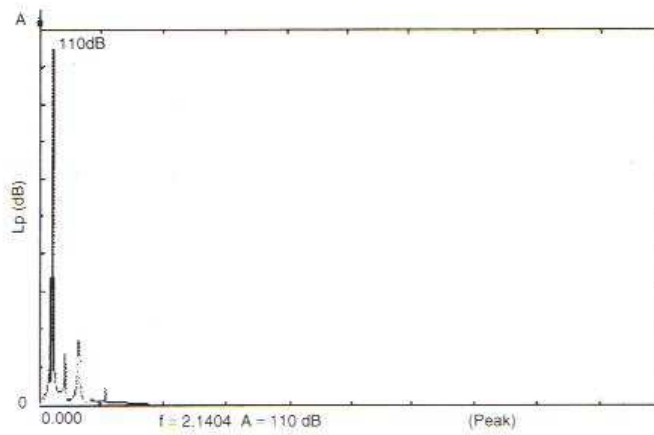


Figure 2. Frequency Spectrum of 2.14 Hz signal.

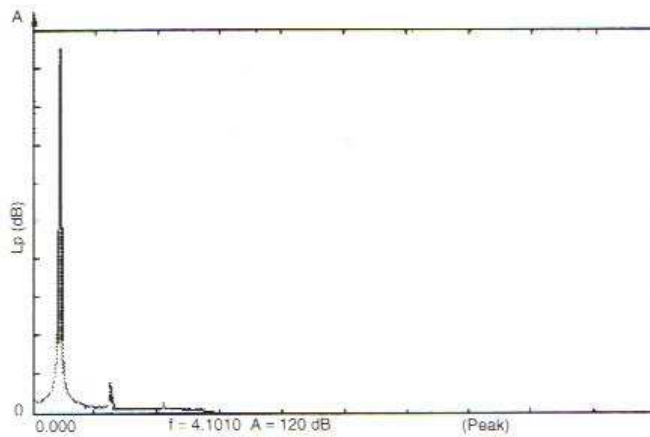


Figure 3. Frequency Spectrum of 4.10 Hz signal.

A total of 6 male and 4 female university students were used as subjects, all in good health, between 22 and 28 years. They were divided into 2 groups—Group A and Group B. Each group includes 3 males and 2 females. The temperature was $25\pm 2^{\circ}\text{C}$, the degree of humidity of the air was $70\pm 5\%$ and the noise level in the experimental room was below 60 dB (A).

Physiological effects were examined by measuring the changes of blood pressure and heart rate and each subject recorded their subjective feelings. Before the experiment, we measured the normal blood pressure and heart rate. After being exposed to infrasound for one hour, blood pressure and heart rate were measured again.

In the normal condition, measurements were performed three times at 3-minute intervals and the average of the three values was regarded as the initial value before starting the exposure. The two groups' blood pressure and heart rate in the normal condition were shown in Table I and Table II (the unit of blood pressure: mmHg and the unit of heart rate: beats/min).

Group A was exposed to infrasound at 4.10 Hz, 120 dB and Group B was exposed to infrasound at 2.14 Hz 110 dB. After one hour, we measured the blood pressure and heart rate 3 times at 2-minute intervals and the average of 3 measurements was regarded as the final value of the experiment. The final values of blood pressure and heart rate are shown in Tables III and IV.

In order to investigate the subjective reactions of the subjects, we have designed a questionnaire of subjective feeling. After the experiment, the subjects were requested to answer questions. Everyone must answer the following questions by himself.

1. Do you feel windy?
2. Do you feel pressure in your ears?
3. Do you feel nauseated?
4. Do you have headache?
5. Do you feel fretful?
6. Do you feel tired?
7. When you feel uncomfortable during the experiment?
8. Do you feel trouble in this room?
9. Where have you ever experienced this feeling?
10. Have you experienced carsickness?
11. Do you have carsickness today?

RESULTS

The physiological and psychological effects of infrasound appeared as changes in heart rate, blood pressure and subjective reactions. Among physiological effects, heart-rate ratio and blood pressure ratio were expressed as the ratio of each final value of the experiment to the initial

Table I. Group A Blood pressure and Heart rate before exposure

	The members of Group A														
	A1			A2			A3			A4			A5		
Measuring Times	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
1	106	64	67	113	62	73	107	60	76	128	79	76	115	76	62
2	109	58	71	111	61	67	106	61	77	126	76	74	115	75	68
3	101	58	73	114	59	68	105	58	76	123	81	80	108	67	61
Average	105	60	70	113	60	69	106	60	76	126	79	77	113	73	64

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (times/min)

Table II. Group B Blood pressure and Heart rate before exposure

	The members of Group B														
	B1			B2			B3			B4			B5		
Measuring Times	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
1	105	62	72	107	68	65	107	64	65	104	60	72	94	54	64
2	105	57	71	105	67	69	107	59	58	102	56	73	94	60	60
3	100	57	76	107	68	69	106	58	60	104	56	70	89	61	59
Average	103	59	73	106	68	68	107	60	61	103	57	72	92	58	61

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (times/min)

Table III. Group A. Blood pressure and heart rate after symptoms of 4.10Hz 120dB

	The members of Group A														
	A1			A2			A3			A4			A5		
	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
Measuring	115	73	68	130	72	78	119	81	82	129	84	84	113	66	74
Times	2	118	74	75	127	75	89	118	81	85	136	89	120	68	78
	3	121	71	68	129	72	73	113	75	86	137	85	113	64	76
Average	118	73	70	129	73	80	117	79	84	134	86	86	115	66	76

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (times/min)

Table IV. Blood B. Blood pressure and heart rate after exposure at 2.14Hz 110dB

	The members of Group B														
	B1			B2			B3			B4			B5		
	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
Measuring	110	74	76	112	75	60	124	77	73	111	73	77	116	72	70
Times	2	107	67	79	105	67	60	117	68	64	113	70	107	68	62
	3	113	72	82	107	72	61	118	65	69	107	67	105	72	65
Average	110	71	79	108	71	60	120	70	69	110	70	77	109	71	66

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (times/min)

Table V. Group A. Heart-rate and blood pressure ratio

	The members of group A														
	A1			A2			A3			A4			A5		
	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
Initial Value	105	60	70	113	60	69	106	60	76	126	79	77	113	73	64
Final Value	118	73	70	129	73	80	117	79	84	134	86	86	115	66	76
Changes	13	13	0	16	13	11	11	19	8	8	7	9	2	-7	12
Ratio (%) (Increase)	12.4	21.7	0	12.4	21.7	15.9	10.4	31.7	10.5	6.3	8.9	11.7	1.8	-9.5	18.8

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (beats/min)R: Heart Rate (times/min)

Table VI. Group B. Heart-rate and blood pressure ratios

	The members of Group B														
	B1			B2			B3			B4			B5		
	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R	SP	DP	R
Initial Value	103	59	73	106	68	68	107	60	61	103	57	72	92	58	61
Final Value	110	71	79	108	71	60	120	70	69	110	70	77	109	71	66
Changes	7	12	6	2	3	-8	13	10	8	7	13	5	17	13	5
Ratio (%) (Increase)	6.8	20.3	8.2	1.9	4.4	-11.7	12	16.7	13.1	6.8	22.8	6.9	18.5	22.4	8.2

SP: Systolic Pressure (mmHg)

DP: Diastolic Pressure (mmHg)

R: Heart Rate (times/min)

value of the experiment before starting the exposure. Psychological effects were expressed as the subjective reactions of the subjects.

Psychological Effects of Infrasound

By analyzing their answers we found: All the subjects felt uncomfortable and 8 persons said they had experienced the same feelings as travelling on vehicles or trains, two of them said they had experienced this feeling elsewhere. No one felt nauseated or carsick. Nine of them felt pressure in their ears. Six persons felt headachy and fretful. Five people felt tired and troubled in this room.

Physiological Effects of Infrasound

The changes of blood pressure and heart rate were shown in Table V and Table VI. Table V is the heart-rate ratio and blood pressure ratio of group A after being exposed to infrasound (4.10 Hz, 120 dB) for over 1 hour. Table VI is the heart-rate ratio and blood pressure ratio of group B after being exposed to infrasound (2.14 Hz, 110 dB) for over 1 hour.

The data in Table V shows: After Group A was exposed to infrasound (4.10 Hz, 120 dB) for over 1 hour we found the changes of systolic pressure, diastolic pressure and heart rate. For each person, at least one index among systolic pressure, diastolic pressure and heart rate changes by more than 10 percent. Some changes exceed 30 percent, for example A3's change ratio of diastolic pressure.

The data in Table VI shows: After Group B was exposed to infrasound (2.14 Hz, 110 dB) for over 1 hour, for each person, at least one index among systolic pressure, diastolic pressure and B4's change ratio of diastolic pressure.

In addition, the change ratio of A5's diastolic pressure was -9.5 percent. This indicates that A5's diastolic pressure fell after A5 being exposed to infrasound (4.10 Hz, 120 dB) for over 1 hour.

CONCLUSIONS

The physiological and psychological effects of infrasound (2.14 Hz, 110 dB and 4.10 Hz, 120 dB) on persons are summarized as follows:

1. Being exposed to infrasound, a person feels headachy, fretful and tired.
2. Infrasound can cause the changes of blood pressure and heart rate.
3. In the infrasound condition with 4.10 Hz and 120 dB for over 1 hour, systolic pressure and heart rate of most subjects rose with the exception that the diastolic pressure of some subjects fell.
4. In the infrasound condition with 2.14 Hz, 110 dB for over 1 hour, systolic pressure and diastolic pressure of subjects rose. But heart rate of some subjects rose and others fell.

5. Different individuals have different responses to infrasound and the change ratio of blood pressure and heart rate are also different.
6. By comparing physiological and psychological effects of infrasound on persons in two different infrasound conditions, we find that there are not obvious differences.
7. Studying the relationships between the physiological and psychological effects of infrasound and the frequency and pressure level of infrasound is very necessary.

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