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Effects of Bone Conduction Device Vibration on Human Health

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Abstract

The purpose of this paper is to clarify the effects of the Bone Conduction Device Vibration on human health. On now days, many bone conduction devices are on the market in the world. But, the effects of vibration from the bone conduction devices do not clear yet. So, we have to understand the effects of vibration from the bone conduction devices. In this paper, the vibrations were measured by using the small and light vibration accelerometer. The vibrations were evaluated by the considerations from the Hand-Arm Vibration Exposure Limit Value and the Whole-Body Vibration Exposure Limit Value of the EU Directive of Physical Agent (Vibration). It was clear that the vibration magnitudes from the bone conduction devices have no problem from the considerations of hand-arm vibration exposure limit values and whole-body vibration exposure limits.

1. Introduction

Advantage of device using bone conduction could communicate in noisy environment as a bone conduction hearing aid. In addition, the mobile phone with bone-conduction speaker on Dec 2003, TS41 (Mitsubishi Electric) has been released from the KK TU-Ka cellular. Also, the use of bone conduction has been validity to the hard of hearing can be clearly [1].

The Bone Conduction Device generates the vibration from the bone conduction device, and transmits the vibration to bone. The transmitted vibration stimulates the auditory nerve by the vibration and propagated to the brain as shown in Figure 1.

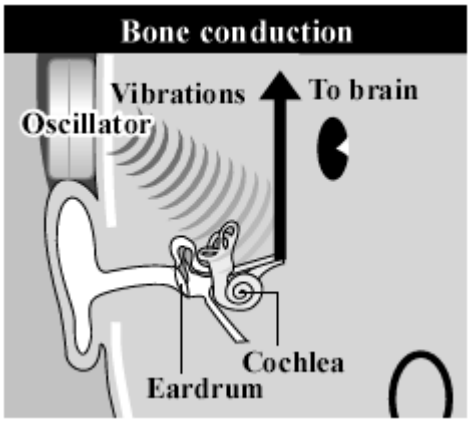

Figure 1 Consideration of bone conduction

Many bone conduction devices are on the market in the world. But, the effects of vibration from the bone conduction devices do not clear yet. So, we have to understand the effects of vibration on human health from the bone conduction devices.

The purpose of this paper is to clarify the effects of the Bone Conduction Device Vibration on Human Health. Therefore, in this paper, the vibrations from the bone conduction devices were measured by using the small and light vibration accelerometer. The vibrations were evaluated by the considerations from the Hand-Arm Vibration Exposure Limit Value and the Whole-Body Vibration Exposure Limit Value of the EU Directive of Physical Agent (Vibration)..

2. Consideration of the effect of vibration on human health from the hand-arm vibration exposure

In this paper, the vibration from bone conduction device considered as a hand-arm vibration exposure effects. The vibration from the bone conduction devices was measured by according to the ISO 5349-2: 2001 [2] (JIS B 7761-2: 2003 [3]) standard “Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 2: Practical guidance for measurement at the workplace”.

2. 1 Measurement, Evaluation and Assessment of Bone Conduction Device Vibration

2. 1. 1 Measurement and evaluation

The weighted r.m.s. acceleration is expressed in meters per second squares (m/s^2) for translational vibration. The weighted r.m.s. acceleration shall be calculated in accordance with the following equation:

$$a_w = \left[\frac{1}{T}\int_0^T a_w^2(t)\,dt\right]^{1/2} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

where.

$a_w(t)$: is the weighted acceleration as a function of time history, in meters per second squared (m/s^2)

T: is the duration of measurement, in second.

2. 1. 2 Assessment: Daily Vibration Exposure

Daily vibration exposure is derived from the magnitude of the vibration (vibration total value) and the daily exposure duration.

In order to facilitate comparisons between daily exposures of different durations, the daily vibration exposure shall be expressed in terms of the 8-h energy-equivalent frequency-weighted total value, $a_{hv(eq,8h)}$, as shown in Equation (2). For convenience, $a_{hv(eq,8h)}$ is defined A(8):

$$A(8) = a_{hv}\sqrt{\frac{T}{T_0}} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2)$$

where

a_{hv} is the vibration total value (m/s^2).

T is the total daily duration of exposure to the vibration a_{hv} (m/s^2)

T_0 is the reference duration of 8 h (28800 s).

The A(8) of the criteria for hand-arm vibration is defining the following:

(a) the daily exposure limit value standardized to an eight-hour reference period shall be 5 m/s^2;
(b) the daily exposure action value standardized to an eight-hour reference period shall be 2,5m/s^2.

Also, the vibration exposure permissible time limits per day is obtained by the Equation (3).

Vibration exposure permissible time limits per day $T_L = \frac{200}{a_{hv}^2}$ [hours] ・・・・・・・・・ (3)

where

a_{hv} is the vibration total value (m/s^2).

The vibration exposure permissible time limits per day of the measured vibration from the Bone Conduction Device was calculated by Equation (3).

3. Consideration of the effect of vibration on human health from the whole-body vibration exposure

In this paper, the vibration from bone conduction device considered as a hand-arm vibration exposure effects. The vibration from the bone conduction devices was measured by according to the ISO 2631-1: 1997 [4] (JIS B 7760-2: 2003 [5]) standard “Mechanical vibration and shock -Evaluation of human exposure to whole-body vibration- Part 1:General requirements”.

3. 1 Measurement, Evaluation and Assessment of Bone Conduction Device Vibration

3.1. 1 Measurement and Evaluation

The weighted r.m.s. acceleration is expressed in meters per second squares [m/s^2] for translational vibration. The weighted r.m.s. acceleration shall be caluculated in accordance with the following equation:

$$a_w = \left[\frac{1}{T}\int_0^T a_w^2(t)\mathrm{d}t\right]^{1/2} \text{・・・・・・・・・・・・・・・・・} (4)$$

where.

$a_w(t)$: is the weighted acceleration as a function of time history, in meters per second squared (m/s^2)

T: is the duration of measurement, in second.

3.1.2 Assessment: Daily Vibration Exposure

Daily vibration exposure is derived from the magnitude of the vibration (vibration total value) and the daily exposure duration.

In order to facilitate comparisons between daily exposures of different durations, the daily vibration exposure shall be expressed in terms of the 8-h energy-equivalent frequency-weighted total value, $a_{v(eq,8h)}$, as shown in Equation (2). For convenience, $a_{v(eq,8h)}$ is defined A(8):

$$A(8) = a_v \sqrt{\frac{T}{T_0}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

where

a_v is the vibration total value (m/s^2).

T is the total daily duration of exposure to the vibration a_{hv} (m/s^2)

T_0 is the reference duration of 8 h (28800 s).

The A(8) of the criteria for whole-body vibration is defining the following:

(a) the daily exposure limit value standardised to an eight-hour reference period shall be 1,15 m/s^2 or, at the choice of the Member State concerned, a vibration dose value of 21 $m/s^{1,75}$;

(b) the daily exposure action value standardised to an eighthour reference period shall be 0,5 m/s^2 or, at the choice of the Member State concerned, a vibration dose value of 9,1 $m/s^{1,75.}$

Also, the vibration exposure permissible time limits per day was obtained by the Equation (6) using Vibration Exposure Limit Value A(8)=1.15 m/s^2.

Vibration exposure limits per hour. $$T_L = \frac{10.58}{a_w^{\,2}} [\ \text{hours}\ ] \cdots\cdots\cdots\cdots \quad (6)$$

where

a_v is the vibration total value [m/s^2].

The vibration exposure permissible time limits per day of the measured vibration from the Bone Conduction Device was calculated by Equation (6).

4. Measurement of bone conduction device and vibration measurement apparatus and method

Figure 2 shows the used Bone Conduction Devices. The GDS-601 and GDS-602 of Figure 2 are using for listening music and the GDS-701 for listening speech.

（GDS-601）　　（GDS-602）　　（GDS-701）

Figure 2 Used Bone Conduction Devices.

For controlling the sound level between the normal headset and the bone conduction headset, the white noise was generated by the PC to normal headset. The Noise level to normal headset was adjusted 85 dB(A). The bone conduction devices connected to the PC with the same volume and measured the vibration acceleration at the surface of bone conduction device and the measuring PULSE system as shown in Figure 3.

Figure 3 Vibration Measurement at surface of Bone Conduction Device and Measurement system.

5. Measurement results

5.1 Results of Measurement and Evaluation from Hand-Arm Vibration Consideration

Table 1 shows the results of the vibration acceleration r.m.s. values from the vibration of surface of bone conduction devices as shown in Figure 2.

Table 1 Results of the vibration acceleration levels from the Bone Conduction Devices.

Bone Conduction Device	Vibration value of (m/s^2) HAV-85dB
GDS-601	0.3725
GDS-602	0.2101
GDS-701	0.0531

5.2 Results of Measurement and Evaluation from Whole-Body Vibration Consideration

Table 2 shows the results of the vibration acceleration r.m.s. values from the vibration of surface of bone conduction devices as shown in Figure 2.

Table 3 Results of the vibration acceleration levels from the Bone Conduction Devices.

Bone Conduction Device	Vibration value of (m/s^2) WBV-85dB
GDS-601	0.2397
GDS-602	0.1074
GDS-701	0.0132

6. Discussions

6. 1 Hand-Arm vibration consideration of health effects

Table 4 shows the vibration exposure permissible time limits per day from the point of the hand-arm vibration exposure evaluation.

Table 4 Vibration exposure permissible time limits per day

Bone Conduction Device	Value of vibration ^{2}(m/s) HAV-85dB	Hand-arm Vibration Permissible Time (hours) : A(8)=5.0(m/s^2)
GDS-601	0.3725	1441
GDS-602	0.2101	4531
GDS-701	0.0531	70932

From Table 4, It was clear that the vibration magnitudes from the bone conduction devices have no problem from the considerations of hand-arm vibration exposure limit value of A(8)=5.0 m/s^2.

6. 2 Whole-Body vibration consideration of health effects

Table 5 shows the vibration exposure permissible time limits per day from the point of the whole-body vibration exposure evaluation.

Table 5 Vibration exposure permissible time limits per day

Bone conduction Device	Value of vibration ^{2}(m/s) WBV-85dB	Whole-Body Vibration Permissible Time (hours) A(8): 1.15(m/s^2)
GDS-601	0.2397	184
GDS-602	0.1074	917
GDS-701	0.0132	60721

From Table 5, It was clear that the vibration magnitudes from the bone conduction devices have no problem from the considerations of whole-body vibration exposure limit value of A(8)=1.15.

7. Conclusions

In this paper, the vibrations were measured by using the small and light vibration accelerometer. The vibrations were evaluated by the considerations from the Hand-Arm Vibration Exposure Limit Value and the Whole-Body Vibration Exposure Limit Value of the EU Directive. It was clear that the vibration magnitudes from the bone conduction devices have no problem from the considerations of hand-arm vibration exposure limit values and whole-body vibration exposure limits.

References

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