EFFECT OF VIBRATOR APPLICATION FORCE ON BONE CONDUCTION OUT-PUT AT DIFFERENT FREQUENCIES

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Introduction

Although the air-conduction pathway generally is considered to be the principal mode of sound transmission, the movements of a vibrating body may also be transmitted to the inner ear through direct contact with the skull' . (Dirks, 1974)

Bekesy was the first investigator to demonstrate clearly that the mode of excitation of the cochlear receptors was the same for air conduction and bone conduction signals. By adjusting the amplitude and phase of air conducted signal he was able to cancel bone conduction signal at 400 Hz. Lowy (1942) also produced air-bone cancellation of the cochlear microphonics within the frequency range from 250 to 3,000 Hz in guinea pigs and cats.

The subject of bone-conduction has been of primary interest to otologists and audiologists because of the diagnostic usefulness of the measurements.

Review of Literature

Generally Bone-conduction threshold is expected to be better when the vibrator application force is increased. But, the studies do not agree with this principle.

B ekesy (1939) and Konig (1955) found that the change in B.C. threshold is maximum when the vibrator application force is less than 750 gms and a very small change was found when the static force was 1000 and 1500 gms. Depending on these findings Konig suggested that the coupling force should be approximately 1000 gms to have a minimum variability of B.C. threshold.

Harris *et al.* (1953) investigated the effects of increased application force from 100 to 500 gms, at the test frequencies of 250, 1000 and 8000 Hz. The greatest change in threshold was found at 250 Hz. According to them, the application force should be standardised somewhere between 200 gms to 400 gms.

The results of the two aforesaid studies do not agree with each other.

Goodhill and Holcomb (1955), Nilo (1968) Watson (1938) and Whittle (1965) have made other contributions concerning the role of force in measuring bone conduction.

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The problem of change in bone conduction sensitivity with respect to vibrator application force is further complicated by the studies which dealt with the Mechanical Impedance of the head. Dadson (1954) observed changes in mechanical impedance by varying the force of application. Corliss and Koidan (1955) however, reported similar impedance values at coupling forces from 500 to 1000 gms. Whether or not the differences are due to the smaller number of subjects used in the latter experiments has been unresolved.

According to the international standards for bone-conduction thresholds, the B.C. vibrator application force should be approximately 550 gms for a bone vibrator with a plain circular face of 1.75 cm^2. Commercially available head bands exert a static force of approximately 300 gms to 400 gms when the vibrator is placed on the mastoid process of adult subjects (Dirks, 1965, Studebaker, 1962). The size of the head and the elasticity of the head band primarily determine the application force on a particular head.

Some other variables which bring a change in B.C. thresholds are:

(1) Air pressure variation in external auditory canal.
(2) Loading of Tympanic membrane.
(3) Alteration or removal of structures of the middle ear.
(4) Occlusion effect.
(5) Size of the B.C. vibrator.
(6) Vibrator placement.
(7) Individual differences in the mass of the head, and
(8) Ambient Noise level.

The review of the literature shows that there is no agreement between the various investigations regarding the changes in B.C. response due to the application of various forces.

The purpose of the present study was to find out experimentally the change in B.C. output for various static loading from 100 gms to 1000 gms in 100 gm steps.

Methodology

Equipment used:

B and K Artificial Mastoid Type 4930—
Madsen OB70 Clinical audiometer (calibrated to ISO (1964) standard)
B.C. vibrator No: X 114 Denmark.
Frequency analyser (B and K 2107)
Different weights 100 gms to 1000 gms.

Particular attention was paid to long term stability regarding mechanical impedance and transducer characteristics.

The artificial mastoid consists of an inertial mass of 3.5 kg with a curved top plate of stainless steel, upon which are mounted the impedance determining elements, built-up of laminated butyl silicon rubber pads.

A light weight spring with nearly massless rubber bands holds the B.C. vibrator under test against the rubber surface of the mastoid with a static force which can be adjusted to any value between 2 and 8 N.

The static load adjustment of artificial mastoid was removed. The B.C. vibrator of the audiometer was kept on the artificial mastoid. Different masses were kept on the light weight loading arm which was kept on the B.C. vibrator. The output from the artificial mastoid was fed to the frequency analyzer which was set to the reference before the instrument was used. The output was measured at 40 dB HL of the audiometer at different frequencies for each mass. When the frequency analyzer was adjusted to reference, the voltage reading could be read on dB scale (i.e., 94dB=50mv, 100dB=100 mv indicating the reference value of **1 μ v.)**

$$dB = 20 \log_{10} \left(\frac{x \ \mu v}{1 \ \mu v}\right)$$

Discussion

Table 1 shows the B.C. output at different frequences and at different values of static load.

At 2 KHz the output values of static load increases as the application force increases. But it is evident from the table that for static forces 500, 600 and 700 gms, the output for all the tested frequencies remained almost same. **This** supports the ISO recommendation. (ISO recommendation; static force of 550 gms for B.C. vibrator output measurements).

RESULTS

Masses in grams

Frequen-cies in Hz	100	200	300	400	500	600	700	800	900	1000
250	56	55	55	54	54	54	53.5	53.5	53.5	53.5
500	54	53	53	52	53	53	52.5	52.5	52.5	53
1 K	50	50	47	46	46.5	46.5	47	47	47.5	48
2 K	51	51	51	52	52	52	53	53	53.5	54
3 K	48	42	40	40	40	40	41	40	41	42
4 K	50	40	35	35	35	34	32	32	32.5	33

TASLE I: Shows the output in dB for various masses at each frequency-dB Ref. one micro volt (1 /J V).

From Fig. I it is observed that the change is more in higher frequencies viz., 3K and 4 KHz particularly at lower static forces (for 100 and 200 gms).

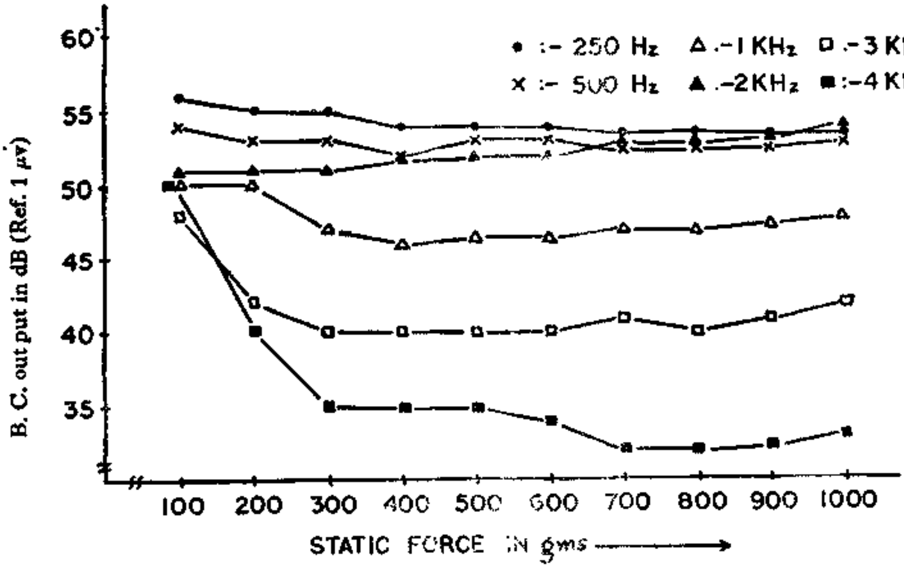

Fig. I

Table II shows the comparison of the results obtained in the present study with the results of the previous studies

TABLE II

Bekesy (1939) & Konig (1955)	Harris *el al* (1953)	Present Study (1978)
1. Largest changes at forces below 750 gms	1. Great change for 250 Hz due to various force app.ication	1. Little change for 250 Hz from 100 to 1000 gms
		Great changes for 3K and 4 KHz at lower static forces (100, 200, 300 gmb) Ref: Fig. I
t. Recommendation:		
100 gms force	200 to 400 gms	400 to 1000 gms

Summary

A review of literature regarding the effect of vibrator application force on bone-conduction output shows a lack of agreement between the various investigations. The present study was undertaken to find out the change in B.C. out-

put for various force values from 100 gms to 1000 gms in 100 gms steps. The B.C. vibrator from an audiometer was kept on the B and K. artificial mastoid (4930). The output from the artificial mastoid was fed to an A.F. analyzer for the purpose of measurements.

The result indicates a little change in B.C. output at 250 Hz for the static forces ranging from 100 gms to 1000 gms and the change was more at the fre-fueneies 3 KHz and 4 KHz for the lower static forces. However the change in B.C. output was very little for a static force of 400 gms to 1000 gms for all the test frequencies. This study supports the **ISO** recommendation of static force for B.C. output measurements.

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