THE LIMITS OF USING MECHANICAL VIBRATIONS IN HUMAN PATHOLOGY

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SUMMARRY

In this paper we present some aspects regarding the limitation of the action of vibrations upon the human organism. The human organism is an heterogeneous elastic environment, that, under the action of vibrations, amplifies or absorbs them, as stated in the laws of mechanics. In medical therapy, through vibrations, the use of certain frequencies towards some organs of the human body is imposed, the ones that exceed a given limit having a negative action upon human health. The appreciation based on quality of the action of vibrations on the human body with the limits that the body can resist to vibrations presented in this paper contribute to the correct application of vibration therapy.

1. INTRODUCTION

A periodic movement of a system from it's given reference point represents a vibratory movement. The simplest periodic movement is the armonic movement, the shifting being expressed through a trigonometrical function. The characteristics of vibrations are elongation, pulsation and phase. The types of vibrations encountered in technique are forced vibrations, own vibration, variable vibrations and selfsustained vibrations. Aside from the negative effects upon the human organism and human activity, armonic vibrations are successfully used in elastic vibration therapy, electromagnetic vibration therapy and mechanic vibration therapy.

The human organism, being an elastic environment under the action of vibrations, amplifies them or absorbs them according to the laws of mechanics. Vibrations that surpass certain limits have a negative influence on the health of a human being. Vibrations that operate on the human body and surpass the tolerance limits can prove injurious to physical and intellectual activities, damaging some parts of the organism. The action of vibrations on physical and mental activities of man is succinctly mentioned, tiredness being the factor that does not allow a measurement, but only an orientative estimation.

In this paper we present the limits that the human organism can undergo to electrical, mechanical and other types of vibrations for one's safety, as well as some procedures used in vibration therapy.

2. FUNDAMENTAL NOTIONS

In medical vibration therapy, the human organism is considered a system of conservative particles with scleronomic connections. The potential energy is a function of the position of the particles in that system. At an exterior action upon the system with the potential:

$$V= V(q_1,q_2,q_3 \dots q_n) \quad (1)$$

The system is in balance if the forces Q_i that act upon the system are equal to 0:

$$Q_i = \left(\frac{\partial v}{\partial q_i}\right)_{o} = 0 \quad (2)$$

Where qi is the balance configuration of the system and; V – potential function.

The balance is stable if after the movement that is obtained as a result of a small perturbation, the system remains at it's initial configuration.

The system is unstable if a perturbation produces a movement. Around the position of balance, the particles that are close to the general coordinates can be observed in the following ecuation:

$$q_{i=q_{oi}+\eta_i} \quad (3)$$

Where η_i are the new coordinates of the points close to the position of balance of the system. With the developing of the Taylor series in the potential function V around the values q_{oi}, we obtain:

$$V = V(q_1, q_2, q_3 \ldots\ldots q_n) = V = V(q_{o1}, q_{o2}, q_{o3}\ldots\ldots q_{on}) +$$

$$\Sigma\left(\frac{\partial v}{q_i}\right)\eta_i + \frac{1}{2}\Sigma_i \Sigma_i \left(\frac{\partial^2 v}{\partial q_i \partial q_i}\right)_{o} \eta_i \eta_j + \cdots \quad (4)$$

In regards to relation (1),the balance relation (4) becomes:

$$V = \frac{1}{2}\Sigma_i \Sigma_i V_{ij}\eta_i \eta_j \quad (5)$$

Where V_{ij} are constants that depend on q_{oi} and define the balance equation; ($V_{ij} = V_{ij}$) are simetrical.

The kinetic energy afferent to the modification of balance is given by the equation:

$$T = \frac{1}{2}\Sigma_i \Sigma_j T_{ij}\eta_i \eta_j \quad (6)$$

The equations of moving particles near the system in balance are Lagrange equations –

$$\Sigma_{i=1}^{n}(T_{ij}\eta_j + V_{ij}\eta_j) = 0 \quad (7)$$

Lagrange's differential equations with generalized coordinates ηi determine the movement of the system near the balance configuration. The solution of equation (7) is:

$$\eta_i = C_o e^{-i\omega t} \quad (8)$$

By substitution, we obtain the following system of equations:

$$\Sigma_{j=1}^{n}(V_{ij} - \omega^2 T_{ij} Q_i) = 0 \quad (9)$$

– with the condition that the coefficient determinant be equal to 0:

$$\left|V_{ij} - \omega^2 T_{ij}\right| = 0 \quad (10).$$

We obtain an equation with the grade n in ω2 that admits as roots a set of fundamental functions ω_k. Over the fundamental frequencies ω_k, the balance system is destroyed, in the case of the human organism being injurious.

From the multitude of situations in which vibrations act on a human being, the only vibrations that present therapeutic interest are the ones that are located at the inferior limit of audible frequencies or in the infrasound domain.

3. LIMITS OF VIBRATION FREQUENCIES ON THE HUMAN ORGANISM

The human organism, when under the effect of vibrations, amplifies or absorbs them in conformity with the laws of vibration mechanics, like any elastic mass. In the construction of the human body we integrate muscles, tissues, blood vessels, bones, elastic and rigid materials, simply characterized by the longitudinal elasticity module E, transversal elasticity module G, Poisson's coefficient and dynamic viscosity coefficient η. According to the above mentioned theory, surpassing some of the human body's own frequencies by continuous vibrations would destroy the balance of the system entrenched on the mechanical skeleton with the friction cups as shown in Fig. 1.
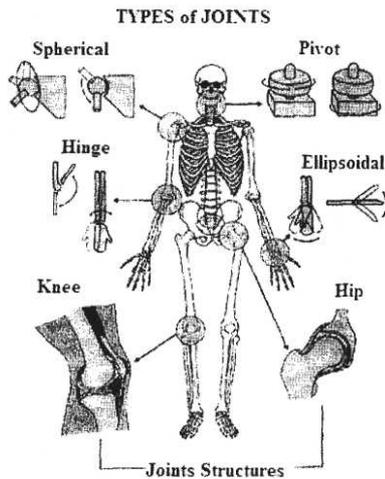
Source: Children's Boston Hospital

Fig 1. – The skeleton of the human body with friction cups.

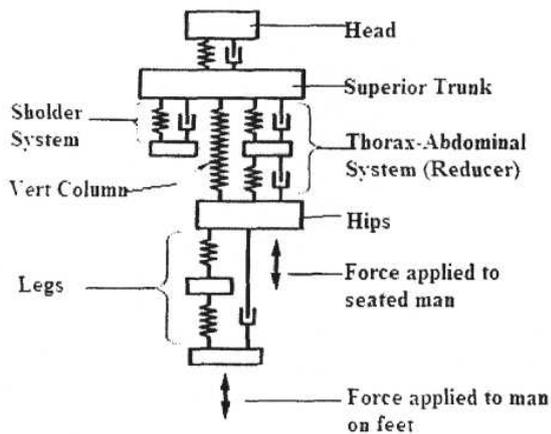An elastic mechanical model of a standing human being presented in fig. 2

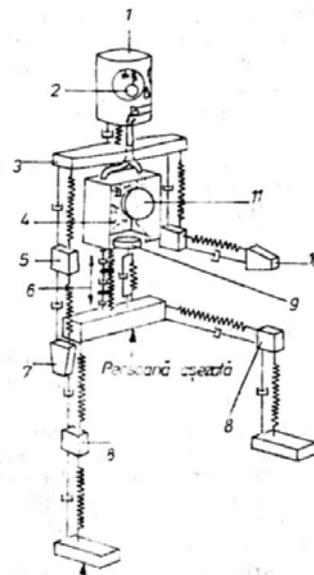*Fig. 2 – An elastic mechanical model.*

Fig. 3 – The model of the human body undergoing vibrations.

1. Head – 2. Ocular globe – 3. Shoulder – 4. Chest volume – 5. Forearm – 6. Spinal cord – 7. Hand – 8. Legs – 9. Abdominal mass – 10. Forearm hand – 11.Chest

In the action of vibrations upon the human body we can define three steps in appreciating the effects of vibrations: 1. Perception – 2. Displeasure – 3. Tolerance.Through tries and interpreting some experimental results ,the appreciation curves of vibrations upon the human organism have been defined as shown in Fig. 4
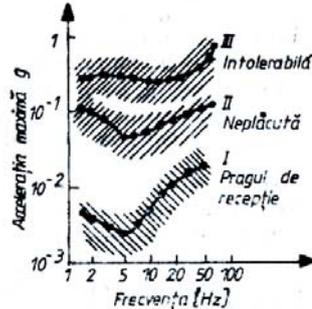

Fig. 4 – Appreciation curves of vibrations upon the human body.

In Fig. 4 ---- 1. Perception curve ; 2. –Displeasure curve ; 3. Intolerance curve.

Till the present day,we cannot indicate the precise limits for the safety and efficiency of a human.In chart 1 we can observe some orientative values of frequencies of the organs of the human body,that can be generalized.For classifying the tolerance criteria,a concomitant study of two mechanical parameters that characterize vibrations: frequency,movement,acceleration or energy.The vibration perception boundry of the human body depends on it's position,solicited organ and way of action.

Chart 1 – Own Frequencies

Nr. Org	Organ Name	Own frequency (Hz)
1	Head	25
2	Eyeball	30-80
3	Shoulder	4 - 5
4	Chest volume	16 – 80
5	Forearm	16 - 30
6	Spinal cord	10 - 12
7	Hand	50 - 100
8	Leg	2 - 20
9	Abdominal mass	4 – 8
10	Chest	16

Apreciating the actions of vibrations is established,taking into consideration the simultaneous action of vibration amplitude α0 and frequency,because of the fact that the body contains different masses and due to the elastic link between them,some parts of the body do not move at the same frequency as different amplitudes.The coefficient K of solicitation to vibrations is calculated through the relationships given in Chart 2.

Frequency	K
Under 5 Hz	K = α0f2
5 – 40 Hz	K = 5X0F
40 – 100 Hz	K = 200 X0 where X0 is given in mm

For different values of K,the way in which vibrations are conceived by a human being and the measure in which they affect the activity are given in Chart B.

Coefficient K of solicitation	Way of perceiving vibrations	Effects of vibrations upon work
0,1	Taking the shape of line-waves	Do not stand in the way of work
0,1 – 0,3	Perceptable,a little bit disturbing	Do not stand in the way of work
0,3 - 1	Well perceptible,uneasy over large periods of time	Can stand in the way of work in some measure.
1 - 3	Pretty trong,but bearable,uneasy over long periods of time	You can still work somewhat normally.
3 – 10	Unpleasant but bearable over long periods of time,tolerable for mostly an hour	Stand in the way of work but can be accepted.
10 - 30	Very unpleasant,can be bearable for no more then 10 minutes	Work is almost grinded to a halt.
30 - 100	Very unpleasant,bearable for no more than one minute	Work is not possible.
Over 100	Unbearable	Work is not possible.

We present,succinctly,the actions of vibrations upon the human body:
- They ameliorate muscular relaxation,coordination and stability
- They induce a growth in muscular force,flexibility and mobility
- They induce a shirinkage of the fatty tissue
- They decrease pain
- They ameliorate periferic blood flow,induce a growth in the periferic and systemic blood flow,peripherical lymphatic flux and venous drainage.
- They positively influence boney masses.
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4. CONCLUSIONS

1. Vibrations that present interest for a human being are those that lie under the inferior limit of audible frequencies or in the infrasound domain.

2. The injurious action of vibrations upon the human body is not yet completely mentioned,a fundamental research on some parts of the human body taken seprately being required.

3. Vibrations can produce both physical and physiological effects upon a human being.

4. Vibrations that produce mechanical and termic effects can be used in medicinal therapy.

5. Mechanical vibrations have a differentiated action upon different organs of the human body when lying in report to diverse mechanical parameters of vibration.

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