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RESPONSE OF THE UTERUS TO ABDOMINAL VIBRATIONS IN SHEEP

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1. INTRODUCTION

There are many different stimuli that pervade our senses daily. We enjoy the voices of our children, the rhythm of the surf, and many kinds of music. However, some sounds are unpleasant. Intense noises and blasts, for example, evoke discomfort and can be detrimental to our hearing. Vibrations, in addition to sounds, are also ubiquitous in our environments. Vibrations of sufficient amplitude and duration may result in complaints ranging from motion sickness to pain [1–3].

The first awareness of over-exposure to vibration often comes in the workplace [4]. The musculo-skeletal morbidity associated with prolonged whole-body vibration, such as that experienced by seated individuals in over-the-road vehicles, is the most common occupational complaint. Health problems most often result when the vibration is in the range of the natural vibration frequency of the body 5–15 Hz [5].

Industry and government officials have worked closely to recommend guidelines for limits to vibration exposure to insure safety and health. Most of the data used in establishing guidelines derive from experiments, observations and clinical records

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of male workers [2–5]. However, there are particular features of female anatomy and physiology which might justify some alteration in the published standards. Currently, with women totaling nearly 50% of the workforce [6], the establishment of these guidelines is clearly indicated.

In a 1986 survey of the world's literature on long-term effects of whole-body vibration, Seidel and Heide [7] cited five studies in which there were a higher risk of menstrual disorders, proneness to abortions, and other complications of pregnancy such as varicosities, increased blood volume during the phases of ovulation and menstruation, and anomalies of the female reproductive organs. However, these experiments were thought to be subject to methodological limitations. To our knowledge, no pathophysiological and epidemiological work has since been done on this important question.

Progress in our understanding of gender differences in response to vibration has been impeded by ethical concerns of experimenting with women, particularly with invasive procedures, and by the lack of bipedal animal models to study major debilitating problems such as lower-back pain. However, for general acoustic and vibration transmission studies through the soft tissue of the abdominal segment, the sheep has proved to be a useful animal model for human exposure. In the present experiment, the transmission of vibration from the abdominal wall to the uterus has been examined as a means to begin to look more carefully into the general area of reproductive tract responses during vibration exposure.

2. METHODS

Guidelines for the care and use of the animals approved by the University of Florida were followed. Four non-pregnant adult ewes weighing between 45 and 60 kg were anesthetized with 2% halothane in oxygen by mask and intubated. They were placed supine on the operating table. Through a low midline abdominal incision, the uterus was identified and retracted sufficiently to insert a miniature accelerometer (Bruel & Kjaer Inst. Co. [B & K], Naerum, Denmark, model 4501) into the body of the uterus. The axis of the accelerometer was positioned in line with the axis of an actuator rod fixed on a mechanical shaker (B & K model 4808). The fibrous uterine body, with its supporting adnexa, provided a secure placement of the accelerometer.

An additional accelerometer (B & K, model 8001) placed on the actuator rod was used to verify a constant input acceleration of 2·5 m/s^2 (r.m.s) (0·25 g) at the external surface of the abdomen of the ewe. The rod and actuator were positioned on the flank of the ewe midway between the ventral abdominal midline and the spinal column and on a cross-sectional plane 20–30 cm caudal to the umbilicus. The abdominal wall was depressed 3 cm corresponding to a static force of 2 pounds (9 N).

The shaker was driven with sine waves generated with a Wavetek Signal Generator (San Diego, CA, model 182A) at the following frequencies: 5, 10, 20, 30, 50, 75, 100, 200, 500, 750, 1000, 2000, and 3000 Hz. The dwell time was 1 min. Spectral analysis was performed with a real-time analyzer (B & K, model 2123) in

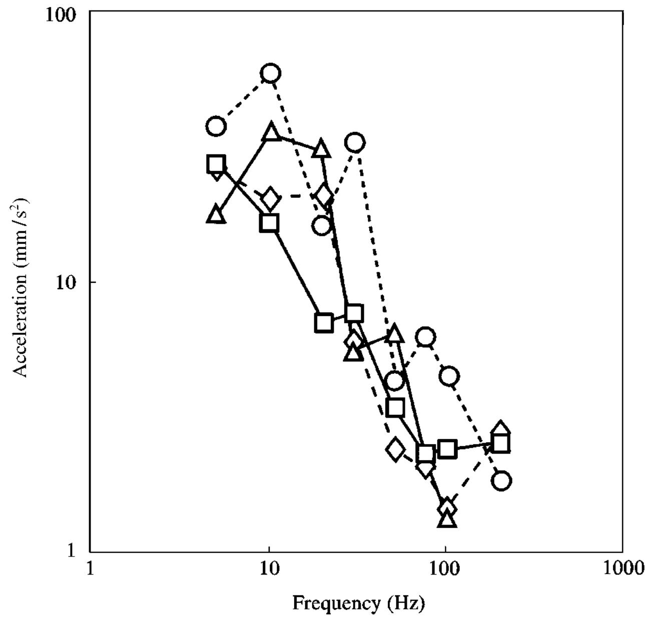

Figure 1. Relation between frequency of vibration of abdominal surface and the acceleration levels of the uterus in non-pregnant sheep numbers: □, 103; ◇, 101; ○, 13; △, 37.

one-third octave bands over a range of 3·15–10 000 Hz. Spectra were stored on diskette and plotted on a graphics plotter (B & K, model 2319). Finally, the noise floor was measured without stimulation, and used to verify each response.

3. RESULTS

Inspection of the reproductive tracts post mortem revealed well vascularized, slightly edematous uteri. Caruncular appearance indicated a previous pregnancy or pregnancies. All four ewes were in active estrous cycles as indicated by ovarian follicles and corpora lutea in various stages of development or regression.

The relation between the magnitude of the acceleration response of the uterus and the frequency of the constant input signal is given in Figure 1. All four response patterns were similar. The frequency range at which best transmission was observed ranged from 5 to 20 Hz. Acceleration levels at higher frequencies dropped rapidly, approaching the lowest levels at 500 Hz and beyond.

4. DISCUSSION

It is well known that the most damaging effects of vibration for the whole body are those in the region of 5–20 Hz [2, 4, 5, 8]. In this frequency range, a seated person absorbs much of the total spectral energy. The most frequently cited health effects of this exposure are pain in the lumbar spine and degenerating or herniated discs [3]. Less is known about the effects of vibration directly on the abdomen.

Repetitive vibration of the abdominal surface in an attempt to damp vibration coming from hand tools is common in the workplace, however, and may have been responsible for a reported case of torsion of the omentum in a jackhammer operator [5].

The data from the current study in non-pregnant animals are consistent with earlier studies of vibration exposures of the abdominal segment of term, pregnant animals. These studies showed maximum acceleration of the fetal head in frequencies between 6 and 12 Hz [7].

Individual components of the abdominal cavity, even the relatively small, loosely suspended and rather mobile uterus, do not appear to have resonant frequencies that differ significantly from the resonant frequency range of the abdominal segment as a whole.

REFERENCES

1. H. Dupuis and G. Zerlett 1986 *The Effects of Whole-Body Vibrations*. Berlin: Springer-Verlag.
2. M. J. Griffin 1990 *Handbook of Human Vibration*. San Diego, CA: Academic Press.
3. D. G. Wilder, J. W. Frymoyer and M. H. Pope 1985 *Automedica* **6**, 5–35. The effect of vibration on the spine of the seated individual.
4. M. Bovenzi 1996 *Seminars in Perinatology* **20**, 38–53. Low back pain disorders and exposure to whole body vibration in the workplace.
5. D. E. Wasserman 1987 *Human Aspects of Occupational Vibration*. Amsterdam: Elsevier.
6. C. Shehan 1996 *Seminars in Perinatology* **20**, 3–10. Sociodemographic perspectives on pregnant women at work.
7. A. J. M. Peters, R. M. Abrams, K. J. Gerhardt and D. E. Wasserman 1996 *American Journal of Obstetrics and Gynecology* **174**, 552–556 Acceleration of fetal head induced by vibration of maternal abdominal wall in sheep.
8. H. S. Seidel and R. Heide 1986 *International Archives of Occupational and Environmental Health* **38**, 1–26 Long-term effects of whole-body vibrations: a critical survey of the literature.