THE EFFECTS OF VIBROACOUSTIC THERAPY ON CLINICAL AND NON-CLINICAL POPULATIONS

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ABSTRACT

Vibroacoustic and vibrotactile devices that transmit sound as vibration to the body have developed over the last 15 years, and have been reported anecdotally to produce relaxation and reductions in muscle tone, blood pressure and heart rate. Vibroacoustic (VA) therapy is used in clinical treatment and involves a stimulus that is a combination of sedative music and pulsed, sinusoidal low frequency tones between 20Hz and 70Hz, played through a bed or chair containing large speakers. There is limited evidence to support the efficacy of VA therapy in the clinical situations in which it is used. The studies in this thesis investigated the clinical effect of VA therapy, and the effect of elements of the stimulus on non-clinical subjects.

A study on 10 multiply handicapped adults with high muscle tone and spasm compared the effect of eight trials of VA therapy with a similar number of trials of relaxing music. A significantly greater range of movement was recorded after VA therapy than relaxing music. No significant difference was found in changes in blood pressure or heart rate.

Comparing the effect of VA therapy with music and movement-based physiotherapy (MMBP) and relaxing music alone on 27 subjects with high muscle tone and spasticity revealed no significant difference in range of movement between VA therapy and MMBP, but a significant difference comparing the combined results of MMBP and VA therapy with relaxing music alone. Additional trials found significant differences between VA therapy and music alone.

A study on non-clinical subjects (n=39), and a second study (n=52) measured perceived location of bodily vibrations in response to sinusoidal tones between 20Hz and 70Hz through a VA bed. Reports indicated some that frequencies caused sensations of resonant vibration consistently in the same places in the body.

A second study on non-clinical subjects (n=60) in three groups found that VA therapy had a significantly greater effect in reducing arousal when compared with relaxing music, and a control, and heart rate when VA therapy was compared with a control. No significant differences were found between the groups in changes in blood pressure.

A third study (n=60) found no significant differences between four groups when evaluating the effect of varying rate of amplitude modulation of a 40Hz sinusoidal tone and a constant tone.

These studies have clarified the efficacy of VA therapy as an intervention for clinical populations, and the effect of the stimulus on normal subjects. Questions remain about the nature of the stimulus that is used, and its effect on behaviour.

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I dedicate this work to all my patients.

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MUSIC THERAPY AND MUSIC IN MEDICINE

1.1. ORIGIN OF STUDY

The development of Vibroacoustic (VA) therapy as a form of treatment began in the early 1980's. VA therapy as defined in the research reported in this thesis is a treatment involving the psychological and physical stimuli of relaxing music and pulsed sinusoidal low frequency tones between 20Hz and 70Hz played through speakers built into a bed (Fig.1 and Fig 2). Patients, or subjects involved in these research studies, lie on the bed, and experience a sensation of vibration from the music and sinusoidal tones, and at the same time hear both of these stimuli. Vibroacoustic units have been developed for both treatment and research, and the design and specifications of these units varies. The beds that were constructed to be used in the research documented in this thesis were designed with bass speakers built into the base of the units capable of reproducing music and pulsed, sinusoidal low frequency sound within the range defined above. Figure 1 shows a vibroacoustic bed, and Figure 2 demonstrates how the speakers are secured into the base of the bed.

FIGURE 1:

FIGURE 2

The studies and experiments documented in this thesis emerged from a desire to research objectively and analyse the effect of VA therapy, both on the clinical population with whom I have been working as a music therapist for a large proportion of my professional career, and also with the non-clinical population. There is limited anecdotal material documenting applications of VA or vibrotactile devices, very little of which has involved any objective research. The historical development of VA therapy is a sequence of apparently unconnected events. It is not confined to one country, and has emerged in America, Scandinavia, England and one or two other countries in Europe. It is quite difficult to put VA therapy into a context, which has affected the way it has developed. It includes aspects of music therapy, music in medicine and music psychology. Medical practitioners, paramedical staff, teachers, researchers and commercial organisations have been developing vibroacoustic units and systems for treatment, and have often independently defined procedures for using equipment, treating patients and monitoring the effect. The application of VA therapy has attracted specific attention within the broadly based field of music therapy. This is natural as the treatment involves the use of different styles of recorded music, and concerns the physiological and psychological effect of the music that is chosen to be used. The simultaneous use of a pulsed low frequency sinusoidal tone together with the vibrational effect of music played through a bed or chair that is designed to transfer a sensation of vibration to the patient does not normally come within the traditional framework of current treatment practice in music therapy. Practitioners in the field of music and medicine, occupational therapy, physiotherapy and nursing have more typically embraced these methods and developed its use. Understanding the relationship between VA therapy and music therapy, and VA therapy and practices in music and medicine is relevant in order to contextualise the research documented in this thesis.

1.2 MUSIC THERAPY

In order to understand how VA therapy comes within the field of music therapy but is nevertheless a distinct form of treatment from that which is conventionally understood as music therapy, it is helpful to look briefly at the development of music therapy.

Music has been a medium of therapy for centuries, and there are numerous examples of the curative or healing powers of music in the historical records of different cultures (Campbell 1991; Pratt and Jones, 1988; Wigram et al., 1995).

Over the last fifty years, music therapy has developed as a clinically applied treatment administered by trained professionals in countries where the development of graduate and post-graduate level training and clinical practice has resulted in qualified and recognised practitioners. Music therapy is now finding a place alongside other paramedical professions such as physiotherapy, occupational therapy, speech therapy and psychology in paramedical services and special educational services provided by health and education authorities. In some countries, music therapy is officially recognised by political, clinical and employing agencies. Styles of work vary considerably, and are influenced by the clinical field within which the music therapist is working, and the training and cultural background from which they come. Recent publications have highlighted the wide application and enormous diversity of music therapy, (Bruscia, 1991; Heal and Wigram, 1993; Wigram, 1992d, 1992e, Wigram et al. 1995). In Europe, music therapy traditions have emerged from the more psychodynamic and psychotherapeutically orientated approaches. Frequently one finds here a model where the therapist is actively using music making through the medium of clinical improvisation in order to establish a musical relationship with the patients through which he or she will be able to help them understand the nature of their problem. This active form of music therapy has involved the development of music therapy training programmes which require, at entry level, highly trained musicians in order to develop their skills in the therapeutic field. Therapists require a knowledge of the potential in therapy of the various elements of music for helping the patient, together with a theoretical framework of therapeutic intervention (Alvin, 1975, 1976, 1978; Austin, 1991; Bang, 1980; Bean, 1995; Bunt et al., 1987; De Backer, 1993; Flower,1993; Nordoff and Robbins, 1971, 1977; Odell-Miller, 1995; Oldfield, 1995; Postacchini et al., 1993; Priestley, 1975, 1995; Ritchie, 1993; Robbins, 1991; Wigram, 1985, 1988, 1991a, 1995, Wigram et al. 1995).

With certain patient groups, music therapy has been found to be effective and beneficial. For example, there is much documented material on the efficacy of music therapy intervention to improve and develop communication and relationship-building with patients with autistic disability, and in assessing communication disorder (Howat, 1995; Muller and Warwick, 1993; Warwick, 1995; Wigram, 1991c, 1992c, 1995a). Neurological disorders, including Alzheimer's disease, Huntington's Chorea and Parkinson's disease have apparently responded positively to music therapy, both in terms of movement activities, singing, and music listening (Bonny, 1989; Bright, 1981; Erdonmez, 1991, 1993; Selman, 1988).

Behavioural approaches in music therapy have emerged mainly in the United States of America and, in their development, they have frequently developed the use of music as a stimulant, a relaxant or a reward. In addition, the structure and properties of music have been applied and manipulated to achieve development, growth and improvement in patients. In this sense, the therapeutic process does not involve a dynamic and responsive interaction with the patient, but the music is structured in order to help the patient overcome emotional, physical or psychological problems from which they are suffering. This is a more prescriptive and applied use of music (Clair, 1991; Darrow and Cohen, 1991; Grant, 1995).

In Europe, there has been a strong tradition for using live, improvised music in music therapy. Participation in active music-making has traditionally been the method by which music therapists are trained to engage and treat patients. An understanding of the nature of a patient's musical behaviour, the way they play, and the non-verbal and musically communicative interaction which they have developed is the method by which the process of therapy is undertaken, and through which a patient will achieve progress. However, there are also a number of methods involving recorded music rather than live music as the medium of therapy. Guided Imagery and Music (GIM) (Bonny, 1975) is a method where patients are not required to make music, but rather to lie on their back and listen to recorded classical music. In this method, patients talk about images and symbols whilst listening to the music, and frequently move into altered states of consciousness where they are able to reveal symbols and figures that have specific meaning in their lives. The therapist acts as a guide during this process, responding to the patient, holding and containing them. The music acts very much as a catalyst which stimulates the process of imaging, and there are a wide range of music programmes used in GIM to meet both the emotional needs and the mental state of patients who are coming for therapy (Bonny, 1975; Clark, 1991; Goldberg, 1995; Moffit, 1991; Rinker, 1991). The practice of GIM and other forms of therapy where recorded music is used both for relaxation and also for reminiscence therapy is not exclusively the province of music therapists. The application of recorded music as a receptive treatment has inevitably captured the interest of psychologists, doctors and musicians, and the research into the role of music in conjunction with medical practice has been defined within the field of music in medicine.

1.3 MUSIC IN MEDICINE

The place of music in the medical treatment of a patient is particularly relevant when considering the application and research undertaken in the field of vibroacoustic therapy, which involves the application of music and low frequency sound to the treatment of specific pathological conditions. Maranto offers the following categorisation of the place of music therapy in the field of medicine:

"Music therapy may relate to the medical treatment of the patient in a variety of ways:

(A) Supportive to medical treatment (eg. the use of music listening during kidney dialysis)

(B) As an equal partner to medical treatment (eg. the use of singing in conjunction with medication as a treatment for respiratory disorders);

(C) As a primary intervention for a medical condition (eg. the use of music listening to directly suppress pain)." (Maranto, 1993)

Medical and dental practitioners use music as a background relaxant, for example in waiting rooms, but this must be clearly differentiated from the specific application of music in a treatment process. This is important when considering the use of recorded music in a variety of situations where it may or may not have a therapeutic purpose. Additionally, it may or may not have a therapeutic effect, something that the institution or unit using music in this way may or may not have intended, and of which they may or may not be aware. It has become more common practice for surgeons to have background music in the operating theatre during operations. The music is to provide a relaxing and conducive atmosphere for the operating team, and is not intended for the anaesthetized patient. However, there is some research on the use of music in surgical procedures, particularly in operations where the patient is conscious and under spinal anaesthesia (Spintge and Droh, 1982; Spintge, 1993). Spintge (1993) describes the use of "anxioalgolytic music" in medical and surgical procedures to reduce the distress, anxiety and pain suffered by patients. From a psychological point of view, Spintge's studies reported significantly reduced anxiety and improved compliance, particularly during the preparation phase before a surgical procedure. From physiological measurements, he reported a significantly reduced need for medication during surgery especially during procedures where the mode of anaesthesia was other than a general anaesthetic.

Spintge looked at the musical elements he was using, in order to define differences in music he would describe as "relaxing music" and the elements in the music he would describe as "anxioalgolytic music". In order to select appropriate music that he expected would have the effect of reducing anxiety, Spintge suggested some specific parameters for "anxioalgolytic music" that differentiated it from relaxing music:

Music element	Relaxing music	Anxioalgolytic music
Frequency	20Hz-10,000Hz	600Hz-900Hz
Dynamics	little change	little change
Melody	in dynamics	in dynamics
Tempo	60-80 beats/min	50-70 beats/min
Rhythm	constant	floating
	little contrast	no contrast"

(Spintge, 1993)

Looking at the role of music in pacification/stimulation of premature infants of low birth weights, Standley (1991) found that music is an optimal early intervention stimulus for infants and parents with medical, social or psychological problems. She commented that music is "heard" and "learned" by the foetus; therefore it may affect development prior to birth. "After birth, music in the neo-natal intensive care unit can mask the aversive sound level of the isolette, thereby facilitating homeostasis which increases the infant's neurological development. Music is a singular stimulus which can both pacify and stimulate in socially beneficial ways, with implications for future preference and interaction." (Standley, 1990; 1991).

Standley (1986, 1992, 1995) has conducted a meta-analysis of the variety of applications where music is used as a therapeutic intervention in medical and dental treatment. These analyses provide evidence from studies of a wide variety of medical or dental interventions, including objective studies on pain, cardiac conditions, pre-operative anxiety, childbirth pain, neonate weight gain, which supports the use of music as an effective element in treatment.

Further studies have looked more specifically at the use of music in the control of human pain (Brown et al. 1991; Chesky and Michel, 1991; Spintge 1993) and the effect of music on premature babies (Standley, 1991b). Brown's study was mainly concerned with evaluating the attributes of music for pain control and considered that the music had two specific qualities which could be used in developing effective pain-coping skills: an attention-distraction dimension and an affect dimension. In terms of the attention-distraction dimension, music had the potential to hold one's attention, challenge the intellect and modify the emotional state regardless of personal preference or knowledge of the music and it required the individual to commit himself or herself to the experience moment by moment. Therefore, music has the potential to alter one's perception of time, and a sensation of pain may not necessarily be diminished but the suffering involved would be greatly reduced. As far as affect is concerned, music can be mood-evoking and can arouse emotional experiences that can provide a heightened meaning to a situation, stir up past memories or allow self-catharsis.

The effect of recorded music on pain relief was investigated by Curtis (1986). Here, personal preferences in music were an important consideration and the researchers prepared fifteen- minute studies based on the patient's stated preference and perception of the calmness of musical excerpts presented from a master tape. The music selections were drawn on the basis of procedures defined by Curtis (1982). This study pointed to the efficacy of music as an intervention tool with terminally ill people, although the sample group in the study was small and a recommendation was made for replication of the study using a larger patient group.

The field of music in medicine is more focused than that of music therapy, and tends to be orientated around specific clinical and pathological disorders. Professionals contributing to this field have mainly been music therapists and medical practitioners. The field is very well documented (Maranto 1991a, 1991b, 1992, 1993; Standley, 1992, 1995; Spintge, 1982, 1988; Spintge and Droh 1982).

A comprehensive analysis of some of the music in medicine studies was also undertaken by Maranto (1994) who reviewed studies evaluating the effect of music in neo-natal intensive care, coronary and intensive care, pulmonology, surgery, specific medical procedures, radiology and oncology. The majority of the 77 studies reviewed by Maranto in her paper employed recorded music in the experimental condition as the method of therapeutic intervention.

Some studies record reductions in blood pressure (Bonny and McCarron, 1984). Maranto points out that there have been inconsistencies in physiological results from some trials that have been undertaken, and that "knowledge of the physiological and psychological effects of music is far from complete, and recent research has been addressing the specific influences of musical elements such as rhythm, tempo, harmony, timbre, etc. on these parameters." (Maranto, 1994). Hodges (1980) has also referred to the conflicting evidence of the effects of music on heart or pulse rate. For example, some studies indicate that, in general, stimulating music will increase heart rate whilst sedative music will cause a decrease in heart rate (Darner, 1966; De Jong et al., 1973; Ellis and Brighouse, 1952). Other studies have found that there are quite unpredictable results or that music has no effect on heart rate (Barger, 1979; Bierbaun, 1958; Coutts, 1965). There are equally contradictory findings from studies on the effect of music listening on blood pressure. Hodges also comments on the difficulties in summarising and collating the literature studying the effects of music on muscular and motion responses. He points to certain conclusions, which influence issues discussed in this study:

- There is no significant difference in muscular activity during stimulative and sedative music in listening situations (Lord, 1968).

- Consistent neuro-muscular responses were detected through EMG as individuals saw and heard music (Holdsworth, 1974).

Music has been proposed as a therapeutic intervention for stress and stress related disorders (Maranto 1993). This field has become a focus of interest for music therapists and doctors, as disorders which have no clear organic origin present may be affected by stressful life situations or significant events. Aldridge and Brandt (1991) studied the value of music therapy for inflammatory bowel disease on the basis that this disorder could have an immunological basis influenced by chronic stress. This research focused on the value of music therapy as a process that stimulated positive emotions, enhanced coping mechanisms and enabled recovery. In their study, Aldridge and Brandt sought correlations between the behaviour of patients with inflammatory bowel disease and elements of their musical improvisation. For example, a lack of gut motility is evident musically in a lack of rhythmic flexibility, and an unresponsiveness to tempo changes. This study is important in scientifically evaluating evidence of a pathological condition through improvisational music therapy.

Therefore whereas in passive approaches and in the principles of music in medicine generally music can influence physical behaviour including autonomic activity, it can also be found that music affects and elicits psychological response, by influencing mood and affective responses in individuals. In addition, these studies demonstrate how the pathological behaviour or state of a patient may influence, and be evident in, music-making. This has also been found to be useful in the use of music therapy as a medium for diagnostic assessment (Wigram, 1992b, 1995a).

In the field of music in medicine, there are more detailed and scientific experimental studies with quantitative methodology and design due to the influence of a medical milieu, and to the requirement for objective data indicating physical changes in the patients as a result of the application or intervention of music. Proponents of the application of VA therapy have frequently claimed physiological changes in their patients or subjects, yet the studies that have been undertaken have often included neither a control group nor a placebo group to attach validity to those physiological changes.

VA therapy is connected to both music therapy and the field of music in medicine. A knowledge and understanding of the nature of music from the point of view of a music therapist is of considerable advantage in the application of VA therapy. In making programmes for the therapy sessions, the selection of music which can be considered appropriate for its sedative and relaxing qualities needs the knowledge and skill of a musically trained person with a therapeutic orientation. The treatment stimulus of VA therapy with which this thesis is concerned involves the use of relaxing or sedative music combined with a pulsed, sinusoidal low frequency tone. This will be more fully explained in the material describing the development of VA therapy.

VA therapy has been used experimentally as a treatment for physical disorders such as high muscle tone, pain, respiratory disorders, high blood pressure, sports injuries, constipation, neck and shoulder pain, abdominal and colic pain, poly arthritis, rheumatoid arthritis, fibromyalgia, oedema and circulatory problems, multiple sclerosis and other neurological disorders (Skille, 1991). In these areas, the application of this treatment has been primarily aimed at physiological change, and little consideration has been given to psychological responses in reports which have been made of the effect of treatment. How much a psychological change in the patient may affect their physiological response can be seen more clearly when comparing a treatment with a placebo treatment, and the studies undertaken in this thesis have included both psychological and physiological measurements of change.

Finally, the development of VA therapy has taken place primarily in patient treatment. The clinical field with which I was involved at the time of this development was in the area of profound and severe learning difficulties (mental handicap), and the patients for whom I was providing a music therapy service presented with a wide range of physical and psychological disabilities and disorders. They were all primarily handicapped with neurological impairment from a genetic or inborn metabolic origin, and many of the patients were multiply handicapped and suffered from cerebral palsy, athetoid disability etc. A number of patients had challenging behaviour, namely aggressive and disturbed behaviour, and the majority were pre-verbal, and therefore could not communicate verbally.

VA therapy was introduced into the hospital in collaboration with the physiotherapy department as an experimental treatment for muscle problems (Wigram and Weekes, 1989a, 1989b; Wigram 1991b). The anecdotal results which had been received from Norway, and also initial findings at Harperbury Hospital during a period of experimental treatment, gave enough evidence of an effect of treatment to embark on objective studies. This thesis contains studies on varied clinical groups, and also studies on the non-clinical population. The studies on the clinical population were undertaken first, and they were concerned mainly with evaluating the outcome of VA therapy as a treatment. Therefore, in the studies on muscle tone, and self-injurious behaviour, the design of each study involves placebo treatments. From clinical experience, requiring patients to lie down on units and then be left for periods of time with no stimulus, and no explanation, can be anxiety provoking and possibly cause distress. Therefore, the clinical studies are structured in a way that compares the treatment with a placebo treatment.

The studies on the non-clinical subjects were undertaken after the clinical studies. Some important questions arose during clinical studies relating to the stimulus which was being used, and from some of the assumptions that had been made in the literature of VA therapy. Two aspects concerning the stimulus used in VA therapy required investigation:

1. There were no objective data supporting the theory that subjects experience low frequencies as a sensation of vibration in different parts of their bodies dependent on the frequency played.

2. There were no objective data on the optimum speed of the pulse or amplitude modulation of the pulsed low frequency sinusoidal tone.

Finally, a controlled experiment was undertaken with non-clinical subjects where a placebo and treatment condition were also used.

1.4 OVERVIEW OF THE THESIS

The first three chapters look at both vibroacoustic literature and related literature. Chapter two reviews the related literature pertinent to this thesis. Because so little research has been undertaken to date in the field of VA therapy, this literature review will draw on related fields including research on psychological and physical responses to music, vibration, infrasound, and vibration and music. Chapter three describes the origins and historical development of VA therapy, and explains how during its growth over the last fifteen years as a clinically applied treatment, procedural and ethical questions have had to be resolved, and how research has grown alongside the commercial development of VA therapy equipment.

Each of chapters four to eight describes a separate experimental study and contains its own literature review relevant to the area it addresses, a write up of the experimental trials, and discussion section. Chapter four and chapter five are concerned with the effect of VA treatment on patients with severe spasticity due to cerebral palsy. In chapter four, ten subjects with cerebral palsy were selected from the population of a hospital for people with severe and profound learning disability, and they received alternately placebo and treatment sessions, randomly ordered. This study attempted to evaluate the effect of the sinusoidal low frequency tone combined with music compared with using the same music presented without a low frequency tone.

The study in chapter five developed from the study in chapter four, and introduced a new condition. Patients with cerebral palsy underwent music and movement-based physiotherapy sessions involving specific passive movements to a live music stimulus, usually appropriate piano music selected or improvised for the movements. It had been noted in these sessions that improvements were made in a range of movement in the spastic patients, and it was decided that this could act as a comparable treatment to VA therapy. Twenty-seven patients were selected, and they received VA therapy, music and movement sessions and a placebo treatment and differences were sought between these three conditions. The question for investigation here was whether active stretching, manipulation and massage of the patient had a more significant effect in improving their range of movement and reducing their muscle tone than was already evident when the patients were treated with VA therapy.

A small additional study included in chapter five involved additional trials of VA therapy compared with the placebo on ten randomly selected patients from the group of twenty-seven.

Chapter six describes the first experiment with non-clinical subjects. Volunteers took part in tests to find out whether, over a range of low frequencies between 30-70 Hz, they consistently reported a sensation of vibration in the same places in their body. There were two experiments, the first involving 39 subjects, and the second with 52 subjects. The test involved the subjects lying on a VA unit while a sequence of frequencies were played through the unit. The subjects were asked to identify, for each frequency, **if** and **where** they felt a sensation of vibration from each frequency in their body.

Chapter seven describes a study undertaken to compare the effect of VA therapy with a placebo and with a controlled condition using non-clinical subjects. Sixty subjects volunteered to participate in the study. They were divided into three groups, and the study concerned the effect of VA therapy on mood, arousal levels, blood pressure and heart rate when compared with a treatment of relaxing music and a control condition.

Chapter eight, the final study in the thesis, reports an experiment looking at the effect of different rates of amplitude modulation of the low frequency tone used in VA therapy. In the development of VA therapy, simultaneous recording of both music and pulsed sinusoidal low frequency tones was made on cassette tapes. A pulsed low frequency vibration has been produced by combining two tones, for example 40 Hz and 40.5 Hz, creating a difference tone and therefore a pulsed effect. The benefits of using a specific speed of pulse, for example whether the peaks occur every six seconds, ten seconds or fourteen seconds, has never been evaluated. It had been assumed that a pulsed tone was more appropriate and relaxing than a constant tone. This study investigated the effect of these three pulse speeds, and used a constant tone as a fourth condition. The experimental design involved using measurements of changes in mood (self reported), blood pressure and heart rate as a method of measuring the responses of the subjects.

Chapter nine is an final discussion, and important issues from the different discussion sections of each chapter will be reviewed. Limitations in the experiments that were undertaken will be examined, and future directions for research in VA therapy will be considered.

CHAPTER 2

EFFECTS OF MUSIC, VIBRATION AND INFRASOUND

2.1 PHYSIOLOGICAL RESPONSES TO MUSIC

There are several relevant studies on the physical and psychological influence of music and sound in the literature that provide some important theoretical foundations for the studies undertaken in this thesis. Vibroacoustic (VA) therapy incorporates both physical and psychological stimuli. The two processes are very closely related and physical feelings are experiences due to a psychological reaction, and conversely, psychological responses are related in part to the physical stimulus of sound.

An early paper written on the effects of music on respiration and heart rate (Ellis & Brighouse, 1952) looked specifically at the role music might play in the treatment of disease conditions related to respiration and cardioactivity. In this study, on 36 college students (18 men and 18 women), three recorded selections of music were used, Hall's "Blue Interval", Debussy's "L'Apres Midi D'Une Faun" and Liszt's "Hungarian Rhapsody No 2." Measurement of changes in heart rate was taken by an electrocardiograph and changes in respiratory activity were measured by pneumograph. The subjects in this study underwent trials where they received 30 minute exposures to the three pieces of music presented in a random order. There were significant differences between conditions in respiration rate, with increases in respiration to the more rhythmic and stimulating Hungarian Rhapsody by Liszt. There were no significant differences between conditions in heart rate. Ellis and Brighouse conclude that there are clearly limitations in the use of music for therapeutic purposes due to the "magnitude of an individual's reaction to music, being specific to the music employed." They propose that there is no general trait or reactivity to music and it would be hazardous to predict a person's individual reaction to different musical selections on the basis of his or her reaction to one or two pieces. The lack of a significant difference between conditions in response to subjects' heart rates to these three quite diverse pieces of music go to support the complex problems in trying to find consistency in the effect of music on physical behaviour.

A study by Zimny and Weidenfeller (1963) looked at the effects of music on galvanic skin response (GSR) in children. They sought to find evidence that stimulating and calming music would have different effects on children. They chose the fourth movement of Dvorak's "New World Symphony" and the "Air on a G-String" from Bach's Suite No. 2 which were judged to be exciting and calming respectively. The subjects were kindergarten, third grade and sixth grade children. They worked on the assumption that GSR is a physiological indicator of emotional response and they found significant differences in arousal effect between these two pieces. They postulated from their results that a decrease in skin resistance indicated an increase in emotional excitement and response to the exciting music, and an increase in electrical skin resistance indicated a decrease in emotional excitement in response to the calming music.

A study by Landreth & Landreth (1974) recorded changes in heart rates of 22 members of a college level music appreciation class while listening to the first movement of Beethoven's Fifth Symphony. They took measurements over a six week period; before, during and after experimental treatment. They were looking at variations in heart rate due to rhythmic, dynamic or orchestral changes in the music and they classified various parts of the music as either "stable" or "alternating". They found significant changes (brachycardia and tachycardia) from monitoring the segments. For example, the test music segments that were characterised by a driving, insistent rhythm, mounting sequential interplay and progressive dynamic intensity produced tachycardia in the listeners. They concluded, however, that music did not cause a consistently reliable effect on listeners' heart rate, particularly as the subjects' heart rates habituated in response the more times they listened to the piece.

Hunter (1968) looked at psychological and physiological changes elicited by musical stimuli. She was attempting to examine and evaluate the use of music as a therapeutic agent and to study the effects of rhythmical stimuli on brain activity through an electro-encephalograph. Her study employed the concept of the "predictability" of music, and in her choice of music, she compared two specific "types" of music. "Type 1" music she categorised as having consistent speed and meter, regular phrase length, limited frequency range, minimal dissonance, clearly defined accentuation and a consistent level of intensity. She compared this with music she categorised as "Type 2", which was typically more variable in speed and rhythm, with irregular phrase length, harsh dissonance, obscure accentuation, wide frequency range and sudden contrasts in intensity. The categorisation of music into specific types has also promoted studies in the United States and has resulted in music used for the purpose of therapy falling into two categories loosely defined as stimulatory music and sedative music (Smith and Morris, 1976, 1977). Hunter evaluated the responses of her subjects to music through an electro-cardiograph (ECG), and she was also concerned with evaluating the effect on sinus arrhythmia (SA). During inspiration, heart rate increases and during expiration, it decreases and this phenomenon, according to Brener (1967), is known as SA. In this process, SA tends to disappear as a subject passes from a relaxed state to one of high arousal. It is possible to monitor the effect of this through an ECG. Hunter also found that non-musicians showed significantly less evidence of SA when listening to predictable music than during silence, and there was also less evidence of SA during listening to predictable music than to unpredictable music (Type 1 compared with Type 2).

From another perspective, Saperston (1989) has developed a Music-Based Individualised Relaxation Training (MBIRT). In his research, he was using music as a specific intervention with the behaviourally disturbed, mentally retarded population in order to facilitate relaxation and a reduction in challenging behaviour. Rather than categorising music in an arbitrary fashion into either sedative music or stimulatory music, Saperston preferred to look at the specific music preferences of each individual patient and incorporate these into his therapy process. Thus, with one patient who identified strongly with the "hippy" sub-culture of the 1960's, he found that the preferred relaxation music was 1960's stimulatory rock music whereas another patient was more inclined to relax to Indian sitar music. In this study, a certain number of therapist-directed relaxation responses were included and the method encouraged a patient to go through a relaxation procedure and respond to bio-feedback in order to develop a personalised and individualised way of relaxing to music. MBIRT is a behaviour therapy approach where one or more elements of music are incorporated in individualized task specific training strategies. These are designed to elicit and/or shape one of more behaviours identified as necessary in the eventual achievement of a generalized state of relaxation. The assumptions here are that the patients' music preferences should be incorporated to facilitate the process. Sedative music is best for facilitating a relaxed psychological and physiological state. The patients' music preferences are based on psychological and physiological factors which can be helpful in interpreting responses to different musical stimuli and the patients' music preferences can be modified to facilitate more relaxed response. Earlier studies documented in American literature (Gaston 1951; Smith and Morris, 1977; Shatin, 1970; Wascho, 1948) had given some evidence of the value of different component parts of music, a combination of which made that music either stimulative or sedative. Therefore, from a psychological and physiological point of view, recorded music of various types can cause measurable change.

Studies on the effect of music in reducing anxiety, both in the acute area and in the psychiatric field, have looked at both physiological and behavioural outcomes (Stoudenmire, 1975; Davis and Thaut 1989). Zimmerman et al. (1988) undertook a study in a coronary care unit to look at the effects of music on patient anxiety. Dividing 75 patients randomly into two experimental groups, one group listened to music and the other to white noise. Effects on physical behaviour and anxiety were recorded using the State Anxiety Inventory (STAI) and physiological measures of blood pressure (BP), heart rate (HR) and digital skin temperature (DST). They found no significant differences between the two groups in the STAI scores or the individual physiological measures. When analyses were conducted of the groups' combined physiological measures, significant differences were found between groups.

Reardon and Bell (1970) undertook a study to look at the effects of stimulating and sedative music on activity levels of severely retarded boys. They found that the subjects were demonstrating lower activity levels during the more stimulating condition.

An important factor in achieving relaxation through the use of music is the degree of liking for the music (Stratton and Zalanowski, 1984). Music can have a calming, soothing and a resting effect, and can be especially helpful when people exhibit a high degree of anxiety, in alleviating tensions and frustrations. In a study on the non-clinical population Peretti and Swenson (1974) found that women demonstrated significantly greater decrements in anxiety compared with men, and the effect of music was more consistent in female responses to anxiety than in the male responses in all the groups they studied. Music in conjunction with autogenic training can also have a significant effect in reducing arousal level and promoting relaxation (Reynolds, 1984).

In relation to the clinical population, studies have looked at the effect of music on anxiety (Hooper and Lindsay, 1989; McPhail and Chamove, 1989). Hooper and Lindsay compared live music, in the form of music therapy, with recorded music on four female subjects with learning disability and challenging behaviour, measuring pulse rate and a rated scale of behaviour. They found no improvement under the control conditions, whereas the music conditions produced some improvements in the behaviour of the subjects and a decrease in heart rate. However the authors reported that the changes in heart rate could equally have been attributable to other factors.

Some studies have focused on the differential effects of stimulating and sedative music on anxiety and concentration, and on the emotional components of anxiety. To find any differences between stimulating and sedative music, Gaston proposes the following differential responses:

Stimulating music enhances bodily energy, induces bodily action, stimulates .... the emotions..... Sedative music is of a sustained melodic nature with strong rhythmic and percussive elements largely lacking ..... (Gaston, 1951 p.43). Stimulatory music is likely to significantly increase both worry and emotionality, while sedative music will decrease worry and anxiety (Smith and Morris, 1976).

Inconsistent and contradictory results have been found on the relationship between relaxing music and heart rate. Hodges (1980) reviewed 21 studies. Seven produced evidence that heart rate increased in response to stimulating music and decreased to sedative music. Another five studies suggested that any music, stimulating or sedative, tended to increase heart rate, and seven other studies indicated that music had no effect on heart rate. The final two studies found both stimulating and sedative music influencing heart rate but the changes were unpredictable.

Relating this to the effect of patient anxiety in coronary care units Zimmerman et al. (1988) found no significant differences either in state anxiety scores or physiological parameters.

The literature referring to methods of obtaining or achieving relaxation in patients with learning disability (mental handicap) is more patchy, and research that has been undertaken has reported disappointing results, especially with people with moderate and severe handicaps. Abbreviated Progressive Relaxation (APR) has successfully been used with adults with severe learning disability, who show a consistent reduction in behavioral and psychological anxiety (Lindsay and Batty, 1986a). Behavioral Relaxation Training (BRT) is also a recently developed method to help individuals cope with their anxiety, and although studies seem to have relied on pulse rates as a significant physiological measure of anxiety, behavioral ratings have also been taken (Lindsay and Batty, 1986a, 1986b,; Lindsay et al. 1989a, Lindsey et al.1989b).

2.2 RESEARCH IN VIBRATION

There has been a substantial amount of research investigating vibratory sensitivity in subjects (Guignard 1968, 1971, Landstrom and Landstrum, 1985; Manninem, 1983). Some studies have focused quite specifically on the cutaneous threshold for vibration (Verrillo 1962). Investigation into the effect of a specific vibratory stimulation, often on the hands, has been undertaken (Berglund and Berglund 1970; Roland and Neilsen, 1980; Skoglund and Knutsson 1985; Verillo, 1962) with various outcomes. In the Roland and Neilsen study, a 100Hz mechanical sinusoidal stimulus was applied with an electro-magnetic vibrator and measurements were taken on eight different points in the human hand in normal subjects and then on patients with Unilateral Suprathalamic lesions of the hemispheres. This research study found that the distribution of the different thresholds suggest that Pacinian corpuscles are the receptors activated by threshold stimulation. However, no significant difference was found when undertaking the same measurement of stimulation and response on brain-damaged patients. An important finding in this study was that mechanical sinusoidal waves are highly unspecific stimuli which can activate many different receptors in the skin and subjacent tissues. It isolated the Pacinian corpuscle as the only known receptor which has approximately the same density all over which will respond to high frequency vibrations between 100Hz-400Hz.

Skoglund and Knugsson (1985) investigated the effects of vasomotor changes in human skin caused by high frequency, low amplitude vibration. Using a technique of infra-red thermography to measure skin temperature and taking a measure of superficial blood flow in the skin, they found that slight vibration can cause an increase in skin temperature which would indicate vasodilation, whereas a strong vibration will cause vaso-constriction resulting in a reduction of blood flow. The optimum frequency range for vibration they found from their tests was between 100Hz-300Hz and they achieved reproducible effects at a frequency of 150Hz. This research focused on the effects of sensory vibration on the hand, using an electro-mechanical vibrator which delivered sinusoidal pulses of variable frequency and amplitude.

Wedell and Cummings (1938) investigated aspects of fatigue of the vibratory sense in an experiment looking at the effect of mechanical vibration on the palm of the hand. They commented that there was a lack of scientific interest in the perception of mechanical vibration, probably due to the fact that although a feeling of vibration is an everyday occurrence it does not seem to play a very important part in the adjustment of the human being to his environment. Their work explored frequencies between 64Hz and 1024Hz generated by a Western Electric free field audiometer into a metal rod connected to the palm of a subject's hand. They took readings over a three minute period between the frequencies mentioned at intensities of 10-40 decibels above threshold. They found that the amount of fatigue depends upon the frequency of stimulation and, in a summary of their trials, they concluded that a sensitivity to vibratory stimulation applied to the palm of the hand is reduced by 5-15 decibels after three minutes of continuous stimulation. They also found that the loss of sensitivity is greater the higher the frequency and the greater the intensity of the tone used. Finally, they found that after stimulation for three minutes to a certain frequency, the loss of sensitivity is the same whether measured at a frequency equal to or higher than the fatiguing frequency but is less if measured at a lower frequency. Further studies indicated the significance of the level of intensity of the tones used.

In a study on adaptation and recovery in vibrotactile perception, Berglund and Berglund (1970) found that perceived intensity decreases exponentially with increased time of stimulation. They were using a sinusoidal tone of 250Hz delivered to a fingertip by means of a circular plastic button. They also found that the decrease in perceived intensity is greater at high intensity levels and a longer time was required for complete adaptation at higher intensities, although the process of recovery is fast, actually requiring only two to three minutes. In terms of perception, this study found that the perception of vibrotactile stimulation is complicated and difficult to evaluate. The interaction which occurs between amplitude, frequency and duration on the perceptual counterparts of these parameters provides interesting questions for psychophysiological research.

Studies on vaso-dilation were carried out by Skoglund (1989), looking particularly at the effect of higher frequencies (150Hz-250Hz) on changes in skin temperature. Areas of the body surface which were tested included the face, hands, parts of the legs, arms and trunk in a total of 130 vibration experiments performed on 80 healthy men and women between 20 and 70 years old. He used the technique of infra-red thermography to indicate temperature changes and vaso-dilation. His results supported the view that vaso-dilation is due to a reflex inhibition of pre-existent vaso tone in the skin by the afferent in-flow from vibration-sensitive mechanoreceptors. As in previous experiments, he also found that high-amplitude vibration which he used in a few comparative experiments caused vaso-constriction. He also found that the increase in temperature to the given stimulus is greater the lower the prevalent skin temperature at inception of the stimulus.

Vibration applicators have become a common tool of therapy in physiotherapy departments, and some research has focused on muscular response to vibration stimulation through this treatment technique. Stillman (1970) made a preliminary report on Vibratory Motor Stimulation (VMS), points from which are significant in considering the outcome of the studies on spasticity documented in this thesis. In 1964, at the Australian Association of Neurology Annual Meeting, one of the earliest reports was made of the effects of low-amplitude, high-frequency vibration on stretch response of human skeletal muscle, noting the effect of the involuntary asynchronous motor unit contraction in the muscle subjected to a mechanical vibration, with a reciprocal relaxation of the prime antagonists. In experiments undertaken by Hagbarth and Eklund (1968), this stretch response was identified as a Tonic Vibration Reflex (TVR).

Stillman (1970) identified the three primary effects of VMS as the "activation of the muscle, reinforcement of an active muscle contraction and inhibition of muscle contraction.". Stillman proposed that, when superimposing VMS on a voluntary muscle contraction, the result will produce a greater muscle tension or a greater range of movement, depending on whether "the initial contraction is against a yielding or unyielding resistance." In some studies he undertook on patients with spastic hemiplegia, spinal quadriplegia and acute incomplete spinal quadriplegia, he found improvements in hand grip, scapular stability, functional use of the limb and range of movement. In this research, the TVR induced by VMS caused improvement in muscle activity to the point where student physiotherapists could gain some insight into the simulation of spasticity in their own muscles. VMS activated muscles and, as a result, Stillman also listed a number of adverse reactions he found in some patients. These included increased spasticity and clonus of spastic muscles, increased rigidity and widespread tremor from application to patients with Parkinsonism, spread response to spastic muscles during the VMS of non-spastic paretic muscles and a general spread response to other muscles, particularly a feeling of discomfort from VMS over bony prominence.

It is important to note the stimulatory effects of VMS applied through the applicator that Stillman was using, which was an electrically powered and commercially available vibrating massage apparatus called "Pifco Vibratory Massager". This vibrator operates on a frequency of 50Hz, transmitting vibration through a slightly curved plastic disc, about 3.5 centimetres in diameter.

Several further studies have been undertaken on the effect of mechanical vibration in Sweden by Hagbarth and Eklund (1968). Their research followed the path of previous studies on Tonic Vibration Reflex (Eklund & Hagbearth 1965). The study they undertook in 1968 was designed to look specifically at the motor effects of muscle vibration in patients with various types of central motor disorders, in particular those associated with spasticity and rigidity. They studied the effect of muscle vibration both during the test and the relaxation periods and also during periods of the voluntary attempts of the patients to move their affected limbs. The vibrator they used consisted of a small electrically loaded motor in a cylindrical shape. They used rubber bands to attach the vibrator over muscle tendons and the motor was rotated at a speed of between 150Hz and 160Hz. The patient population they studied was 75 patients with upper-motor neuro lesions, ten patients with Parkinsonism, and five with Cerebella Syndromes. They found that the strength and the time course of the vibration reflex may be different in spastic muscles when compared with normal muscles. They also found that in spastic patients, vibration potentiates or reduces voluntary power (and range of movement), depending upon whether the subject tries to contract the muscle vibrated or its antagonist. In the patients they studied with Parkinsonism, the vibration reflexes are often of normal strength, but they found that the vibration increased the tremor and may have impaired the patient's ability to perform alternating movements.

2.3 INFRASOUND AND LOW FREQUENCY SOUND

The application of a pulsed, sinusoidal low frequency soundwave is a significant part of VA therapy. The research on human response to infrasound and low frequency sound is extensive, although there are very few studies on its benefits as a stimulus used in clinical treatment.

Between 1983 and 1985, the Forsvarets Materielverk (FMV) of the Swedish Defence Material Administration collected together a substantial bibliography and summary of articles on low frequency sound and infrasound (FMV, 1983; FMV, 1985). FMV were concerned with noise problems generally, and much of the focus for their collation of articles stemmed from a conference held in 1980 in Aalborg, Denmark, entitled "Low Frequency Noise and Hearing". In the introduction section to their summary of interesting articles, it is stated that:

"Infra Sound is of course not at all a new concept within acoustics. According to definition, this means sounds with frequencies below 20Hz. This is what is usually referred to as 'not audible sound'."

It goes on to say:

"We adopt without any reservation, the opinion that instead of "infra sound" we should talk of "low frequency sound" (below 100Hz) where human effects are concerned."

In general infrasound should not be a direct problem for normal people and research results support this. This report states that there is not enough research on low frequency disturbances in the range of 20Hz-100 Hz and that generally people are irritated by low frequency disturbances, both during work, at home and during leisure time where those sounds are part of the environment. This has not been sufficiently noted. The existence of high levels of man-made low frequency noise up to 100 Hz, and in particular infrasonic noise, has been reported in many environments. The research team compiling the report for the Swedish Defence Material Administration consider that noise in the 20Hz-100 Hz range is much more significant than infrasound (below 20Hz) at similar sound pressure levels and that the possible danger due to infrasound has been much overrated.

With regard to the experiments conducted for the purpose of this thesis, acoustic excitation was used as a method of generating low frequency sound vibration into the body. It is possible that the body response to acoustic excitation becomes progressively similar to that due to mechanical vibration as the excitation frequency reduces into the infrasonic region. When a sound wave is large compared with body dimensions, as it is in low frequencies, the result is uniformed compressional excitation which results in greater stiffness than unidirectional vibration excitation, and thus resonances are excited. Therefore, it can be considered that the effect of low frequency noise on the body is different from that of vibration, although they are similar in their ability to excite resonances. Vibration can be transmitted to the human body, however there is very little absorption of acoustic energy by man (2% at 100Hz for example) due to the impedance mismatch between the airborne acoustical energy and the body (Broner, 1978). Therefore, you need to have quite high levels of sound in order to achieve the same level of magnitude of response as you do from vibration and, using infrasound, one would need at least 130 decibels to produce the effects that might begin to cause concern.

Von Gierke and Nickson (1967) found that whole body excitation by means of infrasound is often the subject of specific interest. It is frequently concluded that it is hard to differentiate between airborn sound excitation of the body and vibrational excitation of the body.

There is more conjecture on the debilitating effects of low frequency vibration. Bryan and Tempist (1980) have suggested that there are some quite alarming ways in which infrasound affects human beings, such as a change in the sense of equilibrium, disorientation and nausea. They have also proposed that infrasound exposure may have been a cause of some automobile accidents.

It is known that vibration and infrasound can cause tiredness, discomfort and tracking task errors, affect vision and disturb balance organs. It should be pointed out that the sort of unpleasant subjective experiences or effects on some people of low frequency noise, including nausea, feelings of panic or euphoria are extreme symptoms and are mainly associated with high levels of intensity of low frequency noise and infrasound. Infrasound does affect the human body and physical, psychological, and pathophysiological effects which may be harmful can be measured. The sound may affect different tissues of the body in a variety of ways.

Parts of the body, particularly cavities, which contain different kinds of gasses or air, such as the lungs, the intestines, the stomach, the ear and the nose are more sensitive to infrasound than parts which are homogeneous and which do not contain gasses.

2.4 THE EFFECT OF INFRASOUND ON HUMANS

In a study carried out on the effect of infrasound below 20 Hz on human physiology with regard to Apollo Flights (Alford et al. 1966), 21 men between 21 and 33 years old were subjects in an experiment where stimuli of pure tones between 2Hz and 12Hz were presented at an intensity in the region of 119-144 decibels in a simulation chamber.

"No electric cardiographic alterations were observed during the period of stimulation or afterwards. The heart rate was noted to increase in six subjects by six beats or more per minute during maximum stimulation, but in five other subjects the heart rate was slowed down by six beats per minute with similar stimulation. Respiratory function as observed with impedance pneumography was normal for all subjects during exposure to the low frequency stimulus. In seven subjects, however, the respiratory rate was increased by four or more respirations per minute when a stimulus greater than 140 decibels was delivered. These are probably insignificant alterations." (Alford et al., 1966)

In these experiments, no subjects reported discomfort in respect of body vibrations, disorientation, mental confusion, sensory decrement or post-exposure fatigue.

In another study (Englund et al., 1978) 40 pilots were divided into three groups consisting of one group who were exposed to infrasonic frequencies (14Hz), a second group exposed to a slightly higher infrasonic frequency (16Hz) and a third group exposed to noise generated by a 50Hz alternating current.
In this study, the results indicated temporary threshold shift, changes in blood pressure, decreased vigilance and a somewhat longer reaction time and change of time comprehension. This study demonstrates that even low levels of infrasound can affect the working environment and also affect efficiency, alertness and physical behaviour.

Experiments carried out on healthy male subjects, using a frequency of 16Hz, found no significant change in ECG activity and pulse rate (Landstrom et al., 1981). However, in most cases in this experiment infrasound did cause an increase in diastolic blood pressure and a marked reduction in systolic pressure. The effect on diastolic pressure was statistically significant, whereas the effect on systolic pressure was not significant when calculated on the whole group of subjects.

In the same experiment, measurements were taken of respiration by placing a tension probe on the chest of the subject, in order to measure regulation in the rate of breathing. In most cases it was noted that there was a reduction in the rate of breathing during infrasonic exposition, however, the effect was small and not significant when calculated in respect of the whole material.

Some consideration of the nauseating effect of low frequency sound was also given attention in a study undertaken in Japan (Yamada et al., 1983). In this study, the Japanese measured the effect of low frequency sound on hearing people as compared to profoundly deaf people. This research also took into account the sensation effects of low frequency sound in various parts of the body. The apparatus used in these experiments consists of a low frequency chamber made of concrete blocks, using loud speakers some 76 centimetres in diameter attached to the top of the chamber. The range of frequencies used was between 8Hz and 1000Hz. Between 8Hz and 12Hz the sensations were experienced in the ear, breast, buttock and abdomen. Between 12Hz and 160 Hz, sensations were predominantly experienced in the breast. At 200Hz, the sensation was felt in the leg and above 250Hz it was mainly sensed in the ear. As far as the effect of nausea is concerned, the study conjectured that nausea may occur not from the vibration of semi-circular canals in the ear, but from transmission through the auditory path, brain, autonomic nervous system and stomach. They also concluded that profoundly deaf people detect low frequency sound by sensing the feeling of the vibration, as one might expect. Persons with normal hearing can also detect low frequency sound at high levels in parts of the body other than the ears.

Finally, a study on the psychological and physiological effects of infrasound on humans (Moller, 1984) exposed 16 subjects for three hours to inaudible infrasound, audible infrasound, traffic noise and a quiet control condition while they performed a number of psychological tasks. Cardiovascular and hearing parameters were recorded and the subjects also answered a questionnaire during the noise exposure. The experiments were carried out in an infrasound test chamber and the infrasound was produced by 16 loudspeakers. The stimulus in this case was random noise in the infrasonic frequency range. Condition A in the experiment was quiet background noise (35 decibels); Condition B was a traffic noise level at approximately 70 decibels; Condition C was the highest possible level of random infrasound frequencies where the sound was still audible and Condition D was a level of 20 decibels above the lower level, which in the pilot study was characterised as loud and annoying.

Cardiovascular measurements were taken and the subjects were asked to undertake nine tests in a specific order during the stimulation period. The sequence of the tests for the subjects was varied to account for order effects. Some interesting results emerged from this experiment. A higher degree of dizziness was noted in the condition where the subjects were receiving traffic noise rather than any of the other conditions. Headaches were experienced in all sound conditions but the rating for Condition B was higher than others. An experience of pressure on the ears was noted, particularly at the higher infrasound level. Incidence of nausea in the subjects was noted the longer they participated in the experiments, in particular by the time they had undertaken the tests for the third time. Systolic and diastolic blood pressure was significantly dependent on the day of the test and higher values were found on the first day than on other days. This study concluded that infrasound slightly above the hearing threshold gave a feeling of pressure on the ear and was given a higher rating on the annoyance scale. Infrasound did not cause headaches, nausea, tiredness or dizziness and did not influence the circulatory system. No influence on the cardiovascular system was seen and performance only deteriorated in one of the nine psychological tasks undertaken by the subjects. Infrasound below the threshold had no effect.

Many studies have been undertaken on human response to vibration at the Institute of Sound and Vibration Research in England. Griffin (1986) reports that vibration of the body can cause discomfort and annoyance, interfere with activities, present a hazard to health and cause motion sickness. He considered that the effects vary greatly according to the type of vibration, the individual and other factors. In this paper, Griffin was mainly interested in looking at the effects of mechanical vibration and he identified five responses to vibration that frequently occur:

a) Discomfort or annoyance

b) Interference with activities

c) Impaired health

d) Motion sickness

e) Bio-dynamic response

As far as discomfort is concerned, Griffin refers to those sensations which arise from oscillation of the body. In this respect, he draws some distinctions between the circumstances in which one is experiencing the vibration as to whether it generates a form of discomfort. For example, the psychological component comes into play when one considers that vibration which can be enjoyable at a fairground is, in a different way, uncomfortable when experienced in a car and certainly frightening when experienced in a building. In terms of activity disturbance, he comments that prolonged exposure to vibration can sometimes induce a sense of fatigue but the relationships between vibration and fatigue and between fatigue and performance are even more complex and have not yet been quantified.

In terms of health, he proposes that higher magnitudes of vibration will cause physical harm to the body. In terms of motion sickness, frequencies below 0.5Hz are one of several causes of the signs and symptoms of motion sickness, including pallor, sweating and vomiting. Sickness on sea vessels may be primarily associated with vertical motions and environments associated with motion sickness involve some perception of movement derived from unfamiliar patterns of sensation in the motion sensitive receptors (eyes, vestibular system etc.) Low frequency sound is therefore not the sole cause of motion sickness. Another factor which needs to be taken into consideration in evaluating specific effects is the differences between individuals in both physiological and psychological dimensions. In other words, young people may differ from old people in their response, males from females, extroverts from introverts and, in terms of resonance and body structure, large people might vary significantly from small people and "flabby" people will vary from muscular people.

What can be concluded from many of these studies is that the focus of attention on both vibration and low frequency sound has concentrated on the effects of discomfort, physiological change and annoyance as the parameters for evaluating any significant or stimulatory effect. In fact, the body of material collected by the Swedish Defence Material Administration has looked at infrasound in nature and its propagation, the existence of infrasound in buildings and in transportation (including ships, planes and cars). Other infrasound resources which have been considered in terms of research include natural sources of infrasound, industrial sources and civil and military sources. Many of the experiments have been undertaken using infrasound chambers whereby subjects are given a stimulus of infrasound from loudspeakers within a small enclosed chamber.

2.5 MUSIC AS VIBRATION

One of the earliest studies undertaken on therapeutic effect of music and vibration on physiological activity was by Teirich (1959). He cited a case study by Katz and Revesz describing the experiences of Paster Sutermeister, a deaf and mute patient. Sutermeister was not born deaf but lost his hearing completely, and his speech soon after, through cerebral meningitis at the age of four. It was not until he was 59 years old that he discovered his ability to enjoy music. This completely changed his outlook on life and his inclination towards melancholy turned to cheerfulness and contentment. Music became a vital necessity for him and he became a regular concert goer. He was able to experience the sound waves quite clearly but not in the same way as Helen Keller, who "heard" through the sense of touch in her fingers, but rather through an "inner sense of vibration." Sutermeister described it this way: "My main receiving station is my back. The sound penetrates here and flows through the whole trunk of my body which feels like a hollow vessel struck rhythmically, resounding now louder, now softer, dependent on the intensity of the music. But there is not the slightest sensation in my head and hands - the head is the least sensitive."

Teirich's investigations were also motivated by his interest in the reverberation of organs in small churches and consequently, in his subsequent research, he employed organ music. Teirich built a couch containing loudspeakers for generating vibration straight into the back, particularly in the region of the solar plexus. He used four middle range speakers and also tweeters with a response range from 20Hz to 16Khz.

He used the Toccata and Fugue in D minor by J S Bach because his experience had shown that the low notes of the organ music literally "move" the solar plexus, and because he personally found that the D Minor Toccata was emotionally satisfying in a special way and suggested numerous associations.

He involved his fellow doctors as a subject group and received some interesting comments from his colleagues who were participating in these experiments. One doctor reported: "The solar plexus was immediately radiantly warm. The warmth spread throughout the whole body. There is a remarkable feeling in the arms and the bass tones give a floating sensation."

Another report from a psychiatrist described vibrations in the hands first, some tension around the stomach moving to the heart and then disappearing completely whereupon the stomach became completely relaxed.

He also experimented with musical patients, one of whom described such effects as - "a powerful feeling of vibration in the hands, warmth in the whole body, very pleasant. After a time, a dream-like state comes about. I can see a woman before her mirror quite clearly, as in a miniature. The picture showed lively colours. At other times, I see no images."

Another musical subject commented, "It was quite remarkable. I could hear only with the solar plexus, also the softest notes but nothing at all with my ears. My hands and feet remained cold this time, in spite of the autogenous training which preceded the experience. It is a primeval experience. A pity it is so short."

This study can be seen as inspirational to the early pioneers of VA therapy, and from the experiences described here, the body of literature on the effect of vibration and low frequency sound, and from the principles and application of music therapy and music applied in the field of medicine, VA therapy emerged as a treatment involving the use of music and low frequency vibration.

CHAPTER 3

THE DEVELOPMENT OF VIBROACOUSTIC THERAPY

3.1 ORIGINS

The effect of recorded music, and the specific use of certain parameters in music, or elements of sound for therapeutic benefit of research enquiry has been documented in the first two chapters. The use of sound and sound technology as a treatment procedure is not a new concept, and history has shown evidence in both past civilisations and in present day cultures of the use of sound to treat physical disabilities and pain. In the latter part of this century, developments have included the treatment of certain conditions by means of ultrasound (Forster and Palastange, 1985), and interferential therapy (Savage 1984), a form of low frequency electrical stimulation.

Music therapists and doctors have been applying music generally as a treatment for a number of different conditions. VA therapy has grown out of this, with a specific emphasis on the physical effect of the sound which is used as a stimulus. One of the main figures in the development of VA therapy has been a Norwegian educator and therapist, Olav Skille. While he was working with severely physically and mentally handicapped children in a school in Northern Norway, Skille began to develop a therapeutic intervention by using music played through large speakers which were pressed against a bean bag on which children were lying. He wanted to give them an experience of "feeling" sound. The children were demonstrating significant difficulties because of high muscle tone, and the resulting spasm, which is painful and uncomfortable, was creating problems in their everyday life. Skille was investigating whether sound vibration, transmitted through a bean bag on which the children were lying would be helpful in reducing muscle tone and relaxing the children (Skille, 1982a, 1982b, 1986).

He proposed three universal principles of sound vibration and music:

- Low frequencies can relax and high frequencies can raise tension.

- Rhythmical music can stimulate and non-rhythmical music can pacify.

- Loud music can create aggression and soft music can act as a sedative.

Experimenting with various styles of music, Skille formed a hypothesis from his experiences that low frequencies and slow relaxing music were having the physical effect of relaxing the children. Based on this experiential work, he began to construct "units" which he originally referred to as "music baths" because he felt that he was "bathing" his subjects in sound. In anecdotal reports, he described considerable success in relaxing the children because of the effect of bass frequencies in the music which was the part of the stimulus he thought to be influential. He began to introduce the element of low frequency sound as a pulsed tone which he recorded on tapes together with relaxing music. It is this element which, in many instances, separates the method of VA therapy described in this thesis from many other forms of VA therapy or Vibrotactile stimulation which do not include pulsed, sinusoidal low frequency tones.

Skille defined the method on which he was working, and described the principles of the method at the first symposium of the International Society for Music and Medicine. He summarised the process of vibroacoustics as follows:

"The use of sinusoidal, low frequency sound pressure waves between 30Hz and 120Hz, blended with music for use for therapeutic purposes."
(Skille, 1986)

3.2 HISTORICAL DEVELOPMENT

Incorporating both the elements of low frequency sound vibration and music, Skille initially defined his technique as "Low Frequency Sound Massage". Subsequently, he named it Vibroacoustic therapy (VA Therapy). The basic process of this therapeutic intervention involves lying a patient on a bed, or a chair, into which has been built a number of loud speakers. The mattress or surface of the unit vibrates when music and low frequencies are played through the speakers. The body vibrates in resonance with the sound waves used. There has been limited research on the absorption of sound into the human body, but in a study by Broner (1978), it was found that at 100 Hz, two percent of the energy is absorbed into the body. This study was undertaken on airborne vibration. In VA therapy, the vibrational effect occurs from the contact made between the human body and the surface of the equipment.

Skille's investigations expanded to include other conditions which he found responded well to the treatment of VA therapy (1987, 1991, 1995). He developed taped programmes designed to be varied and effective in treating different problems. Cassette tapes were prepared using a mixture of music and rhythmically pulsed sound waves which he defined as being in harmonic relation to the music. A pulsed tone was created by placing two predominately sinusoidal tones close together (ie. 40Hz and 40.5Hz). The difference tone or amplitude modulation created a pulsed effect, the speed of which varied depending on the rate of amplitude modulation.

Writing about the effects he felt were occurring, Skille said: "The rhythmical, tonal pressure wave will cause a synchronisation of nervous impulses throughout the body, including the central nervous system. This comprehensive stimulation contributes to a harmonisation of a body which has come out of phase with itself because of traumas caused by external or internal conditions". (Skille, 1987, 1989a, 1989b, 1992,)

In 1987, the research undertaken in Norway and Finland was still based mainly on empirical clinical experiences. No objective research had been undertaken, and at a conference in Levanger, Norway in 1987, a number of paramedical and educational professionals, including nurses, physiotherapists, teachers, came together to share their experiences of VA equipment (Wigram and Weekes, 1987a).

VA therapy as defined by Skille began to expand into other parts of Europe, and was introduced as a treatment programme in Harperbury Hospital, Hertfordshire in 1989 (Skille, et al. 1989; Wigram and Weekes, 1989a, 1989b, 1990a, 1990b; Wigram 1989, 1992a). Subsequently, the studies in this thesis were initiated in order to make an objective evaluation of the effect of the treatment. While there was interest in some paramedical and medical milieus, the commercial development of VA equipment was rapidly overtaking the very limited amount of objective research which had taken place in the field. As a result, a plethora of different types of vibrational equipment began to appear on the market, many of them with limited scientific evidence to prove that they were effective.

Additionally, confusion began to emerge within this growing field as to exactly what stimulus was being employed in the different systems being developed. It is important to be clear for the purpose of this thesis, that the stimulus defined in the experimental studies which have been undertaken to investigate VA therapy for the purpose of this research involves a combination of both sedative and relaxing music and pulsed sinusoidal low frequency sound. Of the other equipment that has been designed, produced and marketed, some units have been the focus of scientific research, while others claim beneficial effects without supporting scientific evidence.

Somasonics Incorporated in America have produced a wide range of vibrational equipment, called "Somotron". They define it as "A musical instrument that plays melodies, chords and sounds THROUGH the entire body". Various researchers have investigated the effects of Somotron vibration units. Standley (1991a), found that finger temperature increased significantly in the presence of vibrotactile and auditory stimuli, which was an indicator of deeper relaxation. Madsen et al. (1991), found no significant differences between groups in physical behaviour on trials on college students, but they found that the students did verbally express positive reactions to the vibrotactile stimulation they had received.

Darrow and Gohl (1989) found that children with hearing impairment identified rhythmic changes more successfully when auditory stimuli were paired with vibratory stimulation than when they were presented alone.

Pujol (1994) investigated the effect of vibrotactile stimulation, instrumentation and pre-composed melodies on physiological and behavioural responses of profoundly retarded children and adults. No significant changes were found on respiration, pulse or behaviourally observed relaxation in the treatment condition for either the vibrotactile or the non-vibrotactile stimulation that was being administered.

Somosonics claim that "Somotron" equipment are the most widely used VA devices in the world, and there are a variety of units which are marketed and used in medical and paramedical milieus mainly in America. Some research has taken place on its effect, but many of the studies have shown no statistically significant difference between treatment and control conditions.

Another unit marketed as a vibroacoustic device is the "Quantum Rest", which is described by manufacturers as "an acoustically modulated warm water mattress, resting on a base cabinet from which large speakers emit soothing, massaging sound waves into the body". This item of equipment is advertised as an effective treatment for stress, and the specifications detail very large 18 inch electro voice bass speakers. It is designed for bass vibration but, from the software description, this is only generated through the music, and as with the "Somotron", pulsed low frequency sound waves were not included as part of the stimulus. "Quantum Rest" give a technical description of their equipment (quoted below), but limited information as to the exact stimulus they are using, and the therapeutic qualities of that stimulus.

The manufacturers describe the unit as follows:

"The electronic components, housed in a separate matching cabinet, were selected for their quality and reliability. The main amplifier driving the vibrations into the water mattress is a QSC MA-700, a 700-watt commercial amplifier which is considered to be the Rolls Royce of amplifiers. The QSC MX-700 is mated with a Rane AC-22, an active crossover network also considered to be the best available. The head and foot speaker sections of the platform -- supplied with a full range of high fidelity sound -- are driven by quality consumer electronics. The control amplifier is a Sherwood dual 65-watts/channel with multiple input capability. The five-disc carousel CD player and the cassette tape deck with auto-reverse function are supplied by TEAC, manufacturers of quality products."

A system called "Bodysonic" was developed in Japan. Anecdotal reports are included in literature relating to Bodysonic, and it claims to affect patients physiologically, particularly blood pressure.

"Thor of Genesis 1" is another device claiming an effective intervention for stress: "Thor of Genesis 1" uses 24 specially placed speakers to create a unique, balancing therapeutic movement and massage for the entire body. This produces a relaxed state of body and mind which reduces stress and adjusts the body to return to its natural energy flow."

The specifications given for "Thor of Genesis 1" describe the basic components of the equipment which is being purchased, but the literature gives little information about the therapeutic stimulus, or the treatment process.

"Physioacoustic" is manufactured by Next Wave Corporation, and the equipment developed from the vibroacoustic therapy equipment pioneered by Skille in

Norway, and is similar in some respects but different in others. The manufacturers describe their system as follows:

"The physioacoustic device uses low frequency sinusoidal sound combined with specially selected music. The frequency range varies from 27Hz to 113Hz. This low frequency sound comes from a specially designed computer. Any sound source (a CD or tape player for example) can be used to produce the musical effect. Certain sound parameters are important in the physioacoustic method including pulsation and scanning.

Pulsation:

The low frequency sound is varying in a certain, controlled time sequence. The purpose of power pulsation is to prevent muscle contraction. Continuous stimulation commonly causes numbness and contraction. With the sound pulsating slowly, this effect can be avoided and relaxation is obtained instead.

Scanning:

The computer causes the frequency to vary within a certain rate of amplitude and speed. This is necessary to guarantee that each muscle is treated at its optimal frequency, i.e. the pitch at which the particular muscle responds naturally."

Next Wave Corporation give a technical description of their equipment:

"The physioacoustic method is a unique therapeutic technique. A physioacoustic system consists of the following items: the adjustable chair, the computer unit inside the chair, the audio system and the transformer. The system utilizes normal electric current, with one cord for the transformer and another for the music unit. The transformer reduces the current to two circuits of 15 volts each in the device. Thus there is no risk of electric shock. Low frequency sinusoidal sound comes from the computer which is specifically designed for the physioacoustic system. It controls the basic sound parameters as well as the programs. The music is specially selected, or even composed, for this method. Thus it is possible to choose music which is ideal for this method and which also meets the musical expectations of the patient. The physioacoustic device gives the therapist an extraordinary ability to mix the low frequency sound signal and music together so as to produce the ideal physiological and psychological therapeutic effect."

The "Physioacoustic" method is different from the vibroacoustic method as developed by Skille because it presents a sequence of many frequencies at a time. Vibroacoustic therapy as investigated in this thesis presents only one pulsed, sinusoidal low frequency tone at a time.

3.3 CURRENT APPLICATIONS

In the beginning, the initiative for developing VA therapy was driven by the potential of the treatment to relax people and reduce muscle tone. This has expanded to embrace other pathological disorders.

Skille was influential in developing VA therapy in Norway. Many colleagues from different professional groups began to use various types of vibroacoustic equipment in order to explore its effects on various clinical populations. During the middle 1980's, there was no commercial production of vibroacoustic equipment, and much of it was constructed for clinical purposes. Skille reports in his VA therapy manual that "for ethical reasons it was important and necessary that the therapist and the staff who were experimenting with this equipment tried it on themselves first before they tried it on the patients". The reports that were then submitted which were initially drawn from staff experiences showed Skille that the treatment had effects on several different conditions. In this way, the variety of potential applications of VA therapy began to emerge.

Anecdotal reports have accrued over many years of experimentation and clinical reports from treatment sessions can be looked at as helpful and guiding rather than scientifically significant. There has been a certain amount of objective research into VA therapy, although very few studies that have been undertaken have been replicated. There has been a wide application of VA therapy treatment, and many of these treatments have reported beneficial effects.

Collated reports fall into five main pathological areas:

Pain Disorders

Muscular conditions

Pulmonary disorders

General physical ailments

Psychological disorders

3.3.1 Pain Disorders

There have been reports of the effective use of VA therapy with colic pains, bowel problems, fibromyalgia, migraine and headache, low back pain, menstrual pain, dysmenorrhoea, pre-menstrual tension, neck and shoulder pains, polyarthritis, and rheumatism.

Some of the treatments undertaken with these conditions have been successful. The use of frequencies recommended can vary considerably. For example, for polyarthritis, it has been recommended to use frequencies between 40Hz and 60Hz, whereas for migraine and headaches, the use of frequencies between 70Hz and 90Hz were recommended. Low back pain could be treated by frequencies between 50Hz and 55Hz. Over fifty reports have shown that over fifty per cent of patients treated for fibromyalgia have been successfully helped with a reduction in pain symptoms. There is no objective evidence supporting the specific use of certain frequencies for specific conditions other than the prescriptive suggestions from Skille (1992) and even less evidence to support short or long term effects of VA therapy.

One such objective research study was undertaken by Chesky & Michel (1991) in an analysis of the effect of music vibration on the sensory and mechanoreceptors in a study on pain. Their studies have found a significant effect when given stimulation within a specific frequency range (60Hz to 600Hz) using a Music Vibration Table (MVTtm) on pain receptors resulting in a reduced perception of pain by subjects (Chesky, 1992). They have also drawn attention to the lack of specificity regarding the stimulus used in other studies, in particular the nature of the music used (Michel and Chesky, 1993). Michel and Chesky used equipment which was adjusted to generate greater activity in the frequency ranges known to produce pain relief (approximately 100Hz to 250Hz). This research indicated the effect of music vibration in inducing vasodilatation. The research studies undertaken on pain relief by Chesky and Michel (1991) indicated that pain relief associated with music and controlled music vibration is substantial and significantly greater than music alone or use of a placebo.

3.3.2 Muscular Conditions

VA therapy has been used to aid muscular problems, particularly where those problems can cause painful conditions. Cerebral palsy has received considerable attention from clinicians looking at the effect of VA therapy in reducing muscle tone. Cerebral palsy is a condition which can react with spasm to over excitement, high stimulation, or sudden stimulation, and therefore relaxing and calming music can be helpful. Some of the treatments that have taken place using VA therapy have also involved doing active physiotherapy during or immediately after the session.

Other physically handicapping conditions which have shown a positive response to VA therapy have included multiple sclerosis, Rett syndrome, spasticity, and muscular over-use syndrome. Research in the clinic for children and adults with Rett syndrome at the Harper House Children Service in Hertfordshire, England, has already shown a positive response from almost all of the patients attending the clinic to VA therapy. In short, fifteen minute sessions, using classical and folk music combined with frequencies between 38Hz and 44Hz, observational reports have noted increased levels of relaxation, reduced anxiety, reduced hand plucking, and reduced hyperventilation (Cass et al. 1994; Wigram and Cass, 1995).

Anecdotal reports from people who suffer from muscular pain are interesting. One phenomenon is that during treatment for pain in a specific muscle group, patients have reported an experience that, as they relax to the stimulus, they experience the pain focusing on the particular muscle group where the damage has occurred and the effect of vibration has been to relax all other muscle groups or muscle fibres around this area. In this way, the treatment has heightened the sensation of pain and discomfort in the area of primary damage.

3.3.3 Pulmonary disorders

Further anecdotal results have shown some effect on certain pulmonary disorders, including asthma, cystic fibrosis, pulmonary emphysema and metachromatic leucodystrophy. Both metachromatic leucodystrophy and cystic fibrosis have similar symptoms that involves difficulties patients have in coughing up lung secretions and phlegm in order to keep the lungs clear. VA therapy has a palliative effect here in assisting the patient in coughing up secretions, by generating a vibration into the lungs and shifting mucus on the bed of the lungs causing a cough reflex to occur. Skille reported that up to the end of 1994, four children with this specific disorder in Norway were having VA therapy on a daily basis (Wigram and Skille, 1995).

Asthmatic problems have been alleviated by VA therapy, with easier breathing, reduced wheezing, and decreased viscosity of the expectorates in the lungs. Because severe asthmatic conditions sometimes cause bronchial spasms, the spasmolytic effect of VA therapy has been helpful in reducing the severity of asthma attacks. The evidence of effect on pulmonary disorders are supported only by anecdotal reports.

3.3.4 General Physical Ailments

VA therapy treatment has been used to treat decubiditus ulcers, reduced blood circulation, post operative convalescence and stress- related disorders. VA therapy has been found to be helpful in reducing blood pressure, heart rate and improving blood circulation. There are anecdotal reports of poor circulation in legs causing a purple colour which when subjected to a period of treatment of VA therapy have turned to a more healthy pink or red colour. There have been several studies on the effect of VA therapy on blood pressure. These studies provide conflicting and inconsistent evidence of effect (Saluveer and Tamm, 1989; Skille, 1986; Wigram, 1993a)

3.3.5 Psychological Disorders

The treatment has an effect on psychological state which may or may not affect physiological state. In this group of disorders, VA therapy has been used in the treatment of insomnia, anxiety disorders, self-injurious behaviour, challenging behaviour, autism, depression, and stress. The main claims of the effect of VA therapy with autistic patients are that it relaxes the patient, reduces their resistance to contact, and makes them more open to interaction. It is a tactile experience, so it can also stimulate a feeling of physical pleasure. Insomnia has been treated, and the reports have indicated that patients fall asleep more readily, and that they sleep for a longer period than is usual.

3.4 TREATMENT PROCEDURE

Current treatment procedures in VA therapy are varied and there are, at present, no specific guidelines governing the application of this form of treatment. As the research to date has been somewhat limited, there are also limited indicators in terms of which patient populations are not likely to benefit. However, there is some evidence of which aetiologies it can be most helpful.

Commercial organisations have developed vibroacoustic equipment, and marketed it, but there has been limited instruction to purchasers on the treatment procedure.

The development of VA therapy within a National Health Service hospital has necessitated some defined process or procedure by which people undertake treatment. Initially, this was written up at Harperbury Hospital as a treatment manual (Wigram and Weekes, 1987b). More recently documents have been formulated of good practice relating to VA therapy referral, assessment and treatment, and guidelines for contraindications.

The process by which patients are treated with VA therapy is now more defined, and the subjects who undertook trials for the experiments written up in this thesis were treated using these methods. Guidelines on these procedures currently in use in VA therapy treatment have been documented (Wigram 1995). The process of the treatment can be defined in six stages:

Pre-session preparation

Introduction

Starting the treatment

Monitoring the treatment

Ending the treatment

Post treatment work

Pre-Session Preparation

As part of the preparation for any treatment session with vibroacoustic equipment, the bed or chair needs to be carefully prepared for the patient who is going to be treated. The treatment is adversely affected if there are interruptions during the course of the treatment, so preparation is important. With physically handicapped patients, staff must ensure that the correct amount of support with pillows or wedges is available and ready. The room needs to be comfortable and the position in which the patient is going to lie or sit needs to be quiet, without obvious visual stimulation and well prepared. The equipment should be ready, tape rewound and the controls turned down to zero. This last point is important, as if a vibroacoustic tape is started with the volume turned up, patients will be subjected to a sudden jolt of sound when the music begins, and perhaps an uncomfortable boost of sound from the low frequency tone. The sound stimulus should be introduced gradually.

Introduction

If this is the first time a patient has come for VA therapy, some explanation will need to be given as to what is going to happen. The patient may need reassurance that he or she has control over what is happening and that if the stimulus is uncomfortable or irritating, he or she can get off the unit. With patients who are severely handicapped or profoundly mentally ill, this reassurance period still needs to happen and the tone of voice and the words used can set the scene and create the environment for a successful session. This is just as much a part of building the patient/therapist relationship as in any other form of therapy. People trust the therapist to treat them and need to be reassured by the way the therapist relates. Creating the right environment for the beginning of the session is an important part of the process.

Starting the Treatment

With vibroacoustic equipment the stimulus must be started gradually and increased carefully to a point which seems to be the most effective level of intensity of the stimuli for the patient. It is important to allow a short period of response only to music, then to gradually increase bass frequencies. Experience has shown that some of the non-clinical population trying this equipment have initially wanted the stimulus quite strongly and they ask for the volume or intensity to be increased. After a period of treatment, around ten minutes, it is important to check whether the intensity of the stimulus is too strong. At the beginning of a treatment, the low frequency tone can appear gentle and innocuous. However after some time it is often perceived to be exerting a strong influence. Therefore, until the therapist has established what is the optimum treatment intensity for each patient, a period of evaluation needs to take place. Even then, it cannot be expected that the patient would respond the same every time they come for a treatment. On some days, they may need a greater or a lesser intensity, depending on psychological or physiological state. It is not a precise science and no specific instructions can be given as to what intensity should be experienced by the patient.

Monitoring the Treatment

This varies depending on the patient. During the course of the treatment, the therapist may stay in the room in an unobtrusive way, to give a feeling of reassurance and comfort. However, for other patients, it can equally be more appropriate that the therapist should leave the room for the patient to have privacy and no distractions during treatment. With more handicapped or mentally ill patients, it is necessary to maintain an observation of the patient during the course of the treatment. It is important that the patient does not feel they are being 'watched', as this is a passive form of treatment. Therefore, it is better if the therapist can sit unobtrusively and appear not to be observing the patient.

In order to evaluate the responses of people who are not able to verbalise their responses, some observation of facial expression and body movement will be necessary to check whether the patients are experiencing discomfort or a reaction against this treatment.

Ending the Treatment Session

At the end of the treatment the relationship between the patient and the therapist will be important. Frequently, during VA therapy, patients may go into quite a deep state of relaxation. They may fall asleep and possibly dream, and they may feel vulnerable at the end of the treatment. Patients can move into an altered state of consciousness, and will need the therapist for reassurance, guidance and support.

At the end of the session there will be a need to make some evaluation of the response of the patient. With physically handicapped patients this may include some physical manipulation in order to check the significance of any improvement or lack of improvement.

It may take a little time before patients can be active after a VA therapy session. Experience was shown that some people need to rest for two or three minutes after a session. When they get up off the unit, sitting or standing, they need to have a good stretch and move around, as they may do after a deep sleep. Experience and research has shown that there may be reductions in heart rate and muscle tone during VA therapy, and sometimes also reductions in blood pressure, more than might be expected from thirty minutes lying down, and it might take the patient a little time to come out of such a deeply relaxing state.

Sometimes a patient can be a little emotional after a session, needing comfort and taking some time on the bed or chair to 'recover' from a deep state he or she may have reached. The therapist needs to pay attention to the needs of the patient at this time, but also to take care not to talk too much or to demand too much of the patient.

Post Treatment Work

In some situations, VA therapy is used as a pre-treatment. For example, it can be used as a pre-treatment for physiotherapy where, after the treatment has finished and a time period has allowed for the patient to become aware again, a relaxed, hypotonic state may have been achieved helpful as a preparation for physiotherapy intervention. Verbal psychotherapy may also take place after the treatment.

If the patient has fallen asleep during the treatment, it may be important for them to rest for a period of time before leaving.

Finally, the equipment needs to be checked after the treatment and it is a good practice to ensure that the controls are reduced to zero.

Summary

Treatment procedures will vary depending on the equipment which is being used and the patients who are being treated. The amount of information given in the literature or specification manuals supplied with VA equipment is limited regarding treatment procedures (Wigram, 1995b).

The period of time for which people are treated using VA therapy varies. Skille (1991) has recommended treatments varying between ten minutes and forty minutes. Wigram (1993) has consistently used treatments varying between thirty minutes and forty minutes, except in the case of patients with disturbed or challenging behaviour, where the period of time may be determined by the tolerance period the patient has to being on a vibroacoustic unit.

There is no research on the effective or optimum length of time for treatment. Many tapes have been made with music that lasts for between 25 and 40 minutes. At Harperbury Hospital, treatment tapes have been included which last for 45 minutes.

Different methods or approaches designed to induce relaxation in subjects have often used half hour treatments. This brief period of time for relaxation in various approaches, including progressive relaxation (PR) progressive relaxation with music (PRM), intermediate relaxation (IR), intermediate relaxation with music (IRM), mental relaxation (MR) and self-relaxation (SR) has proven effective. In the comparison undertaken by Miller and Bornstein (1977) of various methods, music itself was not found to have an enhancing effect upon relaxation. All the conditions tested found significant changes in the relaxation from EMG measurements of muscle tone, and also on a state anxiety inventory. They did, however, only use a single trial of a 30 minute session. There were significant decreases in anxiety and muscle tension over the short period of relaxation used. Based on this, and on clinical experience, most of the studies outlined in this thesis involved 30 minute treatment periods. It was not intended to investigate effects over different periods of treatment time in the investigations in this thesis.

When treating patients with certain disorders, such as low blood pressure, it has been considered that caution may be necessary to prevent "overdosing". For example in Harperbury Hospital over a period of some months a 65 year old woman with severe spasticity and dislocated hips, lying flat on her back on a specially adapted wheelchair for most of her life was given VA therapy in order to reduce to her spasm and muscle tone. Over a period of four weeks of treatment, it took an increasingly longer time for her to regain full awareness after a treatment, and she seemed to be very low toned and drained as the treatments went on. Treating her three times a week appeared to be an "overdose", and physically affected her, so her treatments were reduced to once a week.

3.5 Contraindications

VA therapy is still in a period of trial and research and, although various studies have been undertaken to evaluate the efficacy of these treatments, the information regarding any contraindications or unwanted side effects from the treatments is largely anecdotal. There have been no studies specifically aimed at clarifying when this treatment might be contra-indicated.

Some consistent effects have however been noted, which may give rise to concern with certain patients. If people are suffering from acute inflammatory conditions when they come for treatment, the pain arising from these conditions has in some cases been exacerbated. When people have acute back pain due to inflammation, some have experienced a worsening of the condition. Adverse effects have been noted when some treatments were undertaken on psychotic patients who, because of their psychotic condition and lack of reality orientation, became confused about the effect in their body from the stimulus they were receiving. Some subjects have experienced nausea, but this is an intermittent effect which seems to be unrelated to any particular condition. It may be a by product of the treatment that subjects should experience a "motion effect" and for those subjects for whom this experience can cause nausea, it needs to be clear what is the best way of treating them. The motion effect may well be caused by the difference in tone which occurs when a tone is pulsed by matching two tones closely together. For example, if you play 40Hz and 40.5Hz, you can obtain a pulsed tone but you also have a difference in tone of 0.5Hz. This tone may have some effect on vestibular activity and therefore causes "motion effect", and as a result, nausea. Nauseating reactions to infrasound, low frequency sound and vibration have also been identified in previous studies (Griffin, 1986; Yamada et al.1983).

It is also unclear as to the effect on people who are suffering from an acute condition, such as a heart condition. Assumptions have been made that VA therapy reduces blood pressure and therefore may be contraindicated as a treatment for certain conditions.

The process of identifying contraindications for this treatment is therefore based partly on theoretical assumptions, partly on experience, and to a small extent on guess work. The best alternative could be to establish a primary list of contraindications and then encourage patients to seek advice from their general practitioner or specialist in the event that they are unsure.

Skille defined a list of contraindications which he had found when using the equipment regularly in treating patients:

"A. When being treated for an acute condition, eg. Thrombosis, Angina Pectoris.

B. When being treated for active or acute inflammation.

C. When suffering from a recently prolapsed invertebral disc.

D. After an accident, eg. when suffering from head or neck injuries, eg. Whiplash injuries.

E. During internal or external bleeding, or when active bleeding may be started by VA therapy, eg. after an operation. (Does not apply to menstrual bleeding).

F. In case of psychotic, pre-psychotic or borderline psychotic conditions and in severe neurotic conditions.

G. When suffering from hypotension.

H. After having a recent myocardial infarction.

If there is any doubt that any of these conditions may be present, a doctor must be consulted before the treatment is commenced.

Patients with diabetes must be noted that it is possible that they will experience insulin "feelings" during or shortly after therapy sessions. Due precautions must therefore be taken before the start of the therapy session." (Skille, 1991)

The list of contraindications subscribed to in the trials undertaken at Harperbury Hospital, and also in clinical treatment work are as follows:

1 *ACUTE INFLAMMATORY CONDITIONS* - these include conditions where inflammation is exacerbated, such as in the acute phase of rheumatoid arthritis, or in cases of ear ache, tooth ache or back pain due to a prolapsed intravertebral disc (slipped disc).

2 *PSYCHOTIC CONDITIONS* - psychotic patients may be unable to understand what stimulus they are receiving. They can be treated, but only when someone is present who knows them well and can explain what is happening to them.

3 *PREGNANT WOMEN* - no trials have taken place involving pregnant women, and the effect on an unborn foetus is unknown. Therefore, it is, at present, safer to contraindicate pregnant women.

4 *ACUTE CONDITIONS* - When somebody is suffering from an acute condition for which they are already being treated, it would be important to check with the general practitioner or specialist first before undertaking VA therapy. The therapy should be clearly monitored in the event that there are any side effects contra-indicating this treatment in the case of an acute condition.

5 *HAEMORRHAGING OR ACTIVE BLEEDING* - because of the reported effect on blood pressure and heart rate, it would be sensible to contraindicate this treatment where patients are experiencing internal haemorrhaging or bleeding of any sort (excluding menstruation).

6 *THROMBOSIS* - patients suffering from thrombosis or a suspected embolism, should not be treated with VA therapy.

7 *HYPOTONIA* - patients with unusually low blood pressure.

Further contraindications are speculative. For example, some suggestion has been made that patients who have cancer, or heart disease should not receive treatment. However, there is no evidence from the treatment to date that VA therapy is in any way damaging for these conditions, and given the safe and careful use of equipment, and avoidance of either extreme intensities or extreme low frequency, or extreme periods of time in treatment, there should be no harmful effects. General disclaimer has to be employed for the issue of speculative contraindications, without any theoretical foundation, or recorded adverse cases (Wigram, 1995c).

3.6 CONCLUSION

The development of VA therapy has taken place over the last fifteen years and has involved a variety of professionals, including music therapists, music educators, music therapy educators, psychologists, biologists, physicians, nurses and teachers. The theoretical basis for the treatment has come from a variety of sources including music therapy, music in medicine, vibration research, and research in the field of low frequency sound and infrasound. The development of treatment programmes, and applications in the clinical field, both amongst populations with chronic disorders and for people with acute disorders, has moved ahead despite a very limited number of studies, many of which have not established the efficacy and reliability of this intervention. Assumptions have been made regarding the effect of the treatment and attributed to either psychological or physiological events. The studies that will now be documented in this thesis go some way to establishing by objective research the potential effect of VA therapy, and also the specific effects of certain stimuli used in VA therapy.

CHAPTER FOUR

THE EFFECT OF VIBROACOUSTIC (VA) THERAPY ON MULTIPLY HANDICAPPED ADULTS WITH HIGH MUSCLE TONE AND SPASTICITY

4.1 INTRODUCTION

Research has taken place in recent years on subjects with motor dysfunction or disability. In defining motor effects resulting from muscle vibration, Bishop (1974) has identified three specific effects. A vibrated muscle contracts and this sustained contraction is known as Tonic Vibration Reflex (TVR). The excitability of motor neurons innovating the antagonistic muscles is depressed via reciprocal inhibition. The mono-synaptic stretch reflexes of the vibrated muscles are suppressed during the vibration. Investigations have taken place into the use of a variety of vibration devices as a technique for facilitating or inhibiting muscle action (Stillman 1970). The use of Vibratory Motor Stimulation (VMS) is considered to be extremely safe, as there are very few adverse reactions. Developments in the field of physiotherapy have frequently made use of vibratory massagers or applicators, which are designed to provide a stimulus to a specific muscle or muscle group. The muscle which is subjected to vibratory stimulation can be activated, while the prime antagonist muscles are inhibited. The clinical experiments undertaken by Stillman

(1970) found that the localised application of VMS consistently stimulated activation of a muscle group in the form of the TVR.

The use of cylindrical devices containing motors rotating at a speed of 150Hz-160Hz and producing cyclic vibrations had specific effects on spastic muscles (Hagbearth and Eklund 1968). The use of localised vibration in patients with spasticity stimulated significant TVR in the form of a spasm or jerk, following which the vibration potentiated or reduced voluntary power (and range of movement) depending upon whether the subject tried to contract the muscle vibrated, or its antagonist. When considering the value and use of localised vibration as a muscle stimulant, it is evident from the research that the primary endings of the muscle spindles are the receptors mainly responsible for the initiation of the TVR in healthy adults. In patients with spasticity, the responses to vibration can be weaker and less specific in terms of expected reflex patterns (Hagbarth and Eklund 1968).

4.1.1 Whole Body Vibration

Whereas localised vibration can excite muscle activity, whole body vibration can cause a general effect of relaxation and a reduction in muscle tone. A standard physiotherapy technique described by Carrington (Personal communication, 1980) when attempting to reduce spasticity in a patient's limb prior to treatment is to shake the whole limb gently, which creates a vibration effect within the muscle groups contained in the limb. Developing this into a whole body vibration would involve the use of a motor stimulation or a sound generated vibration to introduce a sensation of vibration throughout the body. Studies over the last 10 years have found interesting results in the use of vibration alone, and vibration together with music. Generalised effects of whole body vibration can:

1) Stimulate blood flow throughout the body causing an acceleration in the healing of pressure sores and ulcer.
2) Reduce swelling due to excess tissue fluid.
3) Facilitate relaxation generally, reduce nervous tension and fatigue, ease sore and aching muscles, alleviate high and low back pain and alleviate stiffness in joints through improving the joint motion.

(Boakes 1990; Skille, 1989b; Wigram, 1992a).

Anecdotal reports reference the specific benefits of vibrotactile and vibroacoustic stimulation to people who have multiple handicap. In particular, these reports indicate the treatment as a method of physically inducing relaxation which can lead to functional improvement, including improved functional positioning, and alleviation of tired muscles in a sustained state of spasm (Boakes 1990; Lehikoinen 1990; Skille 1982a, 1986,1989a; Skille et al. 1989; Wigram and Weekes, 1990b).

4.1.2 Low Frequency Vibration

In the studies using vibrotactile and mechanically produced low frequency vibration, reports on the efficacy of a particular stimulus has varied in the research undertaken to date. Boakes (1990) looked in particular at the effects on muscle physiology via muscle receptors, and advocated that vibration within the range of 20Hz-50Hz causes an inhibition of muscle impulses, so inducing spastic muscles to relax. Within the approximate range of 50Hz-100Hz, her research indicated this stimulates most impulses (TVR) so inducing muscles to contract and conversely causing the antagonist muscles to relax. Therefore the stimulation that occurs on the extensor muscles encourages the flexor muscles to relax which is of great benefit to those who have spasticity. This mid-point of 50Hz, according to Boakes, is approximate, depending on the muscle temperature and the amount of muscle tone present. A cold muscle responds sooner than a very warm muscle, and a muscle without any tone will not respond at all. There is also evidence that low frequency vibration works on the proprioceptors of muscles, possibly by-passing parts of the central nervous system, and working directly on the specific muscle or muscle group to achieve balance and improvement in the condition of the muscle (Boakes 1990).

4.1.3 Cerebral Palsy and Spasticity

The study documented in this chapter focused on the effect of VA therapy in reducing muscle tone in patients with spasticity. Cerebral palsy is caused as a result of an injury to a part of the brain before it is fully developed. The three main types of cerebral palsy are spasticity, athetosis and ataxia. The patients in this study suffer from spastic disorders. People with spasticity have different levels of muscle spasm, causing a rigidity of the muscles. A spasm is an involuntary and sometimes painful contraction of the muscle, muscle group or of the muscle wall of a hollow organ. Spasms of the whole body are referred to as convulsions, painful spasms of muscles or limbs as cramp, and those in the stomach and abdomen as colic. In cerebral palsied patients the most common form of spasm is a tonic spasm involving a firm strong contraction causing rigidity in the muscles. The spasm effect in spasticity results from a release of the gamma system from higher inhibitory control, and is characterised by a synchronised excitatory phase followed by a synchronised phase of post-excitatory inhibition. After the passing of this phase of post-excitatory inhibition, one of inhibitory excitation returns. These events can be clinically observed in the phenomenon of a spastic muscle and is demonstrated in an exaggerated stretch reflex, "clasp knife", and the lengthening and shortening of reactions (Bobath, 1972; Bobath and Bobath, 1972).

Patients with spasticity are usually found to have:

1) A loss of control and differentiation of fine voluntary movements.
2) Suppression of normal associated movements.
3) Presence of certain normal associated movements.
4) Hypertonus of the "clasp knife" type, with a following build-up of resistance to passive movement (stretch reflex).
5) Exaggerated tendon reflexes and possible clones of the other joints.
6) Depression of superficial reflexes.

More typically in spastic patients one will find an increase in flexor tone, and this is often greater than extensor tone. Imbalances in the strength of muscles will lead to contracture of spastic muscles and weakness resulting from disuse of their opponents (Jones, 1975).

Research into the effects of background music to assist relaxation in cerebral palsied adults with spasticity shows significantly improved decreases in muscle tension (Scartelli, 1982). A placebo group of patients receiving EMG Bio-Feedback alone showed a mean decrease of 32.5% in muscle tension, whereas a treatment group receiving EMG Bio-Feedback training together with sedative background music demonstrated a mean decrease of 65%. In Scartelli's study, as in other studies, the selection of musical material to be used in treatment conditions is varied in style and non-specific. Scartelli (1982, 1984) used classical music by Copland and Satie, whereas Chesky and Michel (1991) used a variety of popular songs. Skille (1989a, 1992) has developed a wide range of classical, new age, ethnic, and popular music which can be used in conjunction with vibroacoustic stimulation.

4.2 EXPERIMENTAL HYPOTHESIS

The experiment described in this chapter looked at the effect of VA therapy in reducing muscle activity and high muscle tone in patients with cerebral palsy. The following hypotheses were made:

a) Sedative music in combination with a pulsed low frequency sinusoidal tone of 44Hz would have a greater effect in reducing muscle tone in cerebral palsied subjects than sedative music alone.

b) Sedative music and a pulsed low frequency sinusoidal tone of 44Hz would have a greater effect on blood pressure than sedative music alone.

4.3 METHOD

4.3.1 Overview

A repeated measures, within subjects design was used, and ten subjects were selected to take part in the experiment. Two experimental conditions were defined:

Condition A

(Treatment Condition) - The subject experienced a thirty minute treatment on the vibroacoustic unit, which consisted of a tape of sedative music, and a pulsed 44Hz low frequency sinusoidal tone.

Condition B

(Placebo Condition) - The subject received the same sedative music, on the same vibroacoustic unit, but without the pulsed, low frequency tone.

The 44Hz low frequency sinusoidal tone acted as an independent variable. Each subject undertook six trials in each condition, randomly ordered. The subjects undertook two trials each week over a period of six weeks. Blood pressure and heart rate were measured before and after each trial. Electromyography (EMG) is a conventional method of measuring increases or decreases in muscle tone. However, it was decided that with this patient population the effect of repeated applications of surface EMG, involving the attachment of electrodes to pre-determined sites, would have an effect of raising anxiety and increasing muscle tone. An alternative form of measurement and evaluation was sought. Changes in range of movement were measured on spinal mobility and limb flexion and extension using a centimetre ruler/measure to record the range of movement before and after each trial.

The experiment was designed as a within-subjects study with single blind evaluation. The experiment evaluated the influence of VA therapy treatment consisting of relaxing music and a pulsed, sinusoidal low frequency tone, compared with the same music played through the vibroacoustic unit without a pulsed sinusoidal low frequency tone.

4.3.2 Subjects

Three male and seven female subjects resident in a large mental hospital took part in the trials. Ages ranged from 28 to 77 years (Mean 44.2, S.D. 12.39), and they were all diagnosed as profoundly handicapped. The subjects were selected from a wider group of patients in the hospital with motor disabilities, and were selected because they all had spastic cerebral palsy.

All the subjects had measurably high muscle tone which affected each of them in differing ways, although there were some affected muscle groups that were shared in common by all of the subjects. The most common problems shared by the majority of the subjects were flexor-spasm in their arms and legs, and adductor-spasm causing difficulties in separation of the legs, which in turn can lead to "scissoring" of the legs, with a potential consequence of subluxed or dislocated hips.

4.3.3 Materials

The equipment that was used in this experiment was purpose built. The frame of a sprung bed was used, and two 18inch speakers were mounted in boxes underneath the springs with the cones directed upwards. The speaker boxes contained 2" by 8" ports for acoustic balance, and the cone of each speaker was approximately two inches below the springs of the bed, in order that the subject would be lying within two inches of the surface of the speakers.

The speakers were positioned in the bed so that when the subject lay on the bed, one speaker was placed under the thoracic and upper abdominal area of their body , and the other speaker was placed under the lower thighs, knees and upper calves. On top of the springs was a single polythene sheet (as a precaution against incontinence), and on top of this was a half inch pile sheepskin rug.

The speakers were powered by an Amba-414 purpose built amplifier. The maximum potential output from the amplifier was 80 watts per channel(RMS). The vibroacoustic stimulus of relaxing music combined with a pulsed, sinusoidal, low frequency sound wave, and the music in condition 2 was played through a Technics RS-T11 stereo cassette deck.

The intensity and tone controls on the amplifier were graded numerically. In the procedure of this experiment the controls of master volume and bass volume were consistently set at the same point. When the subjects were treated with low frequency sounds and music, the bass and master volume was set at +7 on the

numerical scale. When the clients were treated with music alone, the master volume was set at +7, and the bass and treble tone controls were set at zero ensuring that an equal balance of tone
and equivalent volume was maintained in the music only condition. The subjects were treated horizontally, and the speakers were set into the bed with the cones facing up. The equipment was isolated electrically, and recordings were used so the style of music, intensity of the low frequency tone and general intensity of the music were all constant for each trial.

A marker pen was used to mark points on the subjects' bodies for measurement, and a conventional cloth tape-measure with centimetre markings was used to record the range of movement before and after each trial.

A John, Bell and Croydon Model DS-175 Auto Inflation Digital blood pressure monitor was used to record pressures and heart rate.

The music used in both conditions was "Crystal Caverns" by Daniel Kobialka. This music is described as "New Age", and is tonal, melodic and harmonic non-pulsed music produced on a synthesizer. The piece lasted 30 minutes, and a 44 Hz sinusoidal tone, pulsing at a speed of approximately 8 seconds peak to peak was recorded from a function generator with the music on the tape.

4.3.4 Measures

Blood pressure, heart rate and range of movement were measured before and after the trials. Nine measurements were identified on the subjects' bodies (Table 4.1)

Table 4.1: Physical measurements taken before and after each trial.

Number	Measurement	Purpose of measurement
1	The extreme point of the left shoulder to the extreme point of the right shoulder	To measure rounded shoulders
2	The extreme point of the right shoulder to the right radial artery	To measure extension of the right arm
3	The extreme point of the left shoulder to the left radial artery	To measure extension of the left arm
4	The right elbow to the right seventh rib	To measure raising the right elbow from the body
5	The left elbow to the left seventh rib	To measure raising the left elbow from the body
6	The tip of the nose to the navel	To measure degree of kyphosis
7	The right side greater trochanter to the right side lateral malleolus	To measure extension of the right leg
8	The left side greater trochanter to the left side lateral malleolus	To measure extension of the left leg
9	The centre base of the right patella to the centre base of the left patella	To measure abduction of the hips.

Baseline measurements were taken of the minimum range of movement in measurements that had been decided by the author and the senior physiotherapist as pathologically important and appropriate for each of the subjects. These baseline measurements were taken by measuring the minimum range of movement. For example, if the right arm was flexed to the point where the right radial artery came as close as possible to the right shoulder, this was recorded as the minimum range of movement.

Measurements were taken of the degree of extension for each of these movements before and after each trial. Each subject had a different set of measurements, although there were some measurements that were common to many of the subjects (Table 4.2).

Data were recorded in centimetres of the measurements that were taken before and after each trial. The difference between these measurements indicated an increase, or conversely a decrease, of the subject's range of movement. The best improvement in range of movement that a subject achieved in any of the conditions was considered to be the subject's maximum range of movement in that measurement. The minimum range of movement was then subtracted from this maximum score, in order to define the subject's maximum potential range of movement. Having done this, the difference scores achieved in the trials were converted into a percentage of this maximum potential range of movement. A calculation could then be made of the subject's percentage improvement in range of movement in each of the conditions.

Table 4.2: Measurements taken for each subject during treatment and placebo conditions

SUBJECT	MEASUREMENT
Subject 1	2,3,7,8,9
Subject 2	2,3,9
Subject 3	2,3,7,8
Subject 4	2,3,4,9
Subject 5	1,4,5
Subject 6	3,7,8,9
Subject 7	2,3,8,9
Subject 8	2,3
Subject 9	1,2,3,7,8,9
Subject 10	3,6,7,8,9

In each trial, an independent evaluator measured the maximum possible extended range between each of the two marked points in each measurement. The method of measurement is described in more detail in the procedure section. The independent evaluators were not present during the course of the trial. When the trial had finished the independent evaluator came back in order to take the post-trial measurements. Therefore they were blind as to whether the subject had been treated in condition A or condition B.

Control of order effects

In repeated measures design bias arises due to the fact that experiences change individuals, and the subjects may have learnt what was happening and begun to habituate to the stimuli.

In this experiment, the subjects might have learnt from their experiences in the first few trials they underwent. If they had relaxed more effectively in the treatment condition, this could have affected how they reacted in the placebo condition, as they became conditioned to the stimuli, and possibly began to habituate. Whether or not these particular subjects would be able to tell the difference between the two conditions was not established, because they were all functioning at a pre-verbal level. The order of the trials was therefore randomised to reduce the potential effect of any conditioning to the stimuli.

Blood Pressure and Heart Rate

Seven of the subjects had blood pressure and heart rate measured before and after the trials. There was a five minute resting period at the beginning before the initial blood pressure and heart rate measurements were taken. With three subjects in this group, it was very difficult to measure blood pressure. One subject had such tight flexor-spasm it was physically impossible to put the BP monitor cuff on his arm. Another subject consistently recorded errors due to the fact that she had very short arms, and flexor spasm, making it difficult to record reliable data. Another subject had such thin arms blood pressure measures were unreliable, due again to consistent errors recorded on the electronic sphygnonometer.

Wilcoxon Signed Rank tests were undertaken on the data.

A form was devised to record all the data. (APP. 1)

4.3.5 Procedure

Each subject was taken out of their wheelchair and placed on the vibroacoustic unit. They had a foam rubber pillow (sound dampening material) under their head, and where necessary their body was supported by pillows containing polystyrene beads. After a resting period of five minutes, their blood pressure and heart rate were taken, and then measurements were taken as previously specified for each subject. The measurements were taken by marking with a marker pen a cross at the specified points on the body and then attempting to extend the limb. A measurement was taken of the distance between the two points. This procedure was not used for measurements one and six. The evaluator left after they had taken the measurements, and the researcher began the tape. On the Amba amplifier, the master volume control was increased to seven. In the treatment condition (condition A) where the low frequency tone was being used, the bass control was then also increased to seven. When the sinusoidal low frequency tone was not being used the bass control was left at zero.

As the treatment continued, the therapist remained with the subject, sitting quietly in the room, avoiding eye-contact or any other form of physical or communicative contact.

At the end of the 30 minute tape, the therapist turned all the controls to zero, and the independent evaluator would be asked to come in. Blood pressure was taken immediately. The independent evaluator then measured again the measurements relevant to each individual. Finally, the measurements were entered on to the form (App.1) which also recorded the day and the time. Other observed behaviour may have been recorded for the purpose of clinical records.

During the course of each treatment, a subject was undressed only to a point of absolute necessity in order to take measurements. The subjects were always covered with a blanket during the treatments. Where appropriate, the subjects were reassured verbally while measurements were being taken, especially blood pressure measurements.

4.4. RESULTS

Table 4.3: Mean scores of increased or decreased range of movement within minimum and maximum ranges, shown as percentage scores for both conditions.

Measures:	1	2	3	4	5	6	7	8	9	MEANS
S1: Cond.1 Cond.2		+ 8 - 4	+ 3 - 1				+ 5 - 6	+ 4 - 1	+14 - 4	+7 - 3
S2: Cond.1 Cond.2		+15 - 5	+23 - 2						+27 - 2	+22- 3
S3: Cond.1 Cond.2		+11 +.5	+15 - 1				+22 + 5	+ 5 0		+13 + 1
S4: Cond.1 Cond.2		+16 -13	+21 - 3	+27 -.5					+11 +.5	+19 - 4
S5: Cond.1 Cond.2	+ 4 - 8			+16 + 7	+25 +10					+15 + 3
S6: Cond.1 Cond.2			+ 1 + 3				+ 1 +.5	+ 2 + 1	+26 + 5	+ 7 + 2
S7: Cond.1 Cond.2		+11 + 4	+ 1 + 1					+ 1 + 2		+ 5 + 2
S8: Cond.1 Cond.2		+20 + 2	+10 + 5							+15 + 4
S9: Cond.1 Cond.2	+32 0	+22 -.5	+ 9 +.5				+ 9 + 6	+12 +.5	+31 - 1	+19 + 1
S10:Cond. 1			+ 3			+27	+ 5	+21	+17	+11

Cond.2			+ 2			+16	-.5	+ 1	+ 3	+ 4
Cond.1 Means: **Cond.2 Means:**	+18 - 4	+15 - 2	+ 9 +.5	+22 + 3	+25 +10	+27 +16	+ 8 + 1	+ 9 +.5	+19 0	+13 + 1 +16 + 3

Table 4.3 gives the mean scores in percentages of increases or decreases in range of movement within a minimum and maximum range. In the box on the extreme right are the means of all the measurement means for each subject. The means of all the scores of the subjects are shown in the box in the bottom right hand corner of the table, and show a 13% improvement in their range of movement in the treatment condition, and 1% improvement in the placebo condition. The mean scores of all the measurements in the treatment condition is shown in the same box at the bottom right hand corner of the table, and reveal a 16% improvement in the treatment condition, and a 3% improvement in the placebo condition in range of movement.

The table shows that in all subjects the mean scores revealed an improved range of movement in Condition A over Condition B. In some cases this result is quite dramatic, and in other cases it is less marked.

A Wilcoxon Matched-Pairs Signed-ranks test on the mean percentage improvement in range of movement within the subjects comparing the treatment and placebo conditions found a significant difference between conditions (P = 0.0051). This result indicated that the treatment achieved significantly greater range of movement in the subjects than did the placebo.

A Wilcoxon Matched-pairs Signed-ranks Test on the measurements scores showed the treatment condition obtained significantly better scores than the placebo condition (P = .0051).

Analysis of the difference scores from the blood pressures and heart rate measurements taken before and after the trials from the seven subjects whose blood pressure was monitored revealed no significant difference between conditions. There was an indication that systolic pressure reduced, but there were wide variations in the data taken from diastolic pressure and pulse rate.

4.5 DISCUSSION

The outcome of the experiment on subjects with high muscle tone showed consistently that when pulsed low frequency sinusoidal tones were used in conjunction with sedative music a greater reduction in muscle tone and an improved range of movement was achieved than when music alone was used. The difference between conditions in blood pressure was not significant.

These results indicate improvements in range of movement as a result of the treatment, and have consequences in considering the effect of VA therapy for this clinical group. For example, measurements two and three where all the subjects were measured show a substantial improvement in range of movement, in flexion and extension of arms, which are typically inhibited by flexor-spasms. Measurement nine indicates a substantial improvement in abduction in the subjects. To achieve results of improved range of movement from a passive treatment involving half an hour of whole body vibration with music, averaged over six treatment sessions, is encouraging.

Evidence had already been found in previous studies that sedative music alone can affect muscle activity (Scartelli 1982), and potentially music can facilitate significant decreases in muscle tension. So it was anticipated that in the music alone condition in this study, there should be some reduction in muscle activity, and a consequential improvement in range of motion. The evidence in the literature of the effect of whole body vibration as a catalyst for reducing muscle activity is limited (Boakes 1990; Lehikoinen 1990). The results of this study supported previous studies that found muscle tone can be reduced by vibration both generally and in specific areas (Carrington, 1980; Skille, 1986, 1989).

Individually, subjects showed some variability. For example where they may have demonstrated large improvements in percentage terms in their range of movement or extension in one measurement, the differences may have been much smaller in another measurement. Subject nine is a case in point. The effect on this subject in the treatment condition caused a relaxation of her tension evident in less rounded shoulders which resulted in her being able to lie in a more flat position. Her right arm extension improved by 22%, whereas her left arm only improved by 9%. This can be explained due to the typical asymmetry commonly found in quadriplegic cerebral palsy.

The improvement to her hip abduction, in measurement nine, is also quite marked. This subject had very tight adductor muscles, and the nature of her deteriorating physical condition was threatening a subluxed hip, or dislocation. Regular maintenance of her ability to abduct her hips is important to prevent any further deterioration and potential for developing fixed flexion deformities and permanently contracted limbs.

Subjects one, two and four all had minus scores in the placebo condition. This indicated that they actually became tighter and more flexed as a result of lying on a bed and listening to relaxing music. Subject four was an anxious lady, who found the process of being measured difficult. However, this does provide evidence that for this subject the treatment condition was significantly more successful in helping her to relax, despite raised anxiety and tension during the trials. Subjects one and two were both fond of and physically responsive to music, in a way that when they heard melodies of any sort, they would try to join in with it vocally. Therefore, they may have been stimulated by the music, and an effect of stimulation in subjects who have spasticity due to cerebral palsy is that spasm can increase, and their muscles become tighter. In the treatment condition where they were receiving both music and a sinusoidal low frequency tone they became significantly more relaxed, highlighting the difference between the treatment and the placebo conditions.

There were a number of problems which emerged during the course of the trials, which should be considered as limitations in this experiment. The equipment used needs to be carefully assessed in terms of resonance. Frequencies can cause an increase in vibration in the bed. This appeared to happen at certain points in the music that was used, and it was noticed when a bass tone sounded in the music. However, this was common in both conditions.

The skill and confidence of the staff undertaking the independent evaluation varied. Some were experienced at handling the subjects, and maintained consistency, whereas others began in a more tentative manner, and grew in confidence during the course of the trials which could mean that early results reflected a less reliable result than later results. This may have averaged out, and the data recorded reflects averaged scores. However, in future trials a familiarisation period would be important in order to obtain reliable baselines.

Some evaluators gave supportive verbal encouragement to the subjects, and may have affected the subjects' response during the measurements. Evaluators varied in the length of time they applied pressure to measure range of movement, as there was no defined limit in the experimental procedure, and this may have caused individual differences in ranges of extension. Evaluators may also not have applied enough pressure at times. Most of these influencing variables would be counteracted by the "blind" nature of the trials.

When treating subjects who had high muscle tone, it was frequently necessary to support various parts of their bodies owing to the increasing spasm and fixed deformities that were developing. This was achieved by using pillows filled with polystyrene beads, and typically, one would need to place them under the knees or legs where flexor-spasm had caused contracture. This variable was not taken into consideration in the trials, and it was not clear how much energy was absorbed by the polystyrene beads. Further tests are required to evaluate the amount of sound vibration absorbed by the body. In looking at the results of these trials, it could be conjectured that the differences would become less between the two conditions as the subjects reached a point in time where they had achieved their maximum potential.

The results from these trials give many indications of effect, and require questions to be addressed in future research. Generally, attention could be focused on the influence of low frequency sound on muscle tone. In future experiments, it could be useful to use a spring loaded strain gauge, so that all the measurements taken of increased range of extension can be calculated from base lines standardised across all subjects, and individual bias arising out of variability in the way evaluators take measurements would be eliminated. Exactly how much benefit is achieved by the absorption by the body of low frequency sound as compared with the psychological effect of the music in reducing muscle tone and achieving a level of relaxation is not clear. It could be useful to undertake further experiments to evaluate relaxation or reduced muscle tone achieved purely by auditory means - using headphones or speakers close to the ears, compared with the physical effect of low frequency sound and music through speakers placed under the body.

Notwithstanding these factors, the way the trials were run reduced or counterbalanced the potential effect of influencing variables such as have been described above, and the outcome indicates that pulsed sinusoidal low frequency sound combined with relaxing music is significantly more effective in reducing muscle tone and improving range of movement in spastic subjects than music alone.

CHAPTER FIVE

THE EFFECT OF VIBROACOUSTIC (VA) THERAPY COMPARED WITH MUSIC AND MOVEMENT BASED PHYSIOTHERAPY ON MULTIPLY HANDICAPPED PATIENTS WITH HIGH MUSCLE TONE AND SPASTICITY

5.1. INTRODUCTION

The treatment of children and adults with cerebral palsy has indicated physiotherapy as an effective intervention. This therapeutic treatment typically involves programmes to maintain, develop and extend a range of movement in order to prevent the onset of fixed flexion deformities. Specific methodologies have emerged in the development of treatment strategies for children with cerebral palsy and spastic disability (Bobath 1972), while there has also been some critique of the value and effect of physiotherapy with infants and young children (Palmer et al. 1988).

VA therapy has developed as a form of treatment which employs a relaxing, sedative stimulus through music and low frequency sound. The treatment of cerebral palsy and spasticity has found music can be used in other effective approaches. The concept of involving the elements of music in a specified programme of movements to treat physical disability has grown and become more formalised over the last 15 years (Bean 1995; Cosgriff,1988; Wigram and Weekes 1983, 1985). In a structured design where music is a stimulus to movement, music is not used in the capacity of background music. It is not meant to be relaxing, but provide a motivating stimulus for the staff involved in the session and for the patient. The style and appropriateness of the music used is important for the effectiveness and success of the treatment. The tempo, structure, rhythm and timbre of the music have to be carefully considered for each movement, and the effect on the patient is frequently dependent on the quality of the live performance. The rhythm and tempo in music has a motivating and moving effect, and helps the patient anticipate the movement, increasing their ability to participate. Even with no knowledge of the music being played, for example if it is improvised, both patient and therapist can anticipate the rhythmic emphasis and time the movement with it. (Wigram and Weekes, 1983). Having undertaken an initial study to evaluate the effectiveness of VA therapy on a population of profoundly handicapped, spastic patients (chapter 4) it was considered relevant to then compare the improvement in a range of movement achieved from this treatment to an improvement in range of movement achieved from a Music and Movement Based physiotherapy (MMBP) session. VA therapy is a passive form of treatment, whereas MMBP is an active form of treatment. Besides comparing VA therapy with a placebo, the additional condition added in the experiment described in this chapter was a series of movements in a program of MMBP treatment, presented in the same form as in the experiment described in chapter four.

Clinical experience has already suggested that patients respond positively to MMBP treatment, and it has benefits for the health and well-being of the patients. However, undertaking such treatments is very labour intensive, and the patients need a daily or twice daily session in order to prevent the onset of fixed flexion deformities that come as a result of lack of movement and increasing contracture both in muscle activity and joint movements. Currently, resources available to provide such treatments rarely mean that one is able to provide more than a once or twice weekly session.

The treatment of MMBP also requires quite an intensive input from the staff and for the patient it can be a difficult and uncomfortable experience necessitating, as it does, stretching of muscles and limbs in order to maintain range of movement. For patients with multiple handicap which includes profound learning disability, familiarity both with staff and treatment procedures can play an important role in achieving successful results. In this experiment it was decided to give each subject only one trial in each condition, with the intention of reducing or eliminating bias due to inconsistent development of patient/therapist relationships between the subjects and the staff involved in the trials. However, in order to take into consideration the fact that unfamiliarity with the treatment being administered might play an important role, it was decided to undertake three more trials in both the VA therapy treatment condition and the placebo condition with a randomly selected group of patients from the test group. In the event that there were no significant differences between the treatment condition and the MMBP condition, these follow up trials may shed some light on whether familiarity with the treatment changed the results in any way.

The nature of the pathology of profoundly multiply handicapped cerebral palsied patients and studies supporting the use of sedative music or vibration, or a combination of both has already been described in chapter four.

5.2. EXPERIMENTAL HYPOTHESIS

The hypotheses for this experiment were :

1. VA therapy would have a significantly greater effect in improving range of movement than music and movement or a placebo.

2. MMBP treatment would have a significantly greater effect in improving range of movement than a placebo.

5.3 METHODS

5.3.1. Overview

This experiment employed a repeated measures design across three experimental conditions. Each subject undertook one trial in each condition:

Condition A - A thirty minute treatment of MMBP

Condition B - A thirty minute treatment of VA therapy

Condition C - A thirty minute session of the music used in VA therapy without the pulsed sinusoidal low frequency tone (placebo treatment)

Comparing VA therapy and the placebo, the independent variable manipulated was the influence of a pulsed, low frequency sinusoidal tone of 44Hz. To compare the MMBP treatment and the placebo treatment, the independent variable manipulated was the use of live music and physical manipulation compared with recorded music. In all the three conditions the subjects were treated lying down, either on a bed, or on a mat on the floor. In conditions B and C, there was no active intervention, and the subjects were consistently laid supine on the vibroacoustic unit. In condition A, the treatment programme involved both supine, right and left side lying for the movements. The MMBP treatment session was run by music therapists, physiotherapists, teachers and therapy/education assistants on a one-to-one basis with the subjects. The subjects were treated on mats on the floor and the music was created live on the piano for each session. The same music was used for each of the exercises, and for consistently the same amount of time.

Measurements were taken before and after each trial of the subjects' range of movement, and the evaluators that were used to make these measurements were blind as to whether the subjects were receiving VA therapy (condition B) or a placebo treatment (condition C). However they were not blind during the MMBP trials (condition A), and they were aware the subjects were receiving this form of treatment. Therefore an element of bias was inevitably present for the evaluators in making their measurements before and after the MMBP trials.

The trials were randomly ordered to control for order effects. Baseline measurements were taken to establish a minimum range of movement in order to be able to calculate what changes in range of movement could be found after each trial.

Additional Trials

Ten subjects were randomly selected from the group of 27, and each subject was given an additional three trials of VA therapy (condition B) and three trials of the placebo treatment (condition C). Measurements were carried out in the same way as in the other trials.

5.3.2 Subjects

14 male and 13 female subjects resident in a large mentally handicapped hospital were chosen to take part in the trials. The subjects ages ranged from 24 to 68 years and their level of functioning ranged from severely to profoundly handicapped. All the subjects had high muscle tone which affected each of them in individually differing ways, although there were some affected muscle groups that were shared by all of the subjects.

The mean age of the male subjects was 46 and the mean age of the female subjects was 39. The mean age of the 28 subjects was 41.04 (S.D. 13.01).

5.3.3. **Materials**

The VA therapy equipment, music, low-frequency stimulus and measuring equipment used in these trials were the same as was used in the experiments described in the previous chapter.

5.3.4 **Measures**

In all three conditions, measurements were taken measuring range of movement in limbs and hips of the subjects before and after each trial (Table 5.1).

Table 5.1: <u>Physical measurements taken before and after each trial</u>

Number	**Measurement**	**Range of movement**
1	The extreme point on the left shoulder to the extreme point on the right shoulder	To measure rounded shoulders
2	The extreme point on the right shoulder to the right radial artery	To measure degree of extension of the right arm
3	The extreme point on the left shoulder to the left radial artery	To measure degree of extension of the left arm
4	The right side greater trochanter to the right lateral malleolus	To measure degree of extension of the right leg
5	The left side greater trochanter to the left lateral malleolus	To measure degree of extension of the left leg
6	Centre base of the right patella to the centre base of the left patella	To measure abduction of the hips

These six measures were not used on all subjects. One subject had all six measurements taken, eight subjects had five measurements, five subjects had four, four subjects had three and four subjects had two, and five subjects only had one measurement taken. Decisions about which of the measurements to use on each subject were made with regard to the specific nature of their spasticity and muscle tone.

Baseline measurements were taken of the minimum range of movement in each measurement used with each subject. For example, if the right arm was flexed to the point where the right radial artery came as close as possible to the right shoulder, this was recorded as the minimum range of movement.

Measurements were taken of the degree of extension for each of these movements before and after each trial. Data were recorded in centimetres of the measurements that were taken before and after each trial. The difference between these measurements indicated an increase, or conversely a decrease, of the subjects range of movement. The best improvement in range of movement that a subject achieved in any of the conditions was considered to be the subjects maximum range of movement in that measurement. The minimum range of movement was then subtracted from this maximum score, in order to define the subjects maximum potential range of movement. Having done this, the difference scores achieved in the trials were converted into a percentage of this maximum potential range of movement. A calculation could then be made of the subjects' percentage improvement in range of movement in each of the conditions.

The independent evaluator was not present during the course of the trial. In conditions B and C they were not aware of the condition in which the subject had been treated.

Measurement Materials

A marker pen was used to mark points on the subjects' bodies for measurement, and a conventional cloth tape-measure with centimetre markings was used to record the range of movement.

Because condition A involved a group MMBP treatment, the subjects were treated over four weeks in three groups of seven and one group of six. Each week, on three separate days, randomly ordered, a group of subjects had one trial in condition A, and individual trials in conditions B and C.

5.3.5 Procedure

Condition A: Music and movement based physiotherapy (MMBP)

The subjects were treated in a large treatment room, with mats on the floor. They were taken out of their wheelchairs and laid supine on an individual mat for each subject with a pillow support under their head. Each subject was worked with individually by a therapist, paramedical assistant or teacher. All the staff were trained and experienced in MMBP treatment techniques.

The initial evaluation of range of movement took place and the chosen measurements for each subject were taken. The procedure for taking the measurements was the same as in the experiment described in chapter four, marking points on the body with a marker pen and measuring degree of movement before and after the trial. The session proceeded with a MMBP treatment programme described below:

Table 5.2: Music and Movement Based Physiotherapy Programme

Movement	Time of movement	Music played
Spinal rotation (Right)	3	Fish going to from Showboat
Hip Extension (Right)	2	Main theme from "The Godfather"
Shoulder girdle (supine)	4	Humoresque Dvorak (fast then slow)
Arms - Right arm	3	Mary quite contrary
Left arm	3	Mary quite contrary

Short break (3 minutes)

Movement	Time of movement	Music played
Spinal rotation (Left)	3	Fish going to swim (Showboat)
Hip extension (Left)	2	Main theme from"The Godfather"
Bouncy legs (Supine)	2	The "Can" from Orpheus in the Underworld
Flexion and extension of legs(supine)	4	"Edelweiss" from The Sound of Music
Abduction (supine)	4	Over the sea to SkyeFolk traditional

The researcher played for all of the trials, and kept the time allocated for each movement constant, and the performance of the music for the trial as consistently the same as was possible. While a recording of the music played would have achieved greater consistency in presentation of the stimulus, this experiment was designed to find differences between two different treatment approaches designed to achieve the same result, namely improved range of movement, and live music is consistently used in MMBP treatment sessions. Subjects were also treated in groups of approximately six to seven at a time. It was recognised that this was different from the individual trials in conditions B and C, and would add additional influencing variables. This will be addressed in the discussion.

Description of Movements

a. Spinal rotation

The patient is lying on his or her side. The therapist passively rotates the spine by placing one hand on the buttocks and the other on the front of the shoulder girdle and chest wall. The therapist applies gentle pressure pulling the shoulder back and pushing the buttocks forward and then relaxes. This movement mobilises the spine.

b. Hip extension

The patient is lying on his or her side. Therapist supports the leg under the ankle and behind and in front of the knee, placing their other hand on the patient's buttock. The therapist pulls the leg back and pushes the buttocks forward to develop hip extension.

c. Shoulder girdle movement

The patient is supine, in as straight a position as possible, and the therapist's hands are over the shoulder joints. The shoulder girdle is then moved rhythmically, at first at a fast speed to shake out the tone in the muscles in the shoulder girdle and arms and then changing to a slower speed to encourage rotation of the shoulder joints.

d. Arms

Supporting the patient's arm by holding their hand with one hand, and placing the other hand under the elbow, the therapist moves the patient's arm in a diagonal movement from the base of their left hip to over their right shoulder, and then the other diagonal from the bottom of their right hip to over their left shoulder. This movement increases range of movement in the arms. The majority of the subjects had limited range of movement in their arms, and the full range of both of these diagonal movements was rarely possible.

e. Bouncy legs

The patient is lying supine. Supporting their legs under the knees and ankles, the therapist bounces the legs up and down at quite a fast speed to reduce the tone in their calves, knees, thighs and upper thighs.

f. Flexion and extension of legs

This is a two part movement, where the patient is lying supine.

(1) Supporting the patient by placing their left hand on the ankles and the right hand under their knees, the therapist flexes the patient's legs to bring their knees in towards their chests.

(2) Placing the left hand on the soles of the patient's feet and their right hand above the knees, the therapist extends the patient's legs to as full a range extension as possible.

g. Hip Abduction

The patient is lying supine and the therapist moves the patient's legs apart placing their elbows in between the patients legs and puts their hands on the patients hips.Rocking gently from side to side, the therapist uses his/her elbows to apply pressure and move the patients legs as far apart as possible in order to achieve maximum possible abduction in the hips.

Conditions B (VA therapy) and C (Placebo treatment)

The procedure used in these trials was exactly the same as was used in the trials described in chapter four.

5.4 RESULTS

The data from this experiment were converted into percentage scores for each subject in each condition.

TABLE 5.3: Percentage change in range of movement: Condition A

Measurements

Subject	Meas. 1	Meas. 2	Meas.3	Meas.4	Meas.5	Meas.6
01				+02.08	+02.97	-02.00
02	-75.00	+43.18	+30.15	+14.81	+10.37	+40.00
03		+02.35	+06.45	+05.75	00.00	
04		+06.66	-09.88	00.00	+30.77	+01.92
05		+01.18	-02.29	+01.76	+03.60	-25.00
06						+13.46
07						+63.82
08		-14.81	+22.22			+25.80
09		+42.22	+11.53	-17.14	-04.22	+28.12
10		+07.69	+02.32	+07.07	+-03.06	+22.22
11		-10.93				
12		-01.53	+04.59	+02.65	+05.88	+08.82
13			+06.02			+47.90
14	+26.66	+08.88	00.00		+38.46	
15			+05.37			+24.24
16				+01.25	-01.25	+13.79
17				+03.88		+22.91
18				+07.47	-01.78	-35.48
19						+03.29
20		+09.30	+21.62	+04.34	+01.05	
21			00.00	00.00	+01.92	+15.78
22		+03.57	-03.92	-03.44	00.00	+25.00
23		+03.12	+06.74	-36.89	+10.47	+15.78
24					-10.44	+11.42

25		+18.75	+30.76	+18.18	+14.28	
26		+32.69	+20.77	-11.11	-02.67	+36.53
27						+06.89

Table 5.4: Percentage change in range of movement: Condition B Measurements

Subject	Meas. 1	Meas.2	Meas. 3	Meas. 4	Meas. 5	Meas. 6
01				+01.04	+03.96	
02	+50.00	+13.63	-06.34	+01.85	+07.54	-60.00
03		00.00	+04.30	+02.30	+29.41	
04		+13.33	+01.23	00.00	-38.46	-01.92
05		00.00	00.00	+02.65	00.00	+09.72
06						+14.31
07						+10.63
08		+07.40	+08.33			-03.22
09		+15.55	+15.38	-22.85	+02.81	+43.75
10		-05.12	+09.30	+07.07	-02.04	+12.96
11		00.00				
12		00.00	+03.44	+03.53	+04.90	+00.00
13		+03.61				+14.58
14	00.00	+04.44	+05.40			+61.53
15			+02.15			+37.37
16		-01.75	00.00	+08.75	+03.75	-03.44
17		00.00		+00.97		-16.60
18				00.00	+04.46	+08.06
19						+17.58
20		+13.95	+24.32	00.00	+01.05	
21			-03.29	+03.92	+00.96	+34.21

22		+07.14	+03.92	-03.44	09.37	+25.00
23		+04.68	+04.49	+04.85	+01.90	+30.52
24					-01.49	+21.42
25		+12.50	+76.92	+13.63	+22.85	
26		+21.15	+33.76	+01.11	+04.46	+01.92
27						+03.44

Table 5.5: <u>Percentage change in range of movement: Condition 3</u>

Measurements

Subject	Meas. 1	Meas. 2	Meas. 3	Meas. 4	Meas. 5	Meas. 6
01				-02.08	+01.98	-04.00
02	+25.00	-06 81	00.00	-03.70	+00.94	+05.00
03		00.00	+02.15	-14.95	-O5.88	
04		-08.00	+01.23	+04.17	+00.00	-01.92
05		+01.18	+01.14	+03.53	+06.30	+13.88
06						+09.61
07						+27.65
08		00.00	+55.55			+12.90
09		+08.88	+00.00	-25.71	+01.40	+12.50
10		+23.07	+00.00	+07.07	+02.04	+07.40
11		-03.12				
12		+10.12	+03.44	+02.65	00.00	+16.17
13			+06.02			+18.75
14	00.00	-20.00	+11.11	-13.51		+53.84
15			00.00			+11.11
16		00.00	00.00	-01.25	-12.50	-10.34
17		+03.57		+01.94		00.00

18				+01.86	-03.57	-14.51
19						00.00
20		+32.55	+02.70	00.00	+01.05	
21			00.00	+00.98	-01.92	-13.15
22		-01.78	-01.96	-03.44	00.00	-03.12
23		+12.50	+03.37	-03.88	+12.38	+05.26
24					-02 98	+07.14
25			+15.38	+13.63	+40.00	
26		00.00	00.00	-05.55	+00.89	+09.61
27						-34.48

Table 5.3 shows changes in the range of movement in all the subjects in percentages found after the MMBP trials. The measurements in the table are those taken specifically for each subject. Where zero scores are indicated, the measurements that were taken after the trial recorded no change in the degree of movement for that measurement.

Table 5.4 shows changes in the range of movement in all the subjects in percentages found after the VA therapy Trials (condition B). Where zero scores are indicated, the measurements that were taken after the trial recorded no change in the range of movement.

Table 5.5 shows changes in the range of movements in the subjects in percentages after the music alone trials (condition C). Where zero scores are indicated, the measurements that were taken after the trial recorded no change in the subjects range of movement for that measurement.

Table 5.6: Mean improvements in percentages of changes in range of movement over all three conditions

Subject	Cond. A (MMBP)	Cond.B (VA therapy)	Cond.3 (Placebo)	Optimum Cond.
1	+01.02	+02.50	-01.37	B
2	+10.58	+01.11	+03.40	A
3	+03.64	+09.00	-04.67	B
4	+05.89	-05.16	-00.90	A
5	-04.15	+02.47	+05.21	C
6	+13.46	+14.31	+09.61	B
7	+63.82	+10.63	+27.65	A
8	+11.07	+04.17	+22.82	C
9	+12.10	+10.93	-00.59	A
10	+07.25	+04.43	+07.92	C
11	-10.93	00.00	-03.12	B
12	+03.88	+02.37	+06.48	C
13	+26.96	+09.09	+12.38	A
14	+18.50	+17.84	+07.86	A
15	+14.80	+19.76	+05.55	B
16	+04.60	+01.46	-04.82	A
17	+13.39	-05.21	+01.84	A
18	-09.93	+04.17	-05.41	A
19	+03.29	+17.58	00.00	B
20	+09.08	+09.83	+09.07	B
21	+04.42	+08.95	-03.52	B
22	+04.24	+08.40	-02.06	B
23	-00.15	+09.29	+05.93	B
24	+00.49	+09.96	+02.08	B
25	+20.49	+31.47	+23.00	B

26	+15.24	+12.48	+00.99	A
27	+06.89	+03.44	-34.48	A

Table 5.6 shows the means from measurements taken for each subject, and the changes in their range of movement in percentages over the three experimental conditions. In the right column the condition in which the greatest improvement that was achieved by each subject is indicated. This showed that 11 subjects improved most in condition A, 12 subjects in condition B and four subjects in condition C.

The overall mean percentage scores of changes in range of movement for condition A (MMBP treatment) was +9.26% (S.D. 13.86%) with a maximum individual mean score of improved range of movement in one subject of 63.82% and a minimum individual mean score of -10.93% where the subject's range of movement deteriorated.

The overall mean percentage score of changes in range of movement for condition B (VA therapy) was +7.95% (S.D. 7.88%). In this condition, the maximum improvement found in range of movement in the mean scores of an individual subject was +31.47%, and the largest recorded deterioration in range of movement in an individual subject was -5.21%.

In condition C, the overall mean percentage score of changes in range of movement was +3.36% (S.D. 11.45%). The maximum improvement found in range of movement in the mean scores of any one subject was +27.65%, and the largest recorded deterioration in any one subject was -34.48%.

A Friedman 2-Way Anova found no overall difference between conditions (P = 0.1054). In order to look at comparisons between the conditions, orthogonal planned comparisons were undertaken by partitioning the Friedman Chi squared comparing condition A with condition B, and condition A and B with condition C. No significant difference was found between MMBP treatment (Condition A) and VA therapy (Condition B) (Chi squared = 0.1, ns). For some subjects, the range of movement increased more with VA therapy, while in an equal number of subjects range of movement increased more after MMBP treatment. This issue will be addressed in the discussion section, as it raises important questions about differences between subjects in their response to different treatment approaches.

A significant difference was found when comparing the two treatment conditions combined (A and B) with the placebo condition (C) (Chi squared = 5.3, $p < .05$). There was a significantly greater range of movement in the subjects following the treatment conditions than was achieved in the placebo condition.

In the additional trials, a significant difference was found by Wilcoxon when comparing the mean scores from three additional VA therapy trials (B) with three additional placebo trials (C) (P = 0.0051). The subjects had consistently greater range of movement when treated with VA therapy than when they were given the placebo treatment.

5.5. DISCUSSION

This experiment did not support the hypothesis that VA therapy would have a greater effect in improving range of movement when compared with MMBP treatment. In the planned comparisons, a significant difference was found when comparing the two treatment conditions combined (A and B) with the placebo condition (C). The outcome of an additional series of trials run on a randomly selected group of ten subjects using the VA therapy treatment and the placebo treatment conditions found a significant difference between groups.

This study introduced a new condition, MMBP treatment, while re-evaluating the effect found from the study described in chapter four, to see if by the application of only one trial in each condition, similar effects would be found. The literature supporting the efficacy of music and movement is sparse (Bean 1995, Cosgriff 1988; Wigram and Weekes 1983), and there are no studies comparing music and movement programmes for people with spastic cerebral palsy either with other interventions or a control condition. The treatment technique of using MMBP treatment has evolved over the last ten years, and specialised techniques in handling patients and selecting appropriate music make this session effective with patients who have high muscle tone or athetoid disability. This technique has developed a specific sequence of exercises which is matched carefully to selected music that is presented in a way to evoke best response, a response which allows the patient to contribute to the process of the treatment.

It was assumed from clinical experience of the effect of physiotherapy, and also of collaborative programmes such as MMBP that this form of treatment would be helpful for the patients. This study has indicated that both MMBP treatment and VA therapy achieve significantly larger improvements in range of movement than a placebo treatment. The value of VA therapy compared with a placebo supports the theory that this form of intervention is helpful with patients who have high muscle tone caused by spasticity.

Studies on other clinical populations, including the hearing impaired, profoundly retarded children and adults, and non-clinical subjects, (Darrow and Gohl, 1989: Madsen et. al. 1991; Pugol, 1994; Stanley, 1991), have found limited evidence of the effect of VA therapy. The equipment used in these studies does not employ the use of sinusoidal low frequency tones.

A possibility arising out of the results is that some subjects with high muscle tone respond more to an active treatment approach than to relaxation. Clinical experience has already shown that because some subjects enjoy and respond better to human interaction, the MMBP treatment approach is more helpful for them, stimulating a motivation to move, encouraging greater freedom of movement and therefore greater range of movement. For these subjects, passive exercises to develop their range of movement, coupled with a requirement that they themselves participate in these movements in order to achieve maximum effect achieves the best response. Improvements in range of movement were therefore found in Condition A when these subjects were treated with MMBP.

Conversely, less improvement in range of movement was found in the same subjects in condition B when they were given VA therapy. As the subjects themselves are non-verbal, and are unable to communicate why they should give a more positive response to the active treatment approach compared with the passive effect of vibration and music it is difficult to elicit reasons for this difference. Attention should be paid to the fact that when lying on a bed, exposed to music and low frequency sound, the subjects in this group for whom the results indicated a less successful form of treatment may have responded in this way for the following reasons:

1/ They were uneasy at being left on their own lying on a bed.

2/ They become more responsive given human contact. Voluntary movement can be increased, and consequently range of movement

3/ They are more responsive when the contact involves live music and active movement.

For those subjects who responded better to the VA therapy trial than to the MMBP trial, the converse arguments can be postulated. For these subjects, they may have been intimidated, or have experienced raised anxiety levels at having parts of their body moved during the MMBP trial. MMBP requires staff to undertake exercises where they attempt to extend the range of movement in various parts of the body to the maximum possible range, and the pressure on subjects with severe spasticity can result in increased spasm and a subsequent decrease in their range of movement. The effect of raised anxiety levels and general physical over-sensitivity to being handled during these exercises can result in increased tension in the subjects, and greater resistance to passive movements designed to promote extension in their range of movement.

Therefore when these subjects were lying on a vibroacoustic unit, and their scores indicted greater improvements in range of movements than when they were being treated in the MMBP trial, the following arguments could be postulated for this effect:

1/ These subjects reacted against being handled for a variety of reasons, including anxiety about painful movements, resistance to physical contact, and an anxiety to group situations.

2/ These subjects were more comfortable and relaxed in the quiet environment of a VA therapy treatment session, and preferred to be left alone.

3/ These subjects enjoy the physical sensation of vibrational sound in their bodies, which caused greater relaxation.

There are a number of variables that have not been taken into consideration in this experiment. The music that was used in the MMBP trials will have an influence on the subjects. It could be argued that the subjects who responded better in VA therapy were unresponsive or even resistant to the style, speed or rhythm of music that was used in the music and movement session. The music that was used in the VA therapy trials could be irritating to those patients who responded more positively to the active approach. In MMBP treatment sessions, rhythmic music is used quite frequently in order to help the subjects feel and anticipate the movement that is going to happen to their bodies. In the VA therapy trials, the music tends to be more gentle, non-rhythmic and unstimulating. For some subjects, this music can not only be ineffective but can also be irritating which would raise arousal levels and stimulate raised muscle tone and tension.

Another variable that was not fully taken into consideration during these trials was the human factor. In the music and movement session, the subjects were treated by a variety of physiotherapy and music therapy staff. The sensitivity of these staff to handling the subjects is variable, and it was noticeable that some staff, by their approach, caused greater anxiety in the subjects than others. While the staff are all trained in this approach, there are inevitably individual differences, and some staff have developed more sensitive techniques than others. So the differences found between condition A and condition B could in part be attributed to differences in staff handling. In the VA therapy session, the same staff were responsible for handling all the subjects.

It was reassuring to the staff regularly using MMBP as a treatment, and those regularly using VA therapy that both of these treatment approaches were found to be more effective in reducing muscle tone and improving range of movement in the patients than the placebo treatment.

This poses another question that needs to be examined in more detail. In the study described in chapter four, all the subjects were given eight trials in each condition, and the results were averaged. A significant difference was found between these conditions.

In the additional trials, subjects were given an extra three trials of both VA therapy and the placebo treatment. In the first trials, 18 of the subjects responded more positively to VA therapy, while nine responded more positively to the placebo when comparing differences in measurement scores between these two conditions. In these additional trials, mean scores revealed that all 10 subjects responded more positively to VA therapy than to the placebo.

It could be inferred that in the additional trials of this experiment, the results indicate that, with repetition, subjects become more responsive to this form of treatment, and a greater number of them demonstrate improved range of movement. It is likely that the subjects became familiar and accustomed to the VA therapy sessions. What was not evaluated, is whether further trials of MMBP treatment would also achieve the same effect. Because the VA therapy treatment does not involve handling, and is a predictable form of treatment carried out consistently the same every time it is undertaken, the results that one might expect to improve through repetition are more likely to occur. Patients with these particular problems coupled with severe limitations in expressive and receptive communication may feel more safe and comfortable. Neither this experiment, nor the one described in chapter four, involved evaluation of cumulative effects brought on by a gradual improvement over a number of treatments. But they have indicated VA therapy as a significantly effective treatment when compared with a placebo.

One other variable that needs to be considered is the difference between group and individual trials. This may have influenced the results, as the group environment may have proven intimidating for some, and conducive for others in the trials, and the same arguments can be applied to the effect of individual attention and isolation in the VA therapy and placebo trials. For future studies, undertaking trials individually in all conditions would be a more consistent method, and may produce different results.

Although some conclusions can be drawn from this study regarding the differences found between these three interventions, and there is some evidence from this study and the study in chapter four supporting the efficacy of VA therapy, further studies are necessary before firm conclusions can be drawn about the reliable value of either VA therapy or MMBP treatment with patients from this clinical group.

CHAPTER SIX

TWO EXPERIMENTS TO EVALUATE THE SENSATION OF VIBRATION FROM LOW FREQUENCY TONES IN THE HUMAN BODY.

6.1 INTRODUCTION

Purportedly, one of the important factors in the effectiveness of VA therapy is the influence of pulsed, sinusoidal low-frequency tones, and the resonating sensation of vibration of these tones in the body. Early studies had indicated that when subjected to low frequency sound, people felt localized resonant vibrational effects in different areas in their body (see chapter three). Some anecdotal reports on infrasonic and low frequency vibration had located this sensation of vibration in the solar plexus, the stomach and the abdomen, and other anecdotal reports had indicated that people were experiencing sensations of vibration from frequencies between 30Hz and 80Hz which were perceived in different parts of their body when the frequencies were changed (Skille, 1982; 1985; Teirich, 1959).

Skille (1985) proposed the idea that frequencies between 30Hz and 120Hz could be felt as localized vibrational effects in the body, and that the strength and sensation of effect of this locally felt vibration would vary depending on the frequency played.

Based on the phenomenon of sympathetic resonance, this would not be unexpected or unusual as an effect. Dependent on the density and structure of a solid mass, it will resonate to different frequencies. In so far as the body is a mass consisting of 70% water, but with different densities depending on bone structure, cavities, and the variety of soft and hard tissue, one would expect sympathetic resonance to sound to be variable. In much the same way as an operatic soprano singing a high-pitched note can shatter a wine glass, frequencies will be felt as a vibration on the surface of the body and inside the body. It is this effect of internal vibration that is believed to be important and significant in the application of VA therapy. If specific frequencies could be used in the application of treatment to certain parts of the body which may be affected in a pathological way, the treatment becomes more applicable in targeting specific problems.

Teirich (1959) had found some consistency in the experiences subjects reported from lower frequency vibrational sound produced by the music tapes he was using. Several subjects reported effects in their solar plexus, and an experience of warmth. More recently, a study by Yamada et al.(1983) found a localised sensation of effect in the body from various frequencies, including sensations of perceived effect in the ear, breast, buttocks and abdomen.

There also appears to be a generalised effect of vibration as a result of VA therapy from the pulsating tones of low-frequency sound. This general vibration can be felt throughout the body. Anecdotal reports have suggested that subjects consistently feel certain frequencies in identifiable places in their body, irrespective of weight, height, age or sex. Skille considered that this phenomenon was more than a coincidence in the substantial number of clinical treatment hours that he had accumulated with vibroacoustic equipment in Norway. In treating a variety of disorders and illnesses, he asked subjects/patients to indicate where they felt the most "pain-relieving" effects from the frequency he was using. When ten or more subjects identified the same frequency as being effective with a given disorder, he began to assign certain frequencies, or frequencies within a certain range, to the treatment of specific pathologies. For example, he indicated that frequencies between 60Hz and 70Hz were successful in alleviating conditions such as pulmonary emphysema, cystic fibrosis, broncho-spasm and asthmatic conditions, on the basis that this range of frequencies, particularly in the region of 60Hz, were felt as sympathetic vibration within the chest area. This vibration appeared to encourage the movement of expectorates from lung walls, and phlegm contained on the bed of the lungs, and facilitated the coughing up of mucus which more effectively cleared the lungs.

In treating spastic disorders, aphasia, cerebral palsy and coma, Skille had suggested 40Hz - 60Hz, and in the treatment of migraine or conditions such as chronic headaches, Skille had proposed frequencies of around 70Hz. Numerous other conditions were documented by Skille and frequencies were assigned either at a very specific level or within a broad range (Skille, 1989b; 1992).

There is no objective research to support these theories. The question that needed addressing was whether within a very small frequency band of 20Hz - 70Hz, there were differences in the location of a sensation of resonant vibration in the body. This study sought to find out whether there was any consistency regarding where subjects experienced a sensation of vibration from frequencies, irrespective of weight, height or gender. As well as investigating whether groups of subjects felt the same frequencies in the same places in their body, it would also be important to find out if individuals experienced a frequency in the same place if it was presented a number of times, in order to test whether there is any consistency of effect.

There is a difference between actual resonance in the body and the perception of a sensation of resonance. In order to look at actual resonance of vibration, sophisticated equipment would be needed to record surface and internal effects. On the basis of the anecdotal reports, these experiments were designed to evaluate peoples' perception of a sensation of vibration. The questions that needed addressing were are those perceptions real, and is there any consistency of effect. It is known that the body, as a solid object, vibrates, but what was unclear was whether different parts of the body vibrate, and what is the meaning and reliability of peoples perception of that sensation of vibration.

6.2 EXPERIMENT ONE: Experimental Hypotheses

Low frequency sinusoidal tones between 20Hz and 70Hz played for a period of ten to twelve seconds, will be felt as a resonant vibration in different parts of the human body.

The sensation of vibration will be consistently felt in the same place in the body when a frequency is played more than once.

6.3 EXPERIMENT ONE: METHODS

6.3.1 Overview

The subjects undertook a short 10 minute trial during which a range of frequencies were presented to them, and they were asked to identify where they felt the strongest effect of the vibration in their bodies. It was decided to use a sequence of pure sinusoidal tones between 20Hz and 70Hz in a specific order which was kept constant for each subject. The order of the frequencies presented was as follows: 40,50,60,70,50,40,30,20,40.

6.3.2 Subjects

39 Subjects (14 male and 25 female) volunteered to take part in these short trials. The subjects were professional people working in the hospital, including nurses, therapy staff, administrators, doctors and psychologists, and also some students who were visiting the hospital for their practical work. Their ages ranged between

21 and 57. Each subject attended for one trial.

6.3.3 Materials

The equipment used in this experiment was purpose built. In the frame of a sprung bed, two 18-inch speakers were mounted in boxes underneath the springs with the cones directed upwards. The speaker boxes contained 2" by 8" ports for acoustic balance, and the cone of each speaker was approximately two inches below the springs of the bed, in order that the subject would be lying within two inches of the surface of the speakers. The speakers were positioned in the bed so that when the subject lay on the bed, one speaker was located under the thoracic and upper abdominal area of their body, and the other speaker was located under the lower thighs, knees and upper calves. The sound was generated equally in mono to the speakers which were situated approximately 2 feet apart.

On top of the springs was a single polythene sheet (as a precaution against incontinent patients who were also treated on the bed), and on top of this was a half inch pile sheepskin rug. The overall dimensions of the bed were 200cm by 80cm by 60 cm high.

The speakers were powered by an Amba-414 purpose built amplifier. The maximum potential output from the amplifier was 80 watts per channel (RMS). The vibroacoustic stimulus of relaxing music combined with a pulsed, sinusoidal low frequency sound wave, or music alone was played through a Technics RS-T11 stereo cassette deck.

The intensity and tone controls were graded from zero to ten.

The tones were produced at a constant intensity by setting the master volume control to seven, the bass control to seven, and the treble control to four on the amplifier for each trial, to ensure a consistent intensity and tonal balance.

The equipment was isolated electrically. Low frequency sinusoidal tones were produced by a Jupiter 500 0.1Hz-500kHz function generator (Black Star).

6.3.4 Measures.

Subjects orally reported their response to the stimulus during the trial, and data were recorded. A form was devised for the tester to record where the subjects identified a sensation of vibration in their bodies. The form gave 9 possible sites or areas for the researcher to record a subjects' response:

feet - calves - thighs - sacrum - lumbar - thoracic - cervical -shoulder - head

Each frequency was played for 12 seconds during which time the subject was asked to identify where they felt the sensation of vibration. Moving from one frequency to another was controlled, wherever possible, by a smooth manipulation of the fine control on the function generator, gradually increasing the frequency until it reached the next frequency. There were two points in the test where this was not possible - the move from the 4th to the 5th frequencies (70 - 50Hz) and the move from the 7th to the 8th frequencies (30 - 20Hz). For these two moves, the volume control was reduced to zero and the coarse control (10 Hz at a time) was used to shift to the new frequency after which the volume was increased.

The sequence contained one frequency that was repeated three times (40Hz) and one frequency that was repeated twice (50Hz) in order to find out whether the subjects were recording a similar resonant sensation of vibration each time these frequencies came in the sequence.

The intensity of the stimulus could be varied on the amplifier and on the function generator. The volume controls on both were preset to the same point for all trials.

6.3.5 Procedure

The procedure for administering the test was standardized for all subjects. When the subjects were comfortably settled on the vibroacoustic bed, they were given the following information by the researcher:

"You are going to be played a sequence of nine frequencies. I will stop on each frequency for 12 seconds. As I stop on each frequency, I am going to ask you the following question:

Do you feel a sensation of vibration and where do you feel it?

Please try and tell me where you feel the strongest effect or sensation of vibration in your body from the sound frequency. In the event that you do not know the exact name of the part of the body where you are feeling the vibration, point to the place on your body as well as verbally explaining where you feel it.

If you are unable to identify a specific location on or in your body where you feel the sensation of vibration, but have a general sensation of vibration in your body, please tell me that you are feeling a general effect. If you feel no sensation of vibration from the sound in your body, please tell me it has no effect. If you feel at all uncomfortable with any of the frequencies, or they cause you any pain or feelings of illness, please tell me."

No specific explanation was offered to any of the subjects prior to the trial as to what they might expect to experience, or if the sensation of vibration was going to change when the frequency was changed. Following the conclusion of the test, some information was given to the subject about what they had experienced, and then they were asked to make any additional comments.

Conventional statistical analyses were not undertaken in this study for two reasons. First of all, the appropriate statistical theory covering comparisons between frequencies in within subjects designs is not well developed. More importantly, it was not possible to devise a null hypothesis. This is because the issue was not whether there would be a localised sensation of vibration, but rather the degree to which this would occur. Therefore descriptive statistics were deemed more appropriate as the means to present the data.

6.4 EXPERIMENT ONE: RESULTS

Table 6.1: Numbers of subjects reporting locations of a sensation of vibration.

HZ	40	50	60	70	50	40	30	20	40
FEET	6	1	0	1	2	6	0	5	6
CALVES	22	4	0	0	3	26	22	6	22
THIGHS	8	1	2	0	3	4	7	15	8
SACRUM	2	6	5	1	15	1	2	4	2
LUMBAR	1	11	6	1	4	0	0	6	0
THORACIC	0	7	18	10	4	0	0	0	0
CERVICAL	0	4	2	4	2	0	0	0	0
SHOULDER	0	2	2	2	1	0	3	1	0
HEAD	0	1	2	11	0	0	0	0	0
GENERAL	0	2	2	9	5	2	5	2	1

Table 6.1 shows the number of subjects perceiving a sensation of vibration and the different locations in the body for the nine frequencies played. Each box shows the number of subjects who felt a localised sensation of vibration and where it was felt. The data in this table refer only to the area in their body which they identified as the primary and strongest area of sensation to these different frequencies. There are indications that the majority of subjects felt 40Hz in their calves,thighs or legs, 50Hz in their thighs, sacrum or lumbar area, and 60Hz in their sacrum,lumbar or thoracic area. The other frequencies gave less specific results. 70Hz was predominately felt

in the upper half of the body. On the first occasion it was presented, 50Hz was felt inconsistently throughout the body, but with a larger proportion of subjects reporting sensation of vibrations in the sacrum, lumbar and thoracic areas. On the second occasion, this had changed, and it was felt significantly in the area of the sacrum. 30Hz was felt predominantly in the calves and thighs, and 20Hz in a wide band range between calves and lumbar area.

Table 6.2: Location of sensation of vibration in percentages for each frequency in the trials

Frequency	Presentation	Localised area	%
40Hz	1	Calves,thighs	77
50Hz	1	Thighs,sacrum and lumbar	61.5
60Hz	1	Sacrum,lumbar and thoracic	66.6
70Hz	1	Lumbar,thoracic, cervical and shoulder	69.2
50Hz	2	Thighs,sacrum,lumbar	59
40Hz	2	Calves,thighs	77
30Hz	1	Calves,thighs	74.3
20Hz	1	Calves,thighs,sacrum, lumbar	79
40Hz	3	Calves,thighs	77

Table 6.2 shows more clearly the localised sensation of vibration of these different frequencies when body sites are grouped together. Each time 40Hz was played this frequency was felt in the legs, calves and thighs. 30Hz also shared a similar effect. As the frequency moved up through 50Hz, 60Hz and 70Hz, so the subjects consistently indicated the location of the sensation of vibration was further up their

body, with typical experiences of 60Hz being felt in the thoracic region, and 70Hz in the upper chest and head.

There was therefore consistency in the sensation of vibration felt at 30hz and 40Hz.

6.5 EXPERIMENT ONE: DISCUSSION

At each frequency, nearly all the subjects felt a localised sensation of vibration, except at 70Hz where almost a quarter of the subjects felt a general effect. There was a similar perceived sensation of vibration to 30Hz and 40Hz in their effect on calves and thighs. Nearly half of the subject group experienced 60Hz most strongly in their thoracic area. 70Hz appeared to stimulate a less obvious sensation of vibration. Some subjects reported quite unusual sensations to 20Hz, and many found it a different sensation from the other frequencies, often describing the sensation as "a very unusual overall vibration", which some of the subjects did not find particularly pleasant. This appears to support anecdotal reports that extremely low frequencies, from 20Hz downwards (in the infrasonic range) can cause feelings of nausea or mildly unpleasant physical sensations, and perhaps should be avoided.

There is some evidence in this study to support the anecdotal findings of the experiments undertaken by Teirich (1959) where localised effects from low tones had been reported. This study also provides some evidence to support the theory that people can perceive individual frequencies as resonant vibrational effects.

There are some issues in the design of this study which need to be considered in further studies on the localised sensation of vibration of low frequency sound. The first point is that more data needs to be taken on the subjects, including their weight and height.

The second point is that in a subsequent study it would be important to control for order effects, by randomising the order in which the frequencies are played on a cassette tape. Using cassette tapes would also ensure control over variables which may have been present due to individual differences in the way the frequencies were presented due to manual manipulation of the function generator. The amount of time allowed on each frequency was inevitably going to vary by a small margin each time the trials were done. Recording sequences of frequencies, using a synthesizer to obtain pure, sinusoidal tones, would guarantee that the time of presentation, the time between frequencies and the movement from one frequency to another were all consistently identical in each trial. Also, 12 seconds is not very long for a subject to identify a sensation of vibration, and in future trials a period of at least 15 seconds should be allowed.

However, the study lends some support to the evidence that specific frequencies between 20Hz and 70Hz can be felt as a sensation of vibration in different parts of the body and there is some consistency of effect.

6.6 EXPERIMENT TWO: Experimental Hypothesis

A high proportion of subjects will feel a sensation of vibration to the same frequencies in the same areas of their body.

When frequencies are presented a number of times, subjects will consistently locate a sensation of vibration to that frequency in the same area of their body.

6.7 EXPERIMENT 2: METHODS

6.7.1 Overview

This experiment looked at the phenomenon of the sensation of vibration in the body. Fifty two subjects were played sequences of frequencies ranging from 20Hz to 70Hz. Anecdotal reports from subjects in previous experiments, and from people who had experienced the use of VA therapy, had indicated some discomfort and occasionally nausea when very low frequencies bordering on the infrasonic range were used. Other anecdotal reports had suggested limited localised sensations of vibration to the frequency of 70Hz. In paying attention to these reports, it was decided that each subject in these trials would receive four presentations of 30Hz, 40Hz, 50Hz, and 60Hz, and they would only receive two presentations of 20Hz and 70Hz.

Each subject undertook a trial which lasted 10 minutes, during which a range of frequencies were presented to them and they were asked to identify where they felt the strongest sensation of vibration in their body.

6.7.2 Subjects

Fifty-two subjects (26 male and 26 female) were recruited from staff and students at Harperbury Hospital, England. The subjects were professional people working in the hospital including administrators, doctors, psychologists, therapy staff, nurses, and also students of music and music therapy. Their ages ranged between 19 and 60, and data was collected on their height and their weight. The mean age for the group was 32.3 (Std.Dev 9.90). Height ranged from 150cm to 190cm (mean 171.8, Std.Dev. 9.78), and weight ranged from 50kg to 91kg (mean 67.2kg, Std. Dev. 9.95).

The subjects all attended for one trial. The subjects were randomly assigned to two groups, with equal numbers of male and female subjects in each group. Four different sequences of frequencies between 20Hz and 70Hz were recorded on cassette tape presented in a random order. Group 1 received Sequence 1, followed after a pause of ten seconds by Sequence 2. Group 2 received Sequence 3, followed after a ten second pause by Sequence 4. The sequences of frequencies that were used will be described in the next section.

6.7.3 Materials

The equipment used for this experiment was a purpose-built vibroacoustic unit in the form of a bed containing loudspeakers. The unit consisted of a flat 2 metre x 1 metre wooden surface, raised off the floor by metal legs. Secured underneath the wooden surface were six 10" Otmetka R.E.T. Bass Woofer speakers, mounted in boxes with the cones directed upwards. The speaker boxes contained ports for acoustic balance, and the cone of each speaker was covered by a metal grill. On top of the wooden board containing the speakers was a 2" foam rubber mattress, covered in polyurethane. The subjects were lying on the mattress.

The speakers were powered by a Sherwood Stereo Integrated Amplifier A1 3010. The maximum output from the amplifier was 60 watts per channel (RMS). In order to achieve a consistent presentation of the frequencies in each trial, the sequences of sinusoidal frequencies were recorded using a Roland synthesizer onto a metal cassette tape. The sound was generated equally in mono to all the speakers. The tape containing the sequences of frequencies was played through an Aiwa AD-F410 Stereo Cassette Deck.

Table 6.3: Sequences of sinusoidal frequencies between 20Hz and 70Hz

Sequence 1: 20 40 30 50 40 30 60 50 70 60

Sequence 2: 60 70 50 30 60 40 50 30 40 20

Sequence 3: 70 30 40 30 20 60 50 60 50 40

Sequence 4: 40 50 60 50 60 20 30 40 30 70

The frequencies were recorded onto the tape in such a way that instead of jumps between the frequencies, the effect of a portamento was created as the synthesizer moved from one frequency to the next. Therefore there was a smooth transition from one frequency to another. The main reason for sliding from one frequency to another was that it had been discovered by self-reporting in some experimental sessions before the trials, that it was easier and quicker for subjects to locate the sensation of vibration from a new frequency if the movement from a previous frequency was carried out by a portamento slide, rather than by a sudden jump. Each frequency was played for fifteen seconds before moving to the next frequency.

6.7.4 Measures

Forms were devised for each sequence (Appendix 4-8) in which the following areas of the body were defined:

Feet - ankles - calves - knees - thighs - sacrum - lumbar - thoracic - shoulders - neck - head - arms - hands.

It was anticipated that subjects may not only identify a primary area where they felt the vibration, but would also experience secondary areas in the body where they also felt a sensation of vibration. The sequence of frequencies were placed on the x-axis, and the areas of the body on the y-axis. When the subject reported a primary sensation of vibration, a "1" was placed in the box corresponding to the frequency and the part of the body the subject identified.

When asked to identify a secondary site, a "2" was placed in the relevant box. In the event that the subject described a general sensation of vibration, a wavy line was drawn down the column to cover all these areas. In the event the client reported no sensation of vibration, the column was left blank.

At the bottom of the form a dislike box was included, and during the course of the trials the subjects were asked to indicate which frequencies they disliked, and this was recorded in these boxes. The form also recorded data on the gender, date of birth, weight and height of the subjects.

6.7.5 Procedure

The subjects were first comfortably settled on the vibroacoustic bed and allowed to rest for five minutes. During this time, the following instructions were given to them:

"You will be played a sequence of ten frequencies, and after a pause of 30 seconds you will be played a further sequence of ten frequencies. Each frequency will sound as a continuous tone, lasting 15 seconds. After each tone has started, please indicate if you feel any sensation of vibration and where in your body you feel the strongest effect of this vibration. You will then be asked if there are any other places in your body where you feel a sensation of vibration, in which case you should say if there are additional sites where a vibration is felt. You can either tell me the place on or in your body where you feel the vibration, or point to it with your hand. You may feel the frequencies anywhere in your body from your head to your toes.

Please lie still during the test and try to sense whether you feel a sensation of vibration to the sounds in your body, and where you feel that sensation. If you don't feel any sensation anywhere to a particular frequency, just say that there is no sensation of vibration. If you feel a general sensation of vibration and you can't be specific as to where in your body you feel the vibration, just say there is a general effect."

No explanation was given to the subjects prior to the trial as to what they might expect to experience, or if the sensation of vibration was going to change with each frequency. The tone controls of the amplifier were set at the mid point between +10 and -10, and the volume control was set at 35 for every trial. The tape recorder was switched on and the two sequences of frequencies were automatically played. Following the conclusion of each trial, some explanation was given to the subjects as to why the test was being carried out, and they were shown the form which had been completed during their particular trial.

6.8 EXPERIMENT 2: RESULTS

The data collected in this study revealed that subjects can experience a sensation of vibration in their body, and can describe the area where they experience the stronger sensations of vibration. The most effective way of presenting the substantial amount of data was to tabulate the number of subjects reporting a sensation of vibration in each part of their body for each frequency and look for consistency of the perception of vibration between subjects, and within subjects.

During the trials, a total of thirteen body sites were listed on the form in order to record as accurately as possible where subjects identified a sensation of vibration. In the analyses, tables show the responses of the subjects in primary and secondary sites, and then the sites are grouped into general body areas to see if a clearer profile can be gained.

Table 6.4: Number of subjects reporting a location of a sensation of vibration in a primary site

	FEET	ANCKLES	CALVES	KNEES	THIGHS	SACRUM	LUMBAR	THORACIC	SHOULDERS	NECK	HEAD	ARMS	HANDS	GENERAL	NO EFFECT
20Hz	6	3	4	4	5	17	3	1	1	1	1	0	1	4	1
20Hz	3	4	2	4	3	8	5	0	3	1	1	1	2	14	1
30Hz	1	3	7	2	6	10	5	4	5	2	5	0	1	1	0
30Hz	4	2	2	3	5	9	11	2	2	1	2	0	0	8	1
30Hz	1	9	6	6	5	4	3	2	6	0	5	0	1	5	1
30Hz	2	2	6	1	9	5	3	3	9	2	3	0	0	8	3
40Hz	0	0	15	3	8	6	3	2	2	1	5	1	1	4	1
40Hz	1	0	12	6	6	2	3	1	4	0	7	0	0	9	1
40Hz	0	2	4	5	9	6	6	8	1	1	2	0	0	8	0
40Hz	0	1	11	6	9	4	3	5	2	1	4	0	0	5	1
50Hz	1	1	4	6	5	10	10	0	2	0	6	0	1	6	0
50Hz	1	0	4	6	6	7	8	4	2	0	2	0	1	8	2
50Hz	1	0	3	4	8	9	8	8	4	0	3	0	1	3	0
50Hz	2	0	5	6	7	10	8	3	3	0	1	0	0	5	2
60Hz	4	2	0	2	3	3	5	13	1	1	10	0	2	5	1
60Hz	3	0	2	0	3	3	5	10	2	4	7	1	1	8	3
60Hz	0	5	8	4	7	4	5	5	6	2	0	0	0	6	0
60Hz	2	0	3	2	0	1	8	13	6	2	6	0	2	7	0
70Hz	3	1	2	0	5	1	6	5	8	7	7	0	2	3	2
70Hz	1	0	1	2	3	2	3	8	4	5	13	2	0	6	2

Table 6.4 shows the location on the body where subjects identified a sensation of vibration, and how many subjects identified that place for each presented frequency. The data in this table indicates the primary sites chosen by the subjects for the location of specific sensations of vibration. It presents the complete data, and there are wide variations in response. It is important to note the variability within one frequency band. For example, on the first two occasions that 30Hz was played, only three subjects felt a sensation of vibration to this frequency in their ankles, whereas on the third occasion nine subjects felt this frequency in their ankles. The first time 50Hz was presented no subjects felt this frequency in the thoracic region. On the second presentation four subjects felt this frequency there, eight on the third presentation, and three on the fourth presentation. There is some consistency with 60Hz, and during two of the presentations of this frequency thirteen subjects felt a sensation of vibration in their thoracic area. However, on the third presentation, only five subjects felt it in this area.

This table demonstrates wide variability in subjects' perception of the location in their bodies of a sensitivity to vibration from each frequency.

Table 6.5: <u>Mean scores for primary sites in percentages</u>

	20Hz	30Hz	40Hz	50Hz	60Hz	70Hz
No Effect	1.9	2.4	1.4	1.9	1.9	3.8
Feet	8.6	1.8	0.5	2.4	4.3	3.8
Ankles	6.7	7.7	1.4	0.5	3.3	1.0
Calves	5.7	10.0	20.2	7.7	6.3	2.9
Knees	7.7	5.7	9.6	10.6	3.8	1.9
Thighs	7.7	12.0	15.4	12.5	6.2	7.7
Sacrum/Pelvis	24.1	13.4	8.5	17.3	5.3	2.9
Lumbar/Abdomen	7.7	10.5	7.2	16.6	11.0	8.6
Thoracic	1.0	5.3	7.6	7.2	19.7	12.5
Shoulders	3.8	10.5	4.2	5.3	7.2	11.5
Neck	1.9	2.4	2.3	0.0	4.3	11.5
Head	1.9	7.2	8.6	5.8	11.0	19.2
Arms	1.0	0.0	0.5	0.0	0.5	1.9
Hands	2.9	1.0	0.5	1.4	2.4	1.9
General Effect	17.4	10.5	12.5	10.6	12.5	3.9

Table 6.5 shows in percentages the number of subjects describing a primary sensation of vibration distributed over the 14 sites the body in mean scores from the six presented frequencies. Variability in response is again evident. However, in examining the response to 20Hz for example, 24.1% of the subjects felt the localized effect of this vibration in their sacrum and pelvis. This was the highest figure where a consistent sensation of vibration was felt. At 40Hz a consistent

sensation of vibration was felt by 20.2% of the subjects in their calves, and at 60Hz, 19.7% of the subjects felt the sensation of vibration in their thoracic area. This table shows that if some of the body sites were grouped together, more consistent effects may emerge, and while this method of measuring and recording the data was designed to cover the 14 independent locations in the body which subjects could point to or describe easily, and which could be isolated as a localized area, it was felt that it might be useful to look at the data where body sites were grouped.

Table 6.6: Location of frequencies grouped into main body sites

	No Effect	Legs	Sacrum-Lumber	Chest-Head	Arms/ Hands	General
20Hz	1	22	20	4	1	4
20Hz	1	16	13	5	3	14
30Hz	0	19	15	16	1	1
30Hz	1	16	20	7	0	8
30Hz	1	24	8	13	1	5
30Hz	3	21	8	12	0	8
40Hz	1	26	9	10	2	4
40Hz	1	25	5	12	0	9
40Hz	0	20	12	12	0	8
40Hz	1	27	7	12	0	5
50Hz	0	17	20	8	1	6
50Hz	3	17	15	8	1	8
50Hz	0	16	17	15	1	3
50Hz	2	20	18	7	0	5
60Hz	1	11	8	25	2	5
60Hz	3	8	8	23	2	8
60Hz	0	24	9	13	0	6
60Hz	0	7	9	27	2	7
70Hz	2	11	7	27	2	3
70Hz	3	7	5	30	2	5

In order to obtain a more general view, the data was re-coded into four larger areas of the body, consisting of the legs, from the sacrum/abdomen, the chest, neck and head, and the arms and hands. General effect and no effect were left as separate categories. Table 6.6 shows how subjects were distributed.

Few of the subjects recorded no effect at all. A larger proportion indicated a general effect, particularly on the second presentation of 20Hz. A very small proportion of the subjects recorded the effects of vibration in their arms or hands. So, apart from those reporting general effects, a significant majority of the subjects were recording sensation of vibrations within three main areas of the body: the legs, the thoracic and abdominal area, and the chest and head.

Table 6.7: Mean scores of the sensation of vibration of frequencies in primary sites in grouped body locations in percentages.

	20Hz	30Hz	40Hz	50Hz	60Hz	70Hz
No Effect	2	3	1	3	1	5
Legs	36	39	47	33	24	16
Sacrum - Abdomen	31	23	16	34	16	12
Chest-Head	9	23	22	18	43	55
Arms/Hands	4	1	1	1	3	4
General Effect	18	11	13	11	13	8

Table 6.7 shows the mean scores of the frequencies felt as sensations of vibration in primary sites. This data shows the small number of subjects who either recorded

either no effect at all, or recorded a sensation of vibration in their arms and hands. This table gives a clearer summary of where the majority of subjects experienced a perceived sensation of vibration.

Table 6.8: Number of subjects reporting a location of a sensation of vibration in a secondary site.

	FEET	ANCKLES	CALVES	KNEES	THIGHS	SACRUM	LUMBAR	THORACIC	SHOULDERS	NECK	HEAD	ARMS	HANDS	GENERAL	NO EFFECT
20Hz	1	4	3	3	5	3	4	1	2	2	2	0	1	2	19
20Hz	2	0	0	3	3	4	2	0	3	1	1	0	0	5	28
30Hz	4	3	3	2	4	1	2	5	5	1	2	0	1	2	17
30Hz	2	3	3	3	2	3	3	2	2	0	4	1	0	4	20
30Hz	2	4	3	5	2	5	1	1	5	2	0	0	0	1	21
30Hz	2	1	2	3	1	7	4	2	4	3	2	0	1	2	18
40Hz	1	5	3	4	2	2	6	1	3	2	2	1	1	3	16
40Hz	0	4	5	5	5	5	3	1	3	1	1	0	1	0	18
40Hz	0	2	8	8	6	3	2	0	6	3	0	0	1	1	12
40Hz	2	3	9	5	0	1	3	0	3	2	2	0	1	2	19
50Hz	2	0	3	0	4	4	7	1	6	1	2	0	2	3	17
50Hz	1	0	3	2	3	5	1	1	1	0	1	2	1	2	29
50Hz	2	1	4	2	5	7	4	4	3	1	0	0	0	1	18
50Hz	1	0	2	2	7	6	2	4	4	3	1	1	0	2	17
60Hz	3	1	2	2	0	1	2	7	9	3	4	1	0	1	16
60Hz	0	2	1	2	3	1	3	7	4	1	2	0	1	2	23
60Hz	4	0	1	1	3	2	4	7	6	1	5	1	1	0	16
60Hz	4	2	2	4	5	1	5	2	4	2	5	0	0	2	14
70Hz	2	1	1	1	1	6	3	7	5	2	7	1	0	0	15
70Hz	4	1	0	0	2	0	1	6	5	7	6	1	3	1	14

Table 6.8 shows the location on the body where subjects reporting a secondary sensation of vibration to a specific frequency and how many subjects reported that effect for each presented frequency. It shows that a large number of subjects appeared not to perceive a local sensation of vibration in a secondary site in their body.

Table 6.9: Mean scores for secondary sites in percentages

	20Hz	30Hz	40Hz	50Hz	60Hz	70Hz
No Effect	45.0	36.5	31.2	38.5	33.1	27.9
Feet	2.9	4.8	1.4	2.9	5.2	5.8
Ankles	3.8	5.3	6.7	0.5	2.5	1.9
Calves	2.9	5.3	12.0	6.7	2.8	1.0
Knees	5.8	6.2	10.6	2.9	4.2	1.0
Thighs	7.7	4.3	6.2	9.1	5.2	2.9
Sacrum/Pelvis	6.7	7.7	5.3	10.6	2.5	5.8
Lumbar/Abdomen	5.8	4.8	6.8	6.5	6.6	3.9
Thoracic	1.0	4.9	1.0	4.8	11.0	12.5
Shoulders	4.8	7.7	7.2	6.7	11.0	9.6
Neck	2.9	2.9	3.9	2.4	3.4	9.6
Head	3.0	3.8	2.5	1.8	7.7	12.5
Arms	0.0	0.5	0.5	1.4	1.0	1.9
Hands	1.0	1.0	1.9	1.5	1.0	2.7
General Effect	6.7	4.3	2.8	3.8	2.8	1.0

Table 6.9 gives the mean scores for the location of any secondary effects, and shows that a substantial number of the subjects had no specific secondary sensations of vibration. There were some exceptions. At 40Hz, 22.6% of the subjects located the sensation of vibration of the frequency in their calves and knees, and if one includes ankles and thighs, it can be seen that the overall sensation of vibration on the legs was closer to 37% of the subjects. 60Hz was also perceived by 11% of the subjects in the thoracic area.

Table 6.10: Location of a secondary sensation of vibration to frequencies grouped into main body sites

	No Effect	Legs	Sacrum/ Pelvis/ Lumbar	Chest/ Shoulders/ Neck/head	Arms/ Hands	General Effect
20Hz	19	16	7	7	1	2
20Hz	28	8	6	5	0	5
30Hz	17	16	3	13	1	2
30Hz	20	13	6	8	1	4
30Hz	21	16	6	8	0	1
30Hz	18	9	11	11	1	2
40Hz	16	15	8	8	2	3
40Hz	18	19	8	6	1	0
40Hz	12	24	5	9	1	1
40Hz	19	19	4	7	1	2
50Hz	17	9	11	10	2	3
50Hz	29	9	6	3	3	2
50Hz	18	14	11	8	0	1
50Hz	17	12	8	12	1	2
60Hz	16	8	3	23	1	1
60Hz	23	8	4	14	1	2
60Hz	16	9	6	19	2	0
60Hz	14	17	6	13	0	2
70Hz	15	6	9	21	1	0
70Hz	15	7	1	24	4	1

Table 6.10 shows the sensation of vibration more generally in terms of body sites where the data was re-coded in the same way as for the primary sites in Table 7.5.

Scores were added together from the larger number of body sites to look at a more general area of the body such as the legs or the central section of the body,

Table 6.11: Mean scores of the sensation of vibration of frequencies in secondary sites in grouped locations in percentages

	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz	70 Hz
No Effect	45	37	32	39	33	29
Legs	23	26	37	21	20	12
Abdomen/Sacrum/Lumbar/Pelvis	12	12	12	17	9	10
Chest/Shoulders/Neck/Head	12	19	13	16	33	43
Arms/Hands	1	1	3	3	2	5
General Effect	7	5	3	4	3	1

Table 6.11 presents the mean scores in each frequency band. Besides the high incidence of "no effect", there are some similarities with the data from the primary sites. 20Hz, 30Hz and particularly 40Hz show higher percentages of the subjects experienced a sensation of vibration from these frequencies in their legs, while 60Hz and 70Hz are felt in the upper part of their body. This is also consistent with the data from the primary sites.

Table 6.12: Results of self-reported dislike of frequencies between 20Hz and 70Hz

Frequency presented	Number of presentations in total.	Number of subjects who expressed dislike.	% scores of disliked frequency
20 Hertz	104	20	19.2 %
30 Hertz	208	18	8.7 %
40 Hertz	208	14	6.7 %
50 Hertz	208	16	7.7 %
60 Hertz	208	24	11.5 %
70 Hertz	104	30	28.9 %

Table 6.12 shows the numbers of disliked frequencies as recorded by the 52 subjects during the trials. This is a summative analysis, which reveals that the most disliked frequencies were 70Hz (disliked by 28.9%), and 20Hz (disliked by 19.2 % of the subjects).

TABLE 6.13: Means and standard deviations of number of subjects reporting a disliked frequency

	First sequence of ten frequencies Mean (S.D.)	Second sequence of ten frequencies Mean (S.D.)
Male Subjects	1.8 (1.85)	.96 (1.25)
Female Subjects	1.0 (1.13)	.88 (1.07)

Table 6.13 gives the means and standard deviations of the first and second sequences of frequencies, showing there was no significant overall difference between men and women in the mean number of disliked frequencies, F = 1.9, N.S. However an Analysis of Variance found there was a reduction when comparing the number of disliked frequencies in the first sequence with the number recorded in the second sequence, F = 9.1,

P = .0004. There was a larger reduction in mean number of disliked frequencies in the male subjects than in the female subjects F = 5.4, P = .02.

6.9 EXPERIMENT 2: DISCUSSION

This experiment was designed to investigate in more detail the relationship between the use of sinusoidal low frequencies in the range 20Hz-70Hz, and sensations of vibration locally felt in the body. Generally, from looking at raw scores and averaged data, one can conclude that there are some consistent sensation of vibrations. There are also differences in the way people experience these localised sensations of vibration. Analysis of the data taken from the subjects of height and weight found no evidence that when grouped into weight or height bands consistency of effect began to emerge. Other variables, such as age and sex also provided no additional evidence of a consistent pattern. The experiment indicated that in a large group of subjects, presented with groupings of 10 frequencies in four different sequences, some evidence of consistency among subjects who all felt the same perceived location of a sensation of vibration to the same frequencies can be found in the data.

However there is also considerable variability. The maximum number of subjects who felt a specific frequency (20Hz) in a specified place was 17 (in the sacrum), representing 32%. The data in table 6.4 reveals that there were seven other individual occasions when the presentation of a frequency elicited an agreed response in a localised sensation of vibration from more than 20% of the subjects. These eight occasions come within a framework of 248 different responses crossmatching sensations of vibration of 20 presented frequencies to 12 specific areas of the body, one general area and a category of no effect.

Another point of issue that became clear from the experiment, and can be seen in the data presented in Table 6.4, is that besides the limited number of occasions when consistent effects were found between subjects in where they feel vibrations, on a number of presentations of the same frequency there is also limited consistency of a perceived sensation of vibration within subjects. This was found in the first experiment, subjects consistently reported a sensation of vibration in their calves to three presentations of 40Hz. There is limited evidence of any similar consistency in the second experiment. For example, when 40Hz was presented on four different occasions during the sequences of frequencies, between 21% and 28% experienced it in their calves on three occasions, but on the 4th occasion, only 7.6% felt this frequency in this specific area of their legs.

Having established that there is variability in the localised sensation of vibration from these different frequencies when subjects were asked to point to or name parts of their body where they felt the strongest sensation of vibration, it is interesting to see whether it is possible to find consistency when grouping together body sites, as shown in Table 6.6. Here, some more clear evidence of patterns begins to emerge. High percentages of subjects felt the lower frequencies of 20Hz, 30Hz and 40Hz in their legs, and 60Hz and 70Hz in their chest and head, except on one presentation, when 46% of the subjects felt this frequency in their legs. 50Hz had a wide spread of effect, and even when grouping the body areas into three main areas (excluding the arms), it is difficult to find consistency from the 50Hz frequency.

A high proportion of the frequencies caused a "general effect", and the percentage of subjects feeling a general sensation of vibration ranges from 10% to as much as 27%.

Besides the variable localised sensation of vibration of different frequencies, a general, whole body vibration was being identified by many subjects. Initially, it was thought that subjects became more "attuned" to the sensation of vibration, and as treatment time elapsed, became more "sensitive" to the sensation. But based on the acoustical principles of partial and whole vibration of objects, it could be argued that the "objects" involved in the experiment - in this case the physical bodies of the subjects, may be vibrating in parts and as a whole, and therefore it could be anticipated that some subjects will be more aware and physically responsive to a general feeling of vibration.

Furthermore, another factor made a significant difference to the precision of localised sensation. Spectrum analysis tests undertaken later on the vibroacoustic unit used in the trials have revealed that the stimulus presented is not a pure sinusoidal tone. Measurements taken reveal that in the lower frequencies of 40Hz and 50Hz there is a maximum purity of 65% in the sinusoidal frequencies . Distortions or additionally generated vibrations caused by the speakers and/or the vibrating host unit (the bed) create overtones which together will account for at least 35% of the remaining output. At the higher frequencies, there is less distortion. Therefore, a complex tone will stimulate both whole and partial vibration of the object leading to a sensation of vibration felt in a specific location, and a general vibration in the body, experienced as a whole body vibration.

Another issue that needs to be addressed in future research is the constitution of the equipment that was used, and the resonance of the VA unit. This was not evaluated, and neither was the position in which the subjects were lying. Although they were all asked to lie supine on the bed, height differences may have caused differences in the positioning of their bodies over the speakers.

Some inconsistencies of effect were noticeable in the results. It is unclear why on one occasion such a large percentage of subjects should have felt the frequency of 60Hz in their legs, when on the other three presentations there was agreement amongst around 50% of the subjects that the sensation of vibration was localised in the chest and head. The same question should be considered in respect of 30Hz, where during one of the four presentations, an atypically large number of subjects (39%) experienced this frequency in their sacrum, lumber and abdominal area, compared with the other three presentations where the sensation was felt in their legs. Retrospective analysis of the procedure of the experiment, or the stimulus used for the experiment has revealed no clear explanation for this inconsistency.

Anecdotal reports had indicated that, in addition to primary or immediately located sensations of resonant vibration in the body, secondary effects of a less strong sensation of vibration will be felt. This study includes data collected of reported experiences of secondary effects. The distribution of subjects in Table 6.8 showed that there were individual differences, and no consistent pattern, except a significant increase in the number of subjects reporting no sensation of vibration in secondary sites, compared with the data found in the primary sites. The percentage of subjects reporting no effect to the 6 frequencies presented ranged from 29%-45%, and an average of 35% of subjects reported no effect. This figure was higher in the lower frequencies (20Hz, 30Hz and 50Hz,) and decreased in the higher frequencies (60Hz, 70Hz). This could be accounted for by the more powerful physical sensation of vibration of the lower frequencies causing an enhanced perception in subjects of a primary site. The dominance of the primary sensation may reduce the subjects' ability to identify their experience of a secondary sensation, whereas the higher frequencies permit the subject to experience more than one sensation of vibration.

It is also evident from the data that there is a greatly reduced experience of the frequencies as a "general effect". This is perhaps due to the proportional number of subjects who recorded no effect. From the results described in tables 6.7 and 6.11, it is possible to combine the reports of both primary and secondary effect. 55% of subjects who recorded primary effects of 70Hz in their chest, shoulders neck or head, and a further 43% of subjects (assumedly different) reported secondary effects of 70Hz in the same body area - indicating that a total of 98% of the subjects experienced either primary or secondary effects from 70Hz in this general area. Based on the same assumption, the combined reported effects in either primary or secondary sites would indicate high percentages of sensations of vibration when presented with 20Hz, 30Hz and 40Hz in their legs, and 60Hz in their chest, shoulders, neck and head.

The data collected from all 52 subjects regarding which frequencies they disliked indicated that there was a higher percentage of subjects that disliked 20Hz and 70Hz than the other frequencies. Speculation might suggest that 20Hz is an uncomfortable, deeply vibrating frequency on the border of the infrasonic range. Anecdotal reports from clients in vibroacoustic treatment have recorded a variety of "side-effects" to 20Hz, including, nausea (perhaps caused by a disturbance to the vestibular system), headaches, and a general shaking effect to the whole body. This has also been documented in the studies by Griffin (1986). So the results of this study, which produced data recording 20% of the subjects disliking 20Hz tends to lend some credence to these anecdotal and experimental reports. However there is no clear explanation, because detailed self-reports were not obtained from these subjects as to what effects were experienced that caused this negative reaction.

The apparent dislike of 70Hz is also hard to explain, and the proportion of subjects giving a negative reaction to this frequency was 28.9%. In this case, anecdotal reports of 70Hz had revealed some negative reactions, mainly where patients found this frequency disturbing, particularly as it disturbed their experience of the music. It is a higher tone, and is audibly more noticeable than those in the lower frequencies. However no additional evidence to explain the dislike these subjects reported was obtained.

One additional factor should be considered in explaining disliked frequencies. These were "naive" subjects, and as the test progressed there was a reduction in the reports of disliked frequencies, suggesting that as the subjects became accustomed to the stimulus, the number of times they experienced a negative reaction decreased. An unusual sensation may at first be disliked until the subject becomes comfortable with it.

While there are indications from both of these studies that there is some consistency in the effect of a sensation of vibration that subjects feel in the form of a sympathetic resonance to certain frequencies in identifiable places in their body, the results are not conclusive. However there is enough evidence of groupings of subjects to consider that there is more than just a random effect.

Further experimentation could be undertaken using the same form of experiment, and using similar methods of self reporting. It became clear during the course of this experiment, that some of the subjects were more sensitive to a perception of the sensation of vibration within their body than others. With this in mind, it would be more revealing in future experiments to use a smaller number of subjects, and administer a greater number of trials. An evaluation could be made of any increase in consistency that occurs as the subjects become more familiar with the experience of the trial, and the sensations that they are becoming sensitive to in their body.

7.10 CONCLUSION

The first of these two studies supported the theory of a localised sensation of vibration, while the evidence from the second study indicates that while similar groupings occurred as in the first study, when a greater number of body sites were used to monitor the sensation of vibration, there was a more general and inconsistent effect. A careful analysis of the figures has revealed some patterns. Conversion of the data into groups, individual and grouped body parts both in numbers and percentages of subjects in the form of frequencies of effect provide some evidence of the way subjects were responding, incidence of consistency and individual differences.

Reports from clinical treatment using VA therapy have documented the relaxing and beneficial effects of the low frequency sinusoidal tone used, and subjects have frequently reported a sensation of localised vibration. These two studies have examined this phenomenon particularly with reference to the question of whether there is a consistent and reliable local sensation of vibration that varies depending on the frequency used within a range from 20Hz to 70Hz. Skille (1985) has suggested that there is a localised sensation of vibration, similar to the principles of resonant vibration, which for any given frequency in the above range can be consistently felt by people in specific areas of their body. In his clinical reports, he has sought to identify this and link it to effective frequencies for treating specific pathological conditions.

There is enough evidence of some frequencies causing similar effects in subjects for this phenomenon to be treated as real, and for further investigation to be undertaken. What is more, these trials were undertaken with short, constant tone sinusoidal frequencies, each frequency being presented for a maximum of 15 seconds. In the treatment, patients receive 20 to 30 minute sessions, and over this period of time they have a much greater opportunity for the body to adjust and "sensitize" to the frequencies.

Further experimentation in this field should take into account the potential for changes to the design of the experiment, and ensure that more time is allowed on each frequency before a response is required by the subject.

CHAPTER SEVEN

MOOD AND PHYSIOLOGICAL RESPONSES TO VA THERAPY IN NON-CLINICAL SUBJECTS

7.1 INTRODUCTION

VA therapy has stimulated research primarily focused on clinical populations. It has been applied as a treatment in hospitals for people with severe learning disability (mental handicap), multiple handicap, people with mental illness and for general medical conditions. Empirical work has also been undertaken in schools for physically and mentally handicapped children. The results, both from anecdotal studies, and also from objective research, have indicated improvements in people with both mental and physical disorders (Skille 1986, 1989a, 1992; Skille and Wigram, 1995). With the exception of an inconclusive study by Lehikoinen (1988, 1989) on insurance company executives, where the treatment was evaluated as a relief for stress when compared with normal autogenic stress relaxation, no objective studies have looked at the effect of VA therapy on the non-clinical population. The empirical data collected from the clinical population has focused more specifically on the relief of pain, the reduction of muscle tone and blood pressure and the alleviation of symptoms and behaviours that are closely connected to pathological conditions (Chesky and Michel, 1991; Darrow and Gohl, 1989; Lehikoinen, 1990: Skille, 1989a, 1991). One of the few studies undertaken on non-clinical subjects (Madsen et al., 1991) found no significant changes, but verbally expressed enthusiasm for vibrotactile stimulation from the college students they were using as subjects.

VA therapy had also been observed to have an effect on the mood and psychological state of patients, and in the clinical treatment of patients with high levels of anxiety or stress they had been noted to relax and become more calm and happy during the treatment (Wigram, 1993). Arousal levels were reduced, and this effect on the psychological state of the clients was connected and related to the effect of physiological activity and general behaviour.

In anecdotal reports, VA therapy was noted to have a relaxing effect on subjects, but as this form of treatment involves lying down on either a reclining chair or a bed, relaxation could occur in any event, without the benefit of relaxing music, or the addition of a pulsed, sinusoidal low frequency tone generating vibration. This experiment was therefore set up to measure whether 30 minute treatments of VA therapy, administered in a quiet, contained environment conducive to relaxation, would have a significantly greater effect in achieving changes in both physiological and mental states in non-clinical subjects than a normal resting period of the same time, either with a treatment of relaxing music, or with no treatment at all. Anecdotal information collected from clinical populations had indicated that VA therapy had a significant effect in reducing blood pressure and heart rate, so these measures were included as data points when measuring the non-clinical population.

7.2 EXPERIMENTAL HYPOTHESIS

The hypotheses for the experiments in this chapter were as follows:-

1. Arousal levels, hedonic tone, blood pressure and heart rate would be reduced by VA therapy, when compared with a treatment of relaxing music and a control condition.

2. Pulse rate, measured continuously over a half hour period will fall significantly more when subjects receive VA therapy than to a treatment of relaxing music or in a control condition.

7.3 METHODS

7.3.1 Overview

This experiment investigated the effects of VA therapy compared with a placebo and control condition. Consideration was given to a number of variables in order to identify differences between groups and within groups. Subjects were drawn from different professional groups, and from a wide age range. The subjects were randomly assigned to 3 different groups:

Group 1: Group 1 received sedative "New Age" music, and a pulsed 40Hz sinusoidal low frequency tone played through the vibroacoustic bed. The trial lasted 30 minutes.

Group 2: Group 2 received music alone, also played through the vibroacoustic bed (the same music as in condition 1 without the low frequency tone). The trial lasted 30 minutes

Group 3: Group 3 were the control group, and had a resting time on the vibroacoustic bed where they received no stimulus. The trial lasted for 30 minutes.

Blood pressure and heart rate were measured as indicators of physical change. The UWIST Mood Adjective Check List (UWIST-MACL) was used to measure changes in general arousal, energetic arousal, tension arousal and hedonic tone.

Each subject received one trial. Blood pressure, heart rate and mood was measured before and after the trial. Additional data were collected on changes of heart rate during the course of the 30 minute trial for each subject by continuous measurement of pulse using a Samsung pulseometer. Pulse was measured through the index finger on the right hand. Each subject came for a trial which lasted 30 minutes.

7.3.2 Subjects

60 subjects (30 male, 30 female) between the ages of 18 and 67 volunteered from the staff of a large hospital for people with learning disability (Mental Handicap) to take part in trials to evaluate the effect of VA therapy. The subjects came from mixed professional backgrounds within the hospital, including nurses, social workers,

psychologists, therapists, administrators, secretaries, nursing assistants, domestics, teaching staff and maintenance staff. The subjects were randomly assigned into 3 groups, with equal numbers of male and female subjects in each group.

Each subject was then questioned to see if the treatment of VA therapy was contra-indicated, using the current list of contra-indications (Chapter 3).

Data were also taken on how many of the subjects were smokers, and how many cigarettes they smoked on average per day, in order to consider the effect of nicotine as a variable within groups and between groups.

Subject data and physiological data from the trials were recorded on a form (App.9).

7.3.3 Materials

The equipment that was used in this experiment was purpose built. The frame of a sprung bed was used, and two 18inch speakers were mounted in boxes underneath the springs with the cones directed upwards. The speaker boxes contained 2" by 8" ports for acoustic balance, and the cone of each speaker was approximately two inches below the springs of the bed, in order that the subject would be lying within two inches of the surface of the speakers.

The speakers were positioned in the bed so that when the subject lay on the bed, one speaker was placed under the thoracic and upper abdominal area of their body , and the other speaker was placed under the lower thighs, knees and upper calves.

On top of the springs was a single polythene sheet (as a precaution against incontinent patients who were also treated on the bed), and on top of this was a half inch pile sheepskin rug.

The speakers were powered by an Amba-414 purpose built amplifier. The maximum potential output from the amplifier was 80 watts per channel(RMS). The vibroacoustic stimulus of relaxing music combined with a pulsed, sinusoidal, low frequency sound wave, and the music in condition 2 was played through a Technics RS-T11 stereo cassette deck.

The intensity and tone controls on the amplifier were graded numerically. In the procedure of this experiment the controls of master volume and bass volume were consistently set at the same point. When the subjects were treated with low frequency sounds and music, the bass and master volume was set at +7 on the numerical scale. When the subjects were treated with music alone, the master volume was set at +7, and the bass and treble tone controls were set at zero ensuring that an equal balance of tone and equivalent volume was maintained in the music only condition. The subjects were treated horizontally, and the speakers were set into the bed with the cones facing up. The equipment was isolated electrically, and recordings were used so the style of music, intensity of the low frequency tone and general intensity of the music were all constant for each trial.

Blood Pressure and Heart Rate Measurement

A John, Bell and Croyden model DS-175 auto-inflation digital blood pressure monitor was used to record blood pressure and heart rate before and after the trials.

Continuous Heart Rate Measurement Equipment

A Samsung pulse meter with a photo-electric finger measure was used. Data was collected through a BBC master computer, using a sampler programme to record pulse measurements at 5 minute intervals.

The music used in conditions A and B was "Crystal Caverns" by Daniel Kobialka. This music is described as "New Age", and is characterised as tonal, melodic and harmonic non-pulsed, a-rhythmic music produced on a synthesizer. New age music of this type is useful in trials with non-clinical populations, because the neutral, improvised, perhaps slightly bland character of the music reduces the possibility of associations and prior experiences influencing response. The piece lasted 30 minutes, and a 44 Hz sinusoidal tone, pulsing at a speed of approximately 8 seconds peak to peak was recorded from a function generator with the music on the tape.

7.3.4 Measures

Measurements of physiological and psychological change were recorded in this experiment. Blood pressure and heart rate were recorded before and after each trial. In addition, heart rate was monitored continuously throughout each trial, and average readings were automatically recorded by computer every five minutes. The first measurement was taken after the first five minutes of the trial, and the final measurement was taken 35 minutes after the trial began. A total of seven measures of heart rate at 5 minute intervals were recorded for each subject.

The UWIST-MACL was used for subjective evaluation in this study, both as a general indicator of mood state and, more specifically, to evaluate changes in energetic arousal, general arousal, tension arousal and hedonic tone. Mood was defined by Meyer (1986) as an experience connected to an emotional feeling that lasts for at least several minutes.

The UWIST-MACL is a 24-item adjective checklist which requires the subjects to score on a 1-4 scale, ranging through Definitely - Slightly - Slightly not - Definitely not. (Mathews et al., 1990). The adjectives are selected to indicate positive (+) or negative (-) aspects of energetic arousal (EA), general arousal (GA), tension arousal (TA) and hedonic tone (HT).

TABLE 7.1: UWIST MOOD ADJECTIVE CHECK LIST

EA+	EA-	GA+	GA-
Energetic	Passive	Energetic	Relaxed
Alert	Sluggish	Alert	Passive
Vigorous	Unenterprising	Nervous	Sluggish
Active	Tired	Tense	Restful
		Jittery	Calm
		Active	Tired

TA+	TA	HT+	HT-
Nervous	Relaxed	Happy	Dissatisfied
Tense	Composed	Cheerful	Sorry
Jittery	Restful	Satisfied	Depressed
Anxious	Calm	Contented	Sad

Forms were used to collect data before and after trials (App.9), and the subjects were asked to rate the adjectives on a four point scale. They were encouraged to use a ruler on the form to prevent inaccuracies or omissions.

At the end of the trials scores were recoded according to the scoring procedure of the UWIST-MACL (App.10).

Statistical analysis was undertaken by analyses of variance. Expected differences between the groups were analysed by orthogonal planned comparisons comparing VA therapy vv. music alone and VA therapy combined with music alone vv. control.

7.3.5 Procedure

Subjects were initially asked to fill in the UWIST-MACL. The subjects were then given the following instructions, according to the instructions for the administration of the UWIST-MACL (Matthews et al., 1990):

"You will be given a list of words which describe the moods or feelings which people have. To complete the checklist, you should indicate how well the word describes how you feel AT THE MOMENT (and not just how you usually feel). You must choose one of four possible replies - 'definitely', 'slightly', 'slightly not', and 'definitely not'. These choices are numbered from 1 ('definitely') to 4 ('definitely not') respectively. Simply circle the number which corresponds to the reply that best describes your PRESENT MOOD.

Work quickly, and don't spend too much time thinking about your answers. The first answer you think of is usually the best one. Answer EVERY word, even if you find it difficult. Answer, as honestly as you can, what is true of YOU. Please do not try a reply just because it seems like 'the right thing to say'. Your answers will be kept entirely confidential.

EXAMPLE: If the first word was 'lively', and you felt slightly lively, then you would circle '2', as shown:

	DEFINITELY	SLIGHTLY	SLIGHTLY NOT	DEFINITELY NOT
Lively	1	2	3	4 "

(Matthews et al. 1990)

Subjects were then asked to lie on the bed and make themselves comfortable. After a 5 minute resting period, blood pressure and heart rate were taken using the automatic inflation digital blood pressure monitor. The pulsometer was then attached to their finger to begin continuous monitoring of heart rate. The subjects were given no information about the trial other than the following statements:

Groups 1 and 2:

"We would like you to lie on the bed for 30 minutes. Please don't get up. You will hear music playing. You can think about anything you like, and just allow yourself to relax. We are not going to advise you now as to what you are receiving, but we will tell you more about what we are trying to find out after the trial is over. At the end of 30 minutes, I will come in and take your blood pressure. Please keep your arms resting on the bed until after I have taken the blood pressure measurement. After that the trial will be over".

Group 3:

" We would like you to lie on the bed for 30 minutes. Please don't get up. You can think of anything you like, and allow yourself to relax. We will tell you more about what we are trying to find out when the trial is over. At the end of 30 minutes I will come in and take your blood pressure. Please keep your arms resting on the bed until after I have finished taking the blood pressure measurement. After that, the trial will be over."

Immediately the trial was over a blood pressure measurement was taken. The subjects were invited to complete the UWIST-MACL for the second time recording their mood after the trial and care was taken to ensure they could not reference the scores they wrote before the trials.

7.4 RESULTS

TABLE 7.2: Means and standard deviations of changes in mood and physiological behaviour

	Group 1 (Treatment) Means (S.D.)	Group 2 (Music alone) Means (S.D.)	Group 3 (Control) Means (S.D.)
Energetic arousal (EA)	-5.2 (4.46)	-2.4 (5.10)	+1.0 (4.61)
General arousal (GA)	-11.9 (7.13)	-5.8 (7.22)	-0.8 (7.89)
Tension arousal (TA)	-8.5 (5.92)	-4.7 (5.56)	-2.3 (7.31)
Hedonic tone (HT)	+1.25 (4.17)	0.0 (4.12)	-0.85 (4.65)
Systolic Blood Pressure (SBP)	-9.4 (11.09)	-8.6 (8.67)	-5.3 (9.07)
Diastolic Blood Pressure (DBP)	-6.2 (9.87)	-2.8 (8.13)	-1.5 (9.37)
Heart Rate (HR)	-5.4 (7.38)	-4.2 (9.12)	-0.6 (5.98)

Table 7.2 shows the differences in mood, blood pressure and heart rate in the three groups. The plus score documented in the control group for energetic arousal indicated an increase in energetic arousal, and the plus score in the vibroacoustic group for hedonic tone indicated an increase in hedonic tone. All the remaining scores in this table indicated a decrease in arousal levels, blood pressure and heart rate, or no change or decrease in hedonic tone.

Table 7.3: Analyses of Variance of EA, GA, TA and HT

	D.F. Between Groups	D.F. Within Groups	F Ratio	F Prob
EA	2	57	8.6125	.0005
GA	2	57	11.3147	.0001
TA	2	57	4.8992	.0109
HT	2	57	1.1974	.3094

Table 7.3 shows the results of an Analysis of Variance of energetic arousal, general arousal and tension arousal which reveals significant differences between groups. In the measurements of hedonic tone, although the differences were in the expected direction, no significant difference between groups was found.

Table 7.4: Analyses of Variance of SBP, DBP and HR

	D.F. Between Groups	D.F. Within Groups	F Ratio	F Prob
SBP	2	57	.9848	.3798
DBP	2	57	1.4308	.2476
HR	2	57	2.2579	.1138

Table 7.4 shows the analyses of variance of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Heart Rate (HR). Although the differences were in the expected direction, no significant difference between groups was found.

Table 7.5: Planned comparisons of EA, GA, TA and HT

	Degrees of Freedom	F Ratio	P (1 tail)
Energetic arousal Gr.1 vs Gr.2	1,57	3.7	< .05
Energetic arousal Gr.1 and Gr.2 vs Gr.3	1,57	14.0	< .001
General arousal Gr.1 vs Gr.2	1,57	7.5	< .01
General arousal Gr.1 and Gr.2 vs Gr.3	1,57	16.1	< .001
Tension arousal Gr.1 vs Gr.2	1,57	4.7	< .05
Tension arousal Gr.1 and Gr.2 vs Gr.3	1,57	6.9	< .01
Hedonic tone Gr.1 vs Gr.2	1,57	0.9	N.S.
Hedonic tone Gr.1 and Gr.2 vs Gr.3	1,57	1.5	N.S.

Table 7.5 shows the results of orthogonal planned comparisons that were undertaken to assess whether VA therapy differed from music alone and whether the two conditions combined differed from the control. These showed that the scores in the group receiving VA therapy reduced by more than those receiving music alone and that those two conditions combined reduced by more than those in the control condition in general arousal, energetic arousal and tension arousal. Hedonic tone scores revealed no significant differences between groups.

Table 7.6: <u>Planned comparisons of SBP, DBP and HR</u>

	Degrees of Freedom	F Ratio	P (1 tail)
Systolic Blood Pressure Gr.1 vs Gr.2	1,57	0.06	N.S.
Systolic Blood Pressure Gr.1 and Gr.2 vs Gr.3	1,57	2.12	N.S.
Diastolic Blood Pressure Gr.1 vs Gr.2	1,57	1.5	N.S.
Diastolic Blood Pressure Gr.1 and Gr.2 vs Gr.3	1,57	1.5	N.S.
Heart Rate Gr.1 vs Gr.2	1,57	0.04	N.S.
Heart Rate Gr.1 and Gr.2 vs Gr.3	1,57	4.9	< .05

Table 7.6 shows the results of planned comparisons that revealed no significant differences in blood pressure between the groups. No significant differences were found in heart rate between the group receiving VA therapy and the group receiving music alone. A planned comparison showed that the groups receiving VA therapy and music alone had significantly reduced heart rates compared with the control group.

Table 7.7: <u>Means and S.D.'s of HR over 7 measures</u>

	Group 1 (Treatment) Mean(Std.Dev)	Group 2 (Music alone) Mean(Std.Dev)	Group 3 (Control 1) Mean(Std.Dev)
Heart Rate Meas. 1	72.7 (7.63)	72.3 (13.17)	75.3 (10.10)
Heart Rate Meas. 2	70.7 (7.41)	70.8 (12.07)	73.9 (10.54)
Heart Rate Meas. 3	69.7 (7.06)	70.6 (11.22)	74.0 (10.88)
Heart Rate Meas. 4	68.9 (7.04)	70.2 (12.28)	72.4 (10.67)
Heart Rate Meas. 5	66.3 (6.00)	69.7 (12.76)	70.7 (13.13)
Heart Rate Meas. 6	65.2 (6.48)	69.8 (12.23)	73.7 (11.10)
Heart Rate Meas. 7	64.5 (5.67)	69.8 (12.42)	73.6 (11.26)

Table 7.7 presents data from the repeated measurement of heart rate. Heart rate decreased by different amounts in the three groups. Heart rate was measured at seven points during the treatment, and there was evidence of a general decline in heart rate over time, $F(6,342)= 7.3$, $P < .0001$. There was a significant difference in the rate of decline in heart rate across the groups , $F(12, 342) = 2.04$, $P = .02$ for the group by time interaction.

No significant differences were found in the responses of male subjects compared with female subjects, and no significant differences were found when comparing different age groups. Only 11% of the subjects were smokers, and as these subjects were spread unevenly between the groups, data analysis of any differences between smokers and non-smokers was not expected to reveal significant differences between subjects.

7.5 DISCUSSION

The results of this experiment showed significantly decreased energetic arousal, general arousal and tension arousal in the vibroacoustic group when compared with the music alone group, and when comparing the VA therapy group combined with the music alone group with the control group. No significant differences were found in hedonic tone, although the differences were in the expected direction. No significant differences between groups were found in changes in blood pressure and heart rate. However planned comparisons showed a significantly reduced heart rate in groups one and two (vibroacoustic treatment and music alone) when compared with group three (control), and a difference between the three groups was found when looking at reduction of heart rate measured over time.

An important aspect of this study is that it provides evidence of the effect of VA therapy in the form of self-reporting from subjects which is untypical of previous studies. Much of the development of VA therapy has taken place with populations of patients who were predominately pre-verbal, or with very limited expressive language and comprehension.

Measurements taken during this study revealed the effect of VA therapy on arousal levels, hedonic tone and blood pressure in the non-clinical population when compared with a music alone treatment and a control group. The experiment was expected to show that VA therapy would have a significantly greater effect in reducing arousal levels and increasing hedonic tone in the treatment group than in either of the other two groups, and that blood pressure would also reduce accordingly.

Anecdotal reports to date indicate that energy and arousal levels do reduce as a result of VA therapy, and the experience of having VA therapy is pleasurable, although no quantifiable data has been collected other than collated comments from subjects and patients. While these results report a significant reduction in arousal levels compared with both a music alone treatment, subjects recorded no significant improvement in hedonic tone. The data revealed a small increase in hedonic tone in the VA therapy condition and further trials with a larger sample group might reveal more conclusive results.

In considering the physiological data, anecdotal results from previous trials had shown reductions in blood pressure (Skille, 1989a; Saluveer and Tamm, 1989). However, these trials were undertaken without a control group or a treatment of relaxing music and only measured the results of reductions in blood pressure during treatment. This experiment measured reductions in blood pressure and heart rate when comparing VA therapy with a relaxing music treatment and comparing VA therapy combined with music alone with a control group, and showed no significant difference between conditions, although the results were in the expected direction. The one significant difference found between groups in physiological change was a reduction in heart rate in the treatment and music alone groups combined compared with the control group.

In the experimental design each subject received one trial in each condition. Therefore, the novelty of the experience may have had some effect and influence on the subjects. Further experiments to measure the effect over a number of trials might yield different results. As the data shows in all cases that the differences were in the expected direction, further trials evaluating the difference between VA therapy and other stimuli, or no stimuli, might reveal a more significant effect on blood pressure and heart rate.

The results on hedonic tone are more difficult to explain. While the subjects obviously experienced a reduction in their arousal levels, there was only a small increase in enjoyment and satisfaction with the treatment when compared with the music alone treatment and the control condition. Further studies might give a more clear indication if a number of trials are undertaken over a period of time, where subjects can become accustomed to the form of treatment and more receptive to the stimulus. The subject group was primarily staff within a large hospital for people with mental handicap. Due to difficult working conditions, and the responsibility of caring for patients often demonstrating disturbed and challenging behaviour, this is a stressful occupation, and staff were attending these trials during their working hours.

Therefore, they may have experienced some increase in hedonic tone simply due to the satisfaction of being able to lie down for half an hour during the working day. However there were many subjects whose results from the UWIST-MACL indicated a reduction in hedonic tone. In discussion with some of the subjects after the trials, they confided anecdotally that it was difficult to experience pleasure and contentment lying down in the middle of a busy shift at work. In some cases, they expressed a certain amount of guilt that they were lying down during working hours, which prevented them from gaining satisfaction or pleasure from the experience.

However, it is clear from the results that there were significant reductions in arousal levels. Therefore, it can be conjectured that VA treatment is effective in relaxing a person, even if that person may be experiencing negative feelings such as guilt or dissatisfaction. An argument can be made that, given the reductions in arousal level together with reductions in heart rate, VA treatment has an effect of relaxation irrespective of state of mind. The physical effect of the treatment appears to be significant, which may have an influence on state of mind. Because the effect of pulsed sinusoidal low frequency tones together with music affected their physical state, the subjects reported effects in their scores in the UWIST-MACL of the adjectives, which reflected a reduction in energy, tension and general arousal indicating both a physiological change, and also a psychological awareness of that change.

It could be a matter for further speculation that sustained and continuous treatments of VA therapy may result in a long-term effect with subjects receiving VA therapy becoming increasingly responsive to the treatment, whereas subjects receiving nothing in a control condition might become increasingly bored or resistive to the treatment. However, this doesn't take into account the comparison between vibroacoustic treatment and the music alone condition. Further trials could be undertaken to explore the differences between a VA therapy and a treatment of relaxing music. Research in the field of music therapy and music in medicine has already provided evidence of physical changes including reductions in heart rate and blood pressure when relaxing or sedative music is played, and therefore it could be anticipated that arousal levels, heart rate and blood pressure will be affected. People use music to relax at a mental level, and at the same time people sit or lie down to relax. The treatment of relaxing music used in these trials combines both of these processes, so it can be seen from the differences found the addition of a pulsed, sinusoidal low frequency tone has a significant influence. When people try to relax, either to music or lying down, or both, their state of mind, or emotional state may prevent them from relaxing. In fact, trying to relax when one is in a state of anxiety, irritability or tension may result in increases in any of these states. It would be interesting and relevant in future studies to explore whether VA therapy can override state of mind, by causing a significant change in physical state, thereby influencing psychological state.

In conclusion, this experiment has shown that there were significant reductions in arousal levels in the subjects who had VA therapy, compared with subjects in the music alone group, and in comparing the combination of these two groups with a control group. In terms of the applicability of this treatment to clients with anxious, challenging or difficult behaviour in clinical environments, this is potentially a valuable indicator of the effect of VA therapy.

CHAPTER EIGHT

THE EFFECT OF AMPLITUDE MODULATION OF THE PULSED SINUSOIDAL LOW FREQUENCY TONE USED AS A STIMULUS IN VIBROACOUSTIC (VA) THERAPY.

8.1 INTRODUCTION

Early clinical experiences of the effectiveness of Vibroacoustic (VA) therapy involved the use of bass frequencies that were normally present in the music used in the treatment as part of the composition (Skille, 1986). It was noted in these anecdotal reports that the vibration produced by the bass frequencies appeared to have a relaxing effect on the patients. Verbal reports from the experiments by Teirich (1959) and subsequently Skille (1986) indicated that the vibrational effect of bass frequencies reproduced at comfortable volumes produced a pleasant, internal vibration in the subjects' bodies. Subsequently, Skille experimented with pulsed, sinusoidal low frequency tones. Recording two sinusoidal tones (for example, 40 Hz and 40.5Hz) from two function generators onto one tape, Skille created a pulsed (difference) tone. The speed of the pulse on the tapes that Skille made for use in VA therapy varied. Skille made multi-frequency tapes, and when recording both the music and low frequency tones simultaneously, Skille changed the frequency during the course of the recording by manually manipulating the frequencies using two function generators. The result of these frequency changes was varied, and the speed of the pulse after the frequency was changed was often different from the previous speed of the pulse. Pulse speeds (peak to peak) varied between two and ten seconds on the VA therapy tapes Skille produced for use by early practitioners. The decision to use a pulsed tone rather than a constant tone was made on the basis that it would be a more pleasant sensation for the patients, and would be experienced like a wave, coming and going. The tempo of this wave was assumed to add a calming and relaxing element to the treatment. There have been no investigations to determine the optimum amplitude modulation for the patients who came to VA therapy for treatment.

The tempo or metronomic pulse of music has been used in studies to entrain heart rate and induce relaxation and reduction in physical arousal (Saperston, 1995). The speed of the pulse was therefore considered influential in affecting state of arousal, physical behaviour and general relaxation in VA therapy.

Anecdotal verbal reports in early experiments undertaken at Harperbury Hospital were varied regarding the level of comfort and relaxation experienced from different speeds of the pulsed, sinusoidal tone, but there seemed to be some consensus that a slower speed of the pulsed tone was more relaxing and interfered less with any fixed or variable tempo there might be in the recorded music used in the treatment. Many of the tapes made in Norway during the developmental period had pulse speeds between two and eight seconds. This was felt to be too fast by some of the people who tried the system, and both interfered with relaxation, and with the music. However, these were only anecdotal comments, and it became apparent that a study to investigate this aspect of the stimulus was necessary to test previously held assumptions.

It had also been assumed in experimenting with this part of the stimulus used in the treatment that a pulsed, low-frequency tone was more relaxing and effective than a non-pulsed, constant low-frequency tone. The treatment trials undertaken by Skille (1986, 1987) have measured which frequencies might be used for treatment, and what style of music may be most effective. The speed of the pulsed low-frequency tone had not been investigated. The present experiment was designed to measure differences between three pulse speeds and to measure whether there was any significant difference between using pulsed low-frequency tones or a constant tone.

The experiment was intended to measure the effect of the low-frequency tone at different pulse speeds by varying the amplitude modulation, and to measure response to a constant tone. It was decided to concentrate on evaluating the effect of different speeds of the pulsed low-frequency tone alone, in order to avoid additional confounding variables of tempi and rhythm in the music.

Individual reports of effects people had felt when trying the treatment, together with the previous experience of clinicians experimenting with the treatment had indicated that a longer pulse speed would be more relaxing, and therefore have a greater effect in reducing arousal levels, increasing hedonic tone, increasing relaxation and reducing heart rate and blood pressure. Subjective reports had also indicated that a constant low-frequency tone would be significantly less effective than any of the pulsed tone speeds. This experiment was undertaken to measure differences between groups in order to determine in which way the low-frequency sound stimulus should most effectively be incorporated as part of the whole stimulus used in VA therapy to achieve desired changes in psychological and physiological behaviour.

8.2 EXPERIMENTAL HYPOTHESIS

Based on anecdotal evidence, and evidence from clinical experience, the following experimental hypotheses were posed for these trials:

1. There would be significant differences in arousal level and hedonic tone between subjects receiving varied rates of amplitude modulation of a 44 Hz tone (.17, .10, .07) and a constant tone.

2. A significantly greater reduction in heart rate , blood pressure and arousal levels would be found in the group receiving the slowest pulse speed (rate of amplitude modulation of .07) than in the other groups.

3. Self-reports from subjects would indicate their experience of a greater degree of relaxation, and a greater liking for a slower pulsed low frequency sinusoidal tone than either a constant tone, or faster pulse speeds.

8.3 METHODS

8.3.1 Overview

This experiment measured differences between groups after a fifteen minute trial in four conditions.

Condition 1:

The subjects received a 44 Hz sinusoidal tone, pulsed over a six second period (rate of amplitude modulation = .17) played through a vibroacoustic bed for 15 minutes.

Condition 2:

The subjects received a 44 Hz sinusoidal tone, pulsed over a ten second period (rate of amplitude modulation = .10) played through a vibroacoustic bed for 15 minutes.

Condition 3:

The subjects received a 44 Hz sinusoidal tone, pulsed over a fourteen second period (rate of amplitude modulation = .07) played through a vibroacoustic bed for 15 minutes.

Condition 4:

Subjects received a constant 44 Hz sinusoidal tone played through a vibroacoustic bed for 15 minutes.

Each trial lasted 15 minutes. Both physiological and psychological measures were used to find evidence of change over the trials. Mood was measured as an indicator of changes in general arousal, energetic arousal, tension and hedonic tone. Mood was defined here as an emotional experience that can last for a minimum of several minutes. This definition distinguishes mood from cognitive evaluations per se, and from brief, phasic emotional responses to evaluations (Mayer, 1986). The subjects were required to complete the UWIST Mood Adjective Check List (UWIST-MACL) before and after the trial. Blood pressure and heart rate were considered good indicators to measure change in physical state, and measures were taken five minutes before each trial and immediately on completion of the trial.

The independent variables in this experiment were different speeds of the pulsed sinusoidal tone (6 seconds, 10 seconds, 14 seconds), and the constant tone.

8.3.2 Subjects

Sixty subjects (30 male, 30 female) volunteered to take part in trials. The subjects came from widely differing backgrounds. They consisted of a mixture of students and staff from the Institute for Music and Music Therapy, Aalborg University, Denmark, including music students, music therapy students, music department and music therapy department lecturers, part-time teachers and secretaries, and other ancillary staff from Harperbury Hospital, a large mental handicap hospital in England, including therapists, students, nurses, nursing assistant. Their ages ranged from 18 to 60, with a mean age of 32.4 (S.D. 10.08).

8.3.3 Materials

Vibroacoustic beds were used for these trials. The beds consisted of a solid wooden frame unit with a two and a half inch foam rubber mattress covered in PVC. Secured into the unit were six x 8 ohm bass speakers, with the cones facing up.

The speakers in the units were powered by Marantz Integrated Stereo Amplifiers PM 52, and the pre-recorded tapes were played through Marantz Stereo Double Cassette Decks SD 45. Numerically graded volume and tone controls were used to ensure that a consistent intensity and tonal balance were maintained for all the trials.

Four tapes with low frequency sinusoidal tones of 44Hz were produced for the trials.

:

Tape 1. (Condition 1) 44Hz sinusoidal wave with an amplitude modulation of .17.

Tape 2. (Condition 2) 44Hz sinusoidal wave with an amplitude modulation of .10.

Tape 3. (Condition 3) 44Hz sinusoidal wave with an amplitude modulation of .07.

Tape 4. (Condition 4) constant 44Hz sinusoidal tone .

8.3.4 Measures

Systolic and diastolic blood pressure and heart-rate were measured using an Omron Automatic Oscillometric Digital Blood Pressure Monitor HEM - 704C.

The UWIST-MACL was used for subjective evaluation in this study to evaluate changes in energetic arousal, general arousal, tension arousal and hedonic tone. The UWIST-MACL is described in chapter seven.

Self evaluation of their state of relaxation was scored by the subjects before and after the trials on a 9 digit scale requiring them to give an evaluation of their state from very relaxed to very tense. Whether they liked or disliked the experience was also scored by the subject on a 9 digit scale, after the trial (Appendix 10).

8.3.5 Procedure

The subjects were asked to choose a piece of paper from a container which would randomly assign them to one of the four conditions. The subjects were then asked to complete the UWIST-MACL according to the instructions described in chapter seven.

This form also asked subjects to record their date of birth and sex. The form asked them to indicate their state of relaxation at that moment on a scale of 1 - 9, 1 representing not relaxed and 9 representing very relaxed.

The subject was then asked to lie down on the bed, make themselves comfortable, and a 5 minute rest period was allowed before the initial blood pressure was taken. During this time the therapist talked with the subject, but not about the trial. After the five minute rest period, the subjects blood pressure and heart rate were taken. The cuff of the sphygnonometer was left loosely round the subjects arm so that it was ready for the post trial test. The subject was checked to make sure that they were comfortable, and ready to begin the trial. The subject was then covered with a blanket.

The subjects were told that they would hear a sound coming through the bed. They were asked to relax, think of whatever they wanted. They were asked not to get up. They were told that the experience would continue for 15 minutes, and that the researcher would not remain in the room with them so that they would be on their own, and not distracted by the presence of the researcher.

The researcher began the tape, and increased the volume to +5 on the amplifier scale. The tone controls were pre-set at a constant point for each trial. At the end of the trial they were asked not to get up. The researcher came back in the room three minutes before the end of the trial, and when the 15 minute time period was finished, he reduced the volume of the amplifier to zero, and switched off the equipment.

At this point in the trial the researcher again took blood pressure and heart rate measurements, and then the subjects were asked to complete the UWIST-MACL again, and score on the relaxation scale. Finally, the subjects were asked to score on the like/dislike scale.

8.4 RESULTS

Table 8.1: Means and standard deviations of mood, heart rate, blood pressure, relaxation and like/dislike

	Group 1 6 secs Mean (S.D.)	Group 2 10 secs Mean (S.D.)	Group 3 14 secs Mean (S.D.)	Group 4 Constant Mean (S.D.)
Energetic Arousal(EA)	-1.3 (4.98)	-3.2 (6.79)	-1.9 (5.25)	-3.0 (5.45)
general arousal(GA)	-4.7 (6.28)	-4.6 (6.78)	-5.9 (3.68)	-5.5 (4.8)
tension arousal(TA)	-3.3 (6.05)	-2.3 (4.13)	-3.5 (3.23)	-3.9 (5.76)
hedonic tone (HT)	+1.1 (3.41)	-1.1 (4.73)	+1.3 (2.69)	+.9 (2.08)
Systolic Blood Pressure (SBP)	-4.3 (5.52)	-4.6 (6.66)	-1.5 (7.18)	-3.2 (5.61)
Diastolic Blood Pressure (DBP)	-2.2 (6.33)	-4.1 (8.28)	-2.0 (4.53)	-3.7 (7.89)
Heart Rate (HR)	-1.5 (5.75)	-2.4 (8.66)	-1.3 (6.32)	-5.5 (5.87)
Relaxation (R)	-1.7 (1.95)	-1.3 (2.31)	-1.5 (1.73)	-.86 (1.50)
Like (L)	-3.8 (2.21)	-2.3 (1.22)	-3.7 (1.91)	-3.2 (1.78)

Table 8.1 gives the means and standard deviations of changes in the four

conditions of arousal levels, hedonic tone, blood pressure, heart rate, relaxation and like/dislike.

Table 8.2: Analyses of Variance of changes in mood, physiological measures, relaxation and like/dislike.

	Degrees of Freedom Between Groups	Degrees of Freedom Within Groups	F Ratio	F Probability
Energetic Arousal	3	56	.39	N.S.
General Arousal	3	56	.17	N.S.
Tension Arousal	3	56	.27	N.S.
Hedonic Tone	3	56	1.72	N.S.
Systolic Blood Pressure	3	56	.75	N.S.
Diastolic Blood Pressure	3	56	.40	N.S.
Heart Rate	3	56	1.20	N.S.
Relaxation	3	56	.54	N.S.
Like/ dislike	3	56	2.28	N.S.

The Analysis of Variance in Table 8.2 of energetic arousal, general arousal, tension arousal and hedonic tone of the UWIST-MACL revealed no significant differences between groups. Analyses of Variance of blood pressure, pulse, and degree of reported relaxation measured before and after the trials also indicated no significant differences between groups. There was no significant difference between groups on the scores they recorded for liking or disliking the stimuli. There was no suggestion of any difference between age groups, or between male and female subjects.

8.5 DISCUSSION

The results of this experiment revealed no significant differences between the four groups in either psychological measurements (UWIST-MACL) or physiological measurements (blood pressure and heart rate). Self reported data on the subjects' state of relaxation before and after the treatment, and their liking/disliking of the stimulus they were given also revealed no statistically significant differences between groups.

This experiment was undertaken to measure any differences that might emerge when comparing different pulse speeds of a 44Hz tone and a constant low-frequency tone. Subjective and anecdotal reports from earlier trials and treatment sessions with non-clinical subjects had revealed some preferences, but this was not supported by the data.

Preferences for slower pulse speeds had emerged in anecdotal reports from subjects receiving both the pulsed, low-frequency, sinusoidal tone together with a musical stimulus. Speculating on the differing effects of variable pulse speeds as a phenomenon when combined with music, it might be concluded that the faster the speed of the pulsed tone, the more it interferes with tempi present in the music used in vibroacoustic therapy, unless the music was without consistent tempo, or the tempo was irregular. A faster pulsed tone may add a rhythmic component to a non-rhythmic piece of music, thus

interfering with a subject's state of relaxation and state of general arousal. This may be reflected in changes in both blood pressure and heart rate. However, as these trials excluded the use of music, pulsed sinusoidal low-frequency sound on its own appears to have effects which are not dependent on the speed of the pulse, or whether there is a pulse.

Further trials might be warranted to measure varying pulse speeds against a constant musical stimulus. A subsequent experiment might use the same design, developing trials where a low-frequency tone of 44Hz was pulsed at 6 seconds, 10 seconds, 14 seconds and at a constant tone, together with the same piece of music in each condition. This may reveal more significant differences between the groups. However, pure speculation may suggest that significant differences may be found when using one piece of music, for example a non-rhythmic piece of New Age music, whereas conflicting results may emerge when using other and more varied styles of music.

As VA therapy incorporates the use of a variety of styles of music in order to meet individual preferences in music, it could prove both complex and inconclusive to undertake further trials to find differences between the conditions used in these trials in order to offer some definitive conclusion about the optimum speed of pulse, or whether indeed a pulsed, low-frequency tone is necessary in place of a constant low-frequency tone.

The experiments which have evaluated the sensation of vibration perceived to different tones in different parts of the body (chapter six), and the influence of pulsed low frequency tones compared with a treatment of relaxing music or no stimulus (chapter seven) have already established some meaningful criteria in terms of the choice of stimulus that can be used in VA therapy. VA therapy can be affected by the manipulation of these elements in its prescription and application. However, there are also individual differences both in the non-clinical population and in the clinical population, as regards choice of music. Therefore these individual differences can not be resolved solely in terms of varying the speed of the pulse or using a constant tone, and conflicting or inconclusive results may confound any attempt to establish a consistently effective speed for pulsing the sinusoidal low frequency tone.

Self-reports from patients coming for treatment of VA therapy, and also those people coming to visit the department and observe treatments on other people have indicated that the pulsed sinusoidal low frequency tone used in VA therapy has inconsistent effects additional to those intended in the treatment. Some report feeling a sense of movement, especially when experiencing the vibroacoustic unit for the first time. This has been described as a "motion effect" similar to travelling on a ship, and may be explained by an effect on vestibular activity of the difference tone used in the amplitude modulation. There is no consistent evidence of these side effects, and it is still unknown as to how serious a problem this presents. Some subjects find the motion effect that they experience during the course of a treatment comforting and helpful in moving them into a state of relaxation and sometimes into an altered state of consciousness. Other subjects have reported feelings of nausea, something similar to "sea-sickness", a feeling of motion, and sometimes a feeling of loss of body weight.

Another limitation in the design of this study, was that it used a between groups design. Therefore, each subject in the experiment was only being measured in terms of their response to a single stimulus. Future experiments might approach the problem of finding significant differences between stimuli by presenting all four stimuli to each subject, and monitoring response using a within-subjects design. Randomisation of the order of the trials for each subject may prevent either cumulative effects or order effects.

The results of this experiment show that when measuring differences between groups to the four stimuli that were used, there is very little difference in either physiological or psychological response to the varied amplitude modulation that was used or to the constant tone. In conclusion, there is no evidence to support any of the hypotheses, and the effect of varying the speed of the pulse used in VA therapy or using a constant tone remains inconsistent.

CHAPTER NINE

GENERAL DISCUSSION

9.1 SUMMARY

The purpose of this final chapter is to draw together and summarise the results of the clinical studies, and the studies on non-clinical subjects, and to consider the significance of some of the findings in this research. It will also attempt to give some critique on the limitations of the studies which were undertaken, and consider what should be developed in terms of future research into Vibroacoustic (VA) therapy. The findings will be considered in the light of theoretical ideas underpinning the investigations that have been undertaken as part of this research. The significance of the findings, in terms of the clinical application of VA therapy as a treatment, will also be considered.

9.1.1 Results of investigations in the clinical population

The studies which were undertaken on the population of people with learning disability, physical handicap and multiple handicap found some significant differences between experimental conditions. The first study measured the effect of VA therapy against a placebo treatment of relaxing music, and there was a significant improvement in the range of movement in the treatment condition compared with the placebo. Blood pressure scores taken on seven of the subjects showed no significant differences between groups.

The results of the second study involving patients with similar pathological conditions lent some support to the first study, but added another dimension. This study evaluated the effect of VA therapy as a treatment when compared with Music and Movement Based Physiotherapy (MMBP), and a placebo treatment of relaxing music. In the analysis of variance, no overall difference between conditions was found. However, orthogonal planned comparisons revealed that when comparing the two treatment conditions combined subjects achieved significantly greater range of movement than in the placebo condition. Measuring the treatment against the MMBP in the planned comparisons, no significant difference was found. Subsequent trials on ten subjects revealed a significant difference when comparing VA therapy with the treatment after an additional three trials in each condition.

9.1.2 Results of investigations in the non-clinical population

Three studies were undertaken on non-clinical subjects. The first study looked at the perception by subjects of the location of a sensation of vibration stimulated by low frequency sinusoidal tones between 20Hz and 70Hz in the human body. Two experiments were run in order to try and establish whether certain sinusoidal low frequency tones stimulated sympathetic vibration consistently in the same parts of the body. The first experiment on 39 subjects revealed that there was some consistency of agreement between a majority of the subjects as to the location of a sensation of vibration to frequencies of 30Hz and 40Hz being in their calves and thighs, and to 60Hz in their chest. Frequencies of 20Hz, 50Hz and 70Hz obtained more inconsistent results.

In the second study on 52 subjects two sequences of 10 frequencies were played to each subject. Four frequencies (30Hz, 40Hz, 50Hz, and 60Hz) were repeated four times during the trial, and two frequencies (20Hz and 70Hz) were repeated twice. The results of this experiment, where the responses where recorded at 14 different sites on the body where people reported feeling a perception of a sensation of vibration from these different frequencies, did not show such a clear pattern of localised effect. However, when grouping the body sites together into the legs, the torso, chest, arms and hands and a general effect, patterns began to emerge where certain frequencies appeared consistently to be perceived as a sensation of vibration in the same place. Sensations of vibration to lower frequencies were reported by many subjects to be felt in their legs. 36% of the subjects felt 20Hz in their legs, 39% felt 30Hz, and 47% of the subjects felt 40Hz in this area. 42% of the subjects felt 60Hz and 55% of the subjects felt 70Hz in their chest, shoulders, neck or head. Data were also collected on which frequencies were disliked in self-reports from subjects. This revealed that 20% of the subjects reported a dislike of 20Hz, and 29% of the subjects reported a dislike of 70Hz. The other frequencies obtained fewer reported comments of dislike. There were significant differences in the number of reported disliked frequencies when comparing the presentation of the first ten frequencies to the second ten in each trial, and there were significant differences between male and female subjects.

Reports were obtained on secondary effects felt by the subjects to the different frequencies which were presented. When the numbers of subjects who felt frequencies in the same places in the reports on primary sites, and the reports on secondary sites were combined, high percentages began to emerge of subjects experiencing either primary or secondary sensations of vibration to the same frequencies in similar areas of the body.

The next study undertaken on 60 non-clinical subjects was designed to measure changes in mood and physiological responses when comparing the treatment of VA therapy with a treatment of relaxing music, and with a control condition. Significant reductions in energetic arousal, general arousal, and tension arousal were recorded. No overall difference between groups was found in changes in hedonic tone or blood pressure. A series of orthogonal planned comparisons that were undertaken to assess whether VA therapy differed from music alone, and whether the two conditions combined differed from the control revealed arousal levels in the group receiving VA therapy reduced by more than those in the group receiving music alone, and the VA therapy group and the music alone group combined revealed greater reductions in arousal levels when compared with the control group. Heart rate was measured throughout this experiment on a continuous basis and measures were taken every five minutes. These data indicated that there were significant differences between groups in reductions in heart rate over time.

Finally, an experiment was undertaken with 60 non-clinical subjects to evaluate differences in the speed of the pulse of the low frequency tone (6 seconds, 10 seconds and 14 seconds peak to peak) used in the treatment tapes, and a constant tone. The effect on mood as a measure of arousal level and hedonic tone, together with physiological measurements, showed no significant differences between the groups to these different stimuli.

9.2 DISCUSSION

The experimental studies described in this thesis have revealed important new information regarding the application of vibroacoustic therapy as a treatment, and additionally they have highlighted important aspects of the stimulus used in vibroacoustic therapy which adds to our theoretical understanding of the effect of this treatment. Investigations into the influence of music and its effect on both physical and psychological behaviour yielded contradictory results (Ellis and Brighouse, 1952; Hodges, 1980; Hunter, 1968; Smith and Morris, 1976; Zimny and Weidenfeller, 1963). However, in more recent studies there is a growing body of evidence to support the efficacy of music itself as a method of relaxation, stimulation, distraction from pain, and mood evoking stimuli (Brown et al. 1991; Maranto, 1993; Spintge, 1982, 1988, 1993; Scartelli, 1982, 1984; Stanley, 1986, 1992, 1995) and therefore the theoretical basis for using music in the experiments carried out with clients who have high muscle tone and spasticity, as well as the non-clinical subjects in the studies described in chapter seven, is well founded and supported in the literature.

The main focus of the investigations in the experimental studies in chapters four, five, seven and eight was the relevance and effect of pulsed sinusoidal low frequency vibration, which has attracted attention since the study by Teirich (1959). This study already indicated pleasant and clearly localised sensations from low frequency vibration, and the anecdotal material from clinicians working in the field (Lehikoinen, 1990; Skille, 1986, 1989a, 1991; Skille et al. 1989; Skille and Wigram, 1995; Wigram and Weekes, 1989a, 1990a; Wigram, 1993) provided clinical reports from treatment sessions which support VA therapy as a treatment intervention. The studies described here all employed the use of pulsed low frequency sinusoidal tone, and Skille's original theories regarding the effectiveness of VA therapy were formulated around the concept that different frequencies would be felt in different places in the body as localised sensations of vibration, thereby indicating a more specific potential application of the stimulus (Skille 1989b; 1992).

Following a long period of clinical experimentation in the 1980's, Skille had proposed, from his own experiences and also from reports from patients, that frequencies between 40Hz and 50 Hz would affect muscle activity, and were felt in the lower parts of the body, and frequencies of around 60 Hz would be felt in the chest. He reported instances of the alleviation of symptoms in conditions such as cystic fibrosis and asthma. These conclusions were based purely on informal reports from patients. The phenomenon of a localised sensation of vibration is supported by scientists who have been investigating the effect of human sensitivity to vibration, and Guignard (1968) had already reported that airborne sound of sufficient intensity and low frequency, below 100 Hz, can enter the body by direct absorption through the surface and excite non-auditory sense organs (Guignard, 1968). Guignard also made clear that many of the physiological responses of man to vibration and noise are frequency dependent, and are limited to a fairly narrow band. This indicates a mechanical resonance of elastic structures within the body, and this resonant excitation of mechano-receptors is the process by which subjects will experience or perceive a localised sensation of vibration, dependent on the frequency being transmitted.

This aspect is important when considering the results of the experiments described in this thesis, and in terms of the future application of vibroacoustic therapy. Landstrom and Lundstrom (1985) had already found from their experiments that whole body vibration, created through sinusoidal vibration, caused significant experiences of tiredness and reductions in wakefulness. Anecdotal reports on the effects of vibroacoustic therapy had indicated that clients or patients would frequently fall asleep on the unit, and that the overall effect of the treatment was relaxing.

However, it is clear from the literature that a combination of purely relaxing music and lying down to rest in a quiet place would certainly facilitate a relaxation process, yet this stimulus alone may not achieve reliable and consistent effects as a form of treatment.

There is already evidence that vibration has specific effects on muscle activity (Hagbarth and Eklund, 1968; Stillman, 1970; Verillo, 1962; Wedell and Cummings, 1938), and on vaso-dilation (Skoglund, 1989), and many experiments had concentrated on identifying the frequency range to which mechano-receptors in the body were particularly responsive (Roland and Nielsen, 1980; Chesky, 1992). The two studies undertaken in chapter four and chapter five do support this evidence from the theoretical point of view that a general vibration or whole body vibration throughout the body acts as a relaxant, and induces a reduction in muscle activity, and will therefore reduce the incidence and severity of spasm. This phenomenon had also been explored in terms of mechanical vibration (Boakes, 1990). There was evidence from empirical studies by Boakes that frequencies between 20Hz and 50Hz inhibit muscle impulses, inducing spastic muscles to relax, although the 50Hz figure is approximate and depends on muscle temperature and the amount of muscle tone present (Boakes, 1990). For example a cold muscle will react sooner than a warm one.

The study in chapter four provides clear evidence that a pulsed sinusoidal low frequency tone of 40 Hz has a significant influence in facilitating improvements in range of movement corroborating previous scientific investigation into the effect of auditory and mechanical vibration (Griffin, 1986; Hagbarth and Ekland, 1968). The study in chapter five supported the theories regarding the effect of physical manipulation in the form of a range of movement exercises as a method of reducing muscle tone and improving range of movement. As has been described by Stillman (1970) and later Carrington (1980) and Boakes(1990), the effect of rhythmically moving limbs creates a vibration in muscles, facilitating a reduction in tone (Bean, 1995; Wigram and Weekes, 1985). In the discussion section in this chapter, it was speculated that some clients responded more positively to vibroacoustic therapy because they didn't enjoy the physical manipulation experienced in MMBP, and they would receive the same benefit from VA therapy as it also creates a localised sensation of vibration which will facilitate a reduction in muscle tone as had been found from the trials reported in chapter four. These were very different forms of treatment, and the differences may be reflected in individual preference.

The studies undertaken on the non-clinical population have added important new findings to the growing body of evidence on the effects of vibroacoustic therapy. Studies reported in the literature evaluating the effect of music vibration as having a stimulating or relaxing effect on non-clinical subjects (Madson et al. 1991; Pujol, 1994; Standley, 1991a) had found no important effects on physiological response. Music has a wide spectrum of elements that can vary significantly, and whereas some practitioners have attempted to control these variables by defining parameters by which music can be classified as stimulating or sedating (Hunter, 1968; Smith and Morris, 1976; Spintge, 1982, 1988, 1993; Spintge and Droh, 1982), there are variable and inconsistent effects on the normal population (Hodges, 1980).

The study described in chapter seven found significant differences between groups in changes in mood and levels of arousal, and an interpretation that should be drawn from this is that the stimulus of a pulsed sinusoidal vibration combined with music has a consistent effect in reducing arousal levels and heart rate. There was already evidence that heart rate is reduced by sedative and relaxing music (DeJong et al., 1973; Ellis and Brighouse, 1952), and anecdotal reports that both blood pressure and heart rate decrease during VA therapy (Lehikoinen, 1990; Saluveer and Tamm, 1989, Skille, 1992).

As the theoretical basis for the application of vibroacoustic therapy rests on the effect of pulsed sinusoidal low frequency vibration (Lehikoinen, 1988, 1990; Skille, 1982b, 1986, 1989b, 1992; Wigram, 1991b, Wigram and Weekes, 1989a, 1990a), the importance of the investigation carried out in chapter six is clear, and the results of this have significance for future research and development. Evidence already exists in research studies investigating the effect of sound vibration on the body, identifying mechano-receptors in the nervous system that are sensitive to specific frequency bands (Griffin, 1983; Guignard, 1968; Roland and Nielsen, 1980; Tierich, 1959; Yamada et al. 1983). What became clear in the results of the experiments conducted in chapter six is that there are differences in the perceived sensation of vibration to different frequencies, and there are indications that there is some consistency in this effect. At a theoretical level, this would explain many of the phenomena that have been reported by clinical investigators, and by self-experimentation (Skille, 1986; Lehikoinen, 1988, 1990; Wigram and Weekes,1989a, 1990a). Sinusoidal low frequency vibration is perceived locally in different places in the body dependent on frequency. The potential for applying VA therapy as a treatment may be enhanced and become more specific because of this localised effect of vibration. Despite inconsistencies and differences between subjects, and within subjects, a treatment method could be developed which would take into account these differences, and employ a short assessment at the beginning of each treatment session to isolate the optimum site in the body and the optimum frequency for that site.

The final study in chapter eight appeared not to support the assumptions that there are differences in arousal levels, physical response and preferences to slower or faster rates of amplitude modulation in pulsed sinusoidal low frequency tones, or to a constant tone. However, this study was undertaken without music, and it could be that the experiences of researchers and clinicians in using faster or slower rates of amplitude modulation have been affected by the reported experiences of subjects to a combination of the vibrational and the music stimuli. There were no significant differences between using pulsed tones at different speeds and a constant tone in the trials that were undertaken, yet anecdotal reports have varied, and preference has been expressed for slow pulsed sinusoidal tones. This study has at least established that there are no major differences when this stimulus is presented in isolation, which is an important fact to consider. However when the stimuli are combined and music is added to pulsed sinusoidal low frequency tones, the rate of amplitude modulation of the pulse may significantly affect the patient or subject's experience of the music, and thus affect their physical and psychological response.

Before concluding, it is important to look critically at the methods that were used in the experimental studies, and consider what limitations there are in generalising results, or indicating the applicability and the efficacy of VA therapy as a treatment. The next two sections will address the limitations of the study, and also offer some proposals and recommendations for both replication of some of these studies, and for further research.

9.2.1 Clinical Studies

In the first study, only ten subjects were chosen. This is not a large sample group, albeit the statistic analysis indicated significantly greater improvements in the treatment group. The method used to measure changes in range of movement was practical and workable, but not exact. Electromyography was not used because in pre-experimental trials it was found that the procedures caused raised anxiety-levels in subjects with this degree of handicap for whom no understandable explanation could be given. Given a more sophisticated and less intrusive method of measuring muscle activity, more evidence of the physiological process that occurs during whole body vibration from sinusoidal low frequency tones could be elicited. Finding a method of measurement that reduces bias would be important. For example, a spring loaded strain gauge would be more effective in obtaining unbiased data when measuring range of movement. People with multiple handicap and severe learning difficulties are individually quite different, and pathological conditions such as cerebral palsy vary in the nature and presentation of the degree of the handicap. A larger sample group may provide enough evidence to generalize the results, given a consistent effect, irrespective of pathologically individual differences in the population of people with these disorders. The trials were undertaken in a familiar situation using staff with whom the patients were familiar. However, the experimental nature of the intervention, and the process of measuring range of movement added a dimension to the experience which these subjects may have found anxiety-provoking. It can take months for patients with these pathological conditions to become accustomed to a new intervention, and the high level of significance found that indicated the effectiveness of VA therapy should be considered within this context.

The second study undertaken on 27 profoundly physically and mentally handicapped subjects was limited by a number of factors. Twenty seven subjects is still a small sample group, and the results cannot be generalized to the wider population of people with severe learning disability and spasticity from the evidence in this experiment. The experiment required only one trial in each condition for each subject, and while this obtained results that were not affected by familiarization with the intervention, or affected by cumulative effect, there are again limits on the possibility of generalizing these results. For example, the novelty of the interventions may have affected subjects either in a positive or in a negative way. Consistency of measurement cannot be established reliably based on one trial. Familiarization with the procedure and method of measurement by the evaluators might obtain more consistent results with less variability.

As far as the subjects were concerned, while the results from the one trial in each condition that was undertaken reveal no significant differences between MMBP and VA therapy, additional trials might reveal different results as subjects became familiar with the treatment and began to respond more consistently to one of these two treatments, as had been found from previous clinical experience with patients with difficult behaviour and high levels of anxiety (Wigram 1993). Additional trials in two of the conditions had demonstrated a significantly greater improvement of range of movement after VA therapy when compared with a than had been found from the results of only one trial in each condition. The possibility of progressive improvement in response to therapy over time needs to be addressed in future studies. In both of these studies, the question that was being addressed was the change in range of movement and reduction in muscle tone before and after the treatment. Many questions have been posed regarding long-term effects, and also the cumulative effects of VA therapy, and an evaluation of these phenomena was not included as part of these trials. It would be important in future research to explore both cumulative and long term effects, particularly in attempting to define the frequency and duration of treatment. The duration of the sessions was fixed at thirty minutes, but there was only limited evidence to suggest that this was the optimum time for treatment (Miller and Bornstein, 1988). Additional evidence of effect may be obtained from longer treatments. The alleviation of symptoms and the prevention of deterioration in chronic pathologies also pose questions around frequency of treatment. The first of these studies evaluated effects based on thirty minute treatments twice a week. On the basis of pure speculation, thirty minute treatments three times a day might reveal a significantly different outcome.

There are many different parameters that could be changed, and variables that could be manipulated in order to pursue this research further. The intensity of the stimulus, the frequency of the pulsed sinusoidal low frequency tone used, and the style and content of the music used are all essential elements of VA therapy requiring further investigation. The literature describing the efficacy of music as a medium for relaxation (Ellis and Brighouse, 1952; Landreth and Landreth, 1974; Spintge, 1993; Standley, 1995; Maranto, 1993) all firmly support a wide and diverse application of music generally as an agent or medium to reduce stress and anxiety, and to facilitate relaxation and changes in mood. These two studies have concentrated mainly on evaluating the significant effect of a pulsed low frequency tone combined with music. These studies were not designed to investigate whether low frequency sound alone, without music has the same or a different effect.

9.2.2 Studies on the Non-clinical Population

The results from the studies undertaken to identify whether subjects could detect and to isolate a localised effect from different frequencies within a range of 20Hz to 70Hz were difficult to analyse and interpret. The first study appeared to indicate some consistency of effect, supporting previous studies that found evidence of this phenomenon (Griffin, 1986; Teirich, 1959; Yamada et al., 1983). The second study was designed in a more complex way. Twenty frequencies, (2 sequences of 10 frequencies) were played to each subject, and a longer time was allowed for the presentation of each frequency in order to give the subject time to try and isolate the effect. However, these trials were only undertaken once. It has been conjectured in the discussion section of this particular study (chapter seven) that repeating these trials with subjects over a period of time might develop the subject's ability to be sensitive to where they feel vibration, and therefore obtain more accuracy as well as more consistency in their ability to perceive localised sensations of vibration. While some frequencies achieved greater consistency between subjects in where in their bodies they experienced the same location of a sensation of vibration, when analyzing the data to see if repeated presentations of the same frequency produced the same response within subjects, there was little evidence of consistency.

In the physics of sound and vibration, the concept that solid objects resonate to different frequencies is well defined. However, this experiment was concerned with a relatively narrow frequency range, and it may have been difficult for the subjects to separate the general effect felt in the body from finding a specific location where the effect was strongest. Some subjects were able to pinpoint it quite quickly, whereas other subjects could not. The phenomenon of partial and whole vibration was evident at low frequencies.

Further work should be undertaken to investigate this phenomenon to develop VA therapy as a more scientific and reliable method of treatment. The intensity of the tone needs to be taken into consideration, as indeed does a wider frequency range. Repeated trials on subjects might give a better indication as they become more sensitive to the phenomenon. The equipment that is used to transmit the stimulus needs to be tested and measured and, as there are several different types of vibroacoustic equipment, they need to be individually tested for variations in effect. If the treatment is to be researched in a way that it can be administered with any degree of accuracy and specificity, some method of calibration needs to be addressed when using different vibroacoustic units.

The method of collecting data from this study was important, as it relied upon the ability of a subject to sense and accurately describe the sensations they were experiencing. This was both a strength and a weakness in the design. Given clear parameters, self-reporting can provide important subjective data, and does not rely on the interpretation of observed behaviour or measured physical data. However, in order to obtain responses from "naive" subjects it was necessary to limit relevant information on what subjects might expect to experience in order not to bias them. The method in these studies of finding some evidence of a sensation of vibration therefore relied on spontaneous responses from subjects who were given very limited information regarding the parameters that may have helped them to make a more accurate assessment of the sensation they were supposed to be experiencing and describing. It still holds true that the data obtained was from "naive" and unbiased subjects, and provides a record of the novel sensations people were experiencing.

The second study on non-clinical subjects was undertaken to establish the effect of VA therapy compared with a treatment of relaxing music and a control (no stimulus) condition measuring psychological and physiological responses. A wide age range and population sample was used for this study, and the analysis revealed significant differences between treatment and music alone conditions, and between the two treatment conditions compared with the control condition. There were significant reductions in arousal levels and heart rate in the treatment condition. No significant differences were found between conditions in changes in blood pressure. The subjects only received one trial in each condition. Once again the novelty effect may have played a role in obtaining either increased positive or negative responses. Subjects were given no explanation before the trial, and the control group could have responded with disappointment and possibly even irritation at lying on the bed and receiving no stimulus.

One experimental condition was missing from the design of this experiment. It could have included a condition where the subjects received a pulsed, sinusoidal low frequency tone on its own without music to see if the music element in VA therapy was really necessary.

This experiment added further evidence to support the theory that a combination of a pulsed sinusoidal low frequency tone and relaxing music has a significantly greater effect of reducing arousal levels than music alone, in the light of literature already documenting substantial evidence to support the physiological and psychological relaxing effects of music (Hodges, 1980; Maranto, 1993; Standley, 1989). The music used in these trials was New Age, consisting of a very gentle, relaxing non-rhythmic style of improvisation. Individual differences in terms of response to this type of music compared with other types of music were not taken into account in this experiment. Subjects are likely to relax when sitting or lying in a quite place, undisturbed, listing to gentle, soft, relaxing music; therefore much of the emphasis in this experiment, as in the experiments in chapters four, five and six, was placed on evaluating the effect of the low frequency tone.

Consideration of the influence of the music has been lacking. It is certainly influential, and future experiments should consider the style and structure of the music as an equally influencing stimulus affecting mood state, arousal level and autonomic response. Indeterminate aspects of these trials are concerned with the uncontrollable and unmeasurable influence of music, and the power which music has to stimulate emotions and associations which may well have affected mood and physical state. There have already been studies to establish significant differences between different styles of music and music from different cultures (Ellis and Brighouse, 1952; Zimny and Weidenfeller, 1963), and a limiting factor in this study is the lack of any analysis of the subjects' experience of the music.

The final study was undertaken to evaluate the effect of varying the speed of the pulsed low frequency tone used in VA therapy, and evaluating the effect of a constant tone. This study found no significant differences between conditions. There had been no previous studies undertaken to evaluate this effect, and hypothetical assumptions had been made about whether or not a pulsed tone was more beneficial than a constant tone, and what the speed of that pulse should be. The difference tone was generated at an infrasonic level (0.1Hz - 0.6Hz), and Griffin (1986) had indicated that there could be side effects to frequencies at this level including motion sickness, sweating, nausea, and occasionally vomiting. However, it is unclear in the literature at what intensity of a low frequency sound these side effects begin to occur, and whether this is a generally expected effect, irrespective of the physical state of the subject at the time of receiving the stimulus. There have been anecdotal reports of motion sickness, light body feeling, and occasionally nausea.

Caution needs to be exercised in interpreting the results of these trials considering the limitations of the studies and the small sample groups. The study provided useful information regarding the experience subjects had of a pulsed low frequency sound and a constant tone, but the effect may be significantly different when these same stimuli are presented together with music, as mentioned in the discussion section of this chapter. The effect of a constant tone together with music as a treatment has not been used in VA therapy. It has always been assumed that a pulsed wave effect would be more relaxing for the subjects. Now this is in question and future research should examine this phenomenon more closely. The low frequency sinusoidal tones used in VA therapy are a significant part of the treatment, and the way in which those stimuli are presented together with music separates this stimulus from some others in the field, and attaches importance to it that is relevant to clinical practice. VA therapy is being used as a treatment among populations that include both chronic and acute patients and, while this develops, beneficial and detrimental effects of treatment require careful consideration and analysis.

There were constraints and limitations in this research. The studies were designed and executed with the best expertise and resources available. Given more sophisticated methods for measuring the stimulus and the response of varied subjects, additional data may have established clearer outcomes. VA therapy is delivered as a treatment in a number of different situations and equipment used in treatment has varied. These studies were undertaken on three different vibroacoustic devices, and the presentation of the stimulus varied. This is partly due to the fact that the different pathologies had different treatment needs. Clinical judgement took precedence over research decisions, and in the studies involving the clinical population, patient needs were given priority. This may have contributed to the limitations that are apparent in the conduct of the trials, and the measurement of outcome.

9.3 CONCLUSION

In conclusion, VA therapy influences both psychological and physiological processes. Music is received, processed and interpreted in the brain, and the emotional and associating effect of music stimulates psychological processes. At the same time, physical effects go alongside or are the result of psychological activity, and music has an active effect on physical behaviour. These experiments have not only identified further evidence of the way music affects us at a psychological level, but has also measured physical response. Because VA therapy is an intervention that presents a physical stimulus in the form of a pulsed sinusoidal low frequency tone, these studies have found some evidence of the effect of sound within this frequency range. The psychological and physiological effect of music and sound is gaining increasing importance in treatment theory surrounding music therapy and music in medicine.

These studies have added to the existing research investigating the efficacy of VA therapy. Some of the experiments have supported and validated early anecdotal and experimental treatments, and have given additional evidence of the value of VA therapy for non-clinical subjects and subjects with high muscle tone. The experiments have also called into question some of the assumptions regarding the effect of the stimulus used in VA therapy.

The opening sections of this thesis described some of the potential applications of VA therapy in treatment (Skille, 1991; Skille and Wigram, 1995). This is undoubtedly an enjoyable form of treatment, with few side effects so far recorded. Therefore, it is easy to propose its application in a variety of clinical conditions. The empirical studies and development by Skille in Norway, and by other people in Europe and America have explored the application of VA therapy with a wide variety of conditions. However, it is important to clarify that objective research, and evaluation of the efficacy of VA therapy when compared with either an alternative relaxation treatment or a control condition has, to date, been limited. The commercial organisations who manufacture various different types of VA equipment, and sell it, are reticent about providing concrete research evidence of the efficacy of this treatment, and detailed information regarding the stimulus that is used. The effect of relaxing music can be very influential, and it is known from previous studies that music alone can provide quite a strong influence in reducing anxiety levels, facilitating relaxation, and developing altered states of consciousness (Bonny, 1975; Goldberg, 1995).

There has been some analysis of the effect of VA therapy in reducing blood pressure, and there is variability in the findings. Chesky and Michel (1991) found significant reductions in blood pressure and heart rate which reinforced anecdotal reports from Skille (1991), Saluveer and Tamm (1989) and Lehikoinen (1990). Reductions in heart rate have also been noted. Without objective evidence, the findings in all these anecdotal reports could have been attributed to a quiet environment, resting mentally, resting physically , the music, or various combinations of these parameters.

VA therapy as a treatment will only achieve value if it can be found to be consistently reliable. In these studies this has been found to be true in the case of the experiments on reduction of muscle activity, and on arousal levels. Whether or not VA therapy has long term effects or cumulative effects has yet to be established. These studies contribute to the field but do not answer all the questions. Physiological investigation needs to be undertaken for a more detailed evaluation of physical behaviour during and after VA therapy.

This is a growing field and, due to the beneficial effects that have been noted from some of the studies specified in this thesis, it has been a privilege and a rewarding experience to work in a developing therapeutic application. Music and vibration have historically been used for healing for centuries, but it is only recently that objective research has developed in order to substantiate and validate the healing properties of sound reported anecdotally for hundreds of years.

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APPENDIX 1

VIBRO ACOUSTIC THERAPY FORM

TRIALS ON HIGH MUSCLE TONE

PATIENT..............................
TAPE................................PLACE...................
LFS WITH/WITHOUTCONDITION................

(1).
Date.................am/pm

BEFORE AFTER
Syst. Syst. Pulse

Diast. Diast.

Measurements from...........to			
1.	cm	cm	
2.	cm	cm	
3.	cm	cm	
4.	cm	cm	

(2).
Date.................am/pm

BEFORE AFTER
Syst. Syst. Pulse
Diast. Diast.

Measurements from...........to			
1.	cm	cm	
2.	cm	cm	
3.	cm	cm	
4.	cm	cm	

COMMENTS

APPENDIX 2
VIBROACOUSTIC THERAPY RESEARCH - MEASUREMENTS FORM

PATIENT........................

MMBP/VA/CONTROL.............
LOCATION.......................
DATE...........................
SystolicDiastolic Pulse
Blood Pressure Blood Pressure

Before After Before After Before After

Measurement	Before Treatment	After Treatment	Difference
1. Shoulder to shoulder	cm	cm	cm
2. Right shoulder to right wrist	cm	cm	cm
3. Left shoulder to left wrist	cm	cm	cm
4. Olecranon process of right elbow to right side of body	cm	cm	cm
5. Olecranon process of left elbow to left side of body	cm	cm	cm
6. Tip of nose to navel	cm	cm	cm
7. Greater trochanter to lateral malleolus	cm	cm	cm
8. Greater trochanter to lateral malleolus of left leg	cm	cm	cm
9. Mid point of base of right patella to mid point of base of left patella	cm	cm	cm
COMMENTS			

APPENDIX 3

VIBROACOUSTIC THERAPY RESEARCH:MMBP, VA THERAPY AND CONTROL FORM

Session	Trial Measurements In Centimtres	Max	Bef	Aft	Diff	Min	Range	%
MMBP	1. Shoulder to shoulder 2. Right shoulder to right wrist 3. Left shoulder to left wrist 7.Greater trochanter to lateral malleolus of right leg 8. Greater trochanter to lateral malleolus of left leg 9. Mid point of base of right patella to base of left patella							
VA Therapy	1. Shoulder to shoulder 2. Right shoulder to right wrist 3. Left shoulder to left wrist 7. Greater trochanter to lateral malleolus of right leg 8. Greater trochanter to lateral malleolus of left leg 9. Mid point of base of right patella to base of left patella							
Control	1. Shoulder to shoulder 2. Right shoulder to right wrist 3. Left shoulder to left wrist 7. Greater trochanter to lateral malleolus of right leg 8. Greater trochanter to lateral malleolus of left leg 9. Mid point of base of right patella to base of left patella							

APPENDIX 4

LOCATION OF FREQUENCY TEST - SEQUENCE 1

(CONFIDENTIAL)

NAME:SEX:

DATE OF BIRTH:WEIGHT:HEIGHT:

SEQUENCE 1	20hz	40hz	30hz	50hz	40hz	30hz	60hz	50hz	70 hz	60 hz
Feet										
Ankles										
Calves										
Knees										
Thighs										
Sacrum Pelvis										
Lumbar Abdomen										
Thoracic Chest										
Cervical Shoulders										
Neck										
Head										
Arms										
Hands										
Like/ Dislike										

APPENDIX 5

LOCATION OF FREQUENCY TEST - SEQUENCE 2

(CONFIDENTIAL)

NAME:SEX:

DATE OF BIRTH:WEIGHT:HEIGHT:

SEQUENCE 2	60hz	70hz	50hz	30hz	60hz	40hz	50hz	30hz	40 hz	20 hz
Feet										
Ankles										
Calves										
Knees										
Thighs										
Sacrum Pelvis										
Lumbar Abdomen										
Thoracic Chest										
Cervical Shoulders										
Neck										
Head										
Arms										
Hands										
Like/ Dislike										

APPENDIX 6

LOCATION OF FREQUENCY TEST - SEQUENCE 3

(CONFIDENTIAL)

NAME:SEX:

DATE OF BIRTH:WEIGHT:HEIGHT:

SEQUENCE 3	70hz	30hz	40hz	30hz	20hz	60hz	50hz	60hz	50 hz	40 hz
Feet										
Ankles										
Calves										
Knees										
Thighs										
Sacrum Pelvis										
Lumbar Abdomen										
Thoracic Chest										
Cervical Shoulders										
Neck										
Head										
Arms										
Hands										
Like/ Dislike										

APPENDIX 7

LOCATION OF FREQUENCY TEST - SEQUENCE 4

(CONFIDENTIAL)

NAME:SEX:

DATE OF BIRTH:WEIGHT:HEIGHT:

SEQUENCE 4	40hz	50hz	60hz	50hz	60hz	20hz	30hz	40hz	30 hz	70 hz
Feet										
Ankles										
Calves										
Knees										
Thighs										
Sacrum Pelvis										
Lumbar Abdomen										
Thoracic Chest										
Cervical Shoulders										
Neck										
Head										
Arms										
Hands										
Like/ Dislike										

APPENDIX 8

VIBROACOUSTIC RESEARCH DATA - TRIALS ON NON-CLINICAL SUBJECTS

CONFIDENTIAL

NAME: D.O.B.

Medication: Sex:

Cigarettes p.d.: Post:

Coffee p.d.: Grade:

Contra-indications: Sector:

Trial Date: Shift:

Last cigarette (time): Time of trial:

How many smoked this day: Alcohol that day or previous day:

B.P. Problems?

	Before	After
B.P. Systolic		
Diastolic		
H.R.		

APPENDIX 9

UWIST MOOD ADJECTIVE CHECK LIST

Mood Adjective Checklist

SEX: Name: Date of Birth: Time of Day Todays Date:

DOES THE ADJECTIVE DEFINE YOUR PRESENT MOOD?

	Definitely	Slightly	Slightly not	Definitely not
1. Happy	1	2	3	4
2. Dissatisfied	1	2	3	4
3. Energetic	1	2	3	4
4. Relaxed	1	2	3	4
5. Alert	1	2	3	4
6. Nervous	1	2	3	4
7. Passive	1	2	3	4
8. Cheerful	1	2	3	4
9. Tense	1	2	3	4
10. Jittery	1	2	3	4
11. Sluggish	1	2	3	4
12. Sorry	1	2	3	4
13. Composed	1	2	3	4
14. Depressed	1	2	3	4
15. Restful	1	2	3	4
16. Vigorous	1	2	3	4
17. Anxious	1	2	3	4
18. Satisfied	1	2	3	4
19. Unenterprising	1	2	3	4
20. Sad	1	2	3	4
21. Calm	1	2	3	4
22. Active	1	2	3	4
23. Contented	1	2	3	4
24. Tired	1	2	3	4

BLOOD PRESSURE:BEFORE AFTER DIFFERENCE

SYSTOLIC

DIASTOLIC HEART RATE:

APPENDIX 10

UWIST MOOD ADJECTIVE CHECKLIST - SCORING FORM
Scoring Procedure
This version of the UMACL comprises the three factorial scales of Energetic arousal (EA), Tense arousal (TA), and Hedonic tone (HT), plus the composite General arousal scale (GA). The three factorial scales consist of four positive and four negative items; the GA scale consists of six positive and six negative items. For each scale find eight (or twelve) individual item scores, and add them together to give the total scale score. A subject responding 'definitely' (1) to the 'Happy item would be assigned an item score for the HT scale of four, a subject responding slightly (2) a score of 3 and so on.

ADJECTIVE	RESPONSE	SCALE(S)	SCORING
Happy	1 2 3 4	HT+	1-4 2-3-2 4-1
Dissatisfied	1 2 3 4	HT-	1-1 2-2 3-3 4-4
Energetic	1 2 3 4	EA+ GA+	1-4 2-3-2 4-1
Relaxed	1 2 3 4	TA- GA-	1-1 2-2 3-3 4-4
Alert	1 2 3 4	EA+ GA+	1-4 2-3-2 4-1
Nervous	1 2 3 4	TA+ GA+	1-4 2-3-2 4-1
Passive	1 2 3 4	EA- GA-	1-1 2-2 3-3 4-4
Cheerful	1 2 3 4	HT+	1-4 2-3-2 4-1
Tense	1 2 3 4	TA+ GA+	1-4 2-3-2 4-1
Jittery	1 2 3 4	TA+ GA+	1-4 2-3-2 4-1
Sluggish	1 2 3 4	EA- GA-	1-1 2-2 3-3 4-4
Sorry	1 2 3 4	HT-	1-1 2-2 3-3 4-4
Composed	1 2 3 4	TA-	1-1 2-2 3-3 4-4
Depressed	1 2 3 4	HT-	1-1 2-2 3-3 4-4
Restful	1 2 3 4	TA- GA-	1-1 2-2 3-3 4-4
Vigorous	1 2 3 4	EA+	1-4 2-3-2 4-1
Anxious	1 2 3 4	TA+	1-4 2-3-2 4-1
Satisfied	1 2 3 4	HT+	1-4 2-3-2 4-1
Unenterprising	1 2 3 4	EA-	1-1 2-2 3-3 4-4
Sad	1 2 3 4	HT-	1-1 2-2 3-3 4-4
Calm	1 2 3 4	TA- GA-	1-1 2-2 3-3 4-4
Active	1 2 3 4	EA+ GA+	1-4 2-3-2 4-1
Contented	1 2 3 4	HT+	1-4 2-3-2 4-1
Tired	1 2 3 4	EA- GA-	1-1 2-2 3-3 4-4

APPENDIX 11

VA THERAPY - CLINICAL TREATMENT PROCEDURE

N.W. HERTS HEALTH AUTHORITY

MENTAL HANDICAP UNIT

HARPERBURY HOSPITAL

VIBROACOUSTIC THERAPY 1990

TREATMENT PROGRAMME

Consult Tony Wigram or Lyn Weekes before giving Vibroacoustic Therapy to a new patient - see list.

Current residents receiving treatment -
Remember there are contra - indications

PLEASE FOLLOW THIS PROCEDURE

1.Before each treatment check whether the resident has any acute inflammation, i.e. ear infections, other infections and whether there is any area of bleeding, e.g. blood in urine.
N.B. it is safe to give VA therapy when the resident is menstruating.

2.Put the resident on the VA therapy bed and support them with pillows as required. Inco pads may be needed if the resident is incontinent. N.B. Pillows filled with polystyrene beads allow the passage of low frequency sound waves. Foam pillows dampen the effect.

3.Complete Resident's record form (before side).

4.Cover with a blanket - the body will lose heat as it relaxes.

5.Check that the volume and body controls are turned down to O and the Vibro/Music control is turned to Vibro +2.

6.Switch on and insert resident's tape.

7.Start tape then turn volume control to 3 - Resident is lying on the speakers, the music will sound louder to them than you. Check their expression.

8.Gradually increase 'body' controls for feet, thighs, and chest to full.

9.Increase gradually the head control to half way.

10.Observe resident's face and reduce the volume control if necessary (i.e. if resident becomes distressed).

11.Always stay with or within hearing distance of the resident. (If you are not in room with them during treatment, check every 5 minutes).

12.Always ensure a quiet peaceful atmosphere near the treatment room during treatment sessions.

13.<u>At the end of treatment</u>:

(1)Turn controls to zero
(2)Speak gently to the resident - do not suddenly disturb them.
(3)Complete the resident's record form. (After side)
(4)Sit the resident up slowly. If the resident has fallen asleep, they may be left for a further period of time at the discretion of the senior nurse on duty.

14.Leave the equipment ready for the next resident.

FILE THE RESIDENT'S RECORD FORM.

APPENDIX 12

VIBROACOUSTIC THERAPY - GUIDELINES FOR CLINICAL TREATMENT:

TONY WIGRAM - NOVEMBER 1995

1. Pre-session Preparation:

1.1 Prepare bed or chair. Ensure required pillows and wedges are available, and prepare lifting equipment where appropriate.

1.2 Check stereo equipment. Ensure controls are turned to zero. Ensure tapes are ready and rewound.

1.3 Ensure required forms and noting charts are available.

2. Introduction:

2.1 Explain to patient what is going to happen. Reassure them about the treatment and the equipment.

2.2 Tell them that if they find the treatment uncomfortable or irritating they can get off the equipment.

2.3 Talk quietly and gently to set the atmosphere for the treatment.

2.4 Ask the patient if they would like to go to the toilet before the treatment starts. Internal vibration can stimulate a need to go to the toilet

2.4 Help the patient onto the VA equipment and ensure that they are settled and comfortable.

3. Starting the Treatment:

3.1 Advise the patient you are going to start the treatment

3.2 When the client is ready, begin the tape, and slowly increase the volume control. You should already have decided the optimum volume for each patient. This will vary.

3.3 After a short time (between 30 seconds and 1.5 minutes) gradually

increase the bass control to introduce the low-frequency tone.

3.4 Check for at least the first 5 minutes the response of the patients to be sure that they are comfortable and are not having difficulty or pain form the treatment. If in doubt (i.e. with non-verbal patients where you may be monitoring only facial expression) reduce the intensity of the treatment.

4. Monitoring the Treatment.

4.1 Establish during the assessment phase whether you will stay in the room during treatment, stay for 10 minutes and leave, or leave for the whole of the treatment.

4.2 With non-verbal clients, and clients who have limited ability to look after themselves, monitor every 5 minutes.

4.3 If you stay in the room during treatment, watch unobtrusively.

4.4 In the case of non-verbal patients, monitor the patients body language.

5. Ending the Treatment:

5.1 If the patient is asleep:

- **Talk quietly to them for a few minutes**
- **gently stroke them to "bring them back to earth"**
- **leave them for a few minutes after they have woken before moving them**

5.2 Suggest to the client they might stretch before they get up

5.3 Help them to sit upright. Wait some moments before lifting them or expecting them to stand. Their blood pressure may be down.

5.4 Be prepared to comfort and reassure the client.

6. Post-Treatment:

6.1 Allow the patient to rest if necessary.

6.2 Record changes in the client.

6.3 If this is part of research, make measurements and record data.

6.4 Ensure that all controls on the equipment are reduced to zero in readiness for the next treatment.