TurboSonic Vertical Whole-Body Vibration Training to Improve the Quality of Life for Seniors in the Areas of Participation, Activities of Daily Living and Mental Health

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<th>Description</th>
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<tbody>
<tr>
<td>ADL</td>
<td>Activities of Daily Living</td>
</tr>
<tr>
<td>BADL</td>
<td>Basic Activities of Daily Living</td>
</tr>
<tr>
<td>BASE</td>
<td>Berlin Aging Study</td>
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<tr>
<td>CNS</td>
<td>Central Nervous System</td>
</tr>
<tr>
<td>DSM</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
</tr>
<tr>
<td>EMG</td>
<td>Electromyography</td>
</tr>
<tr>
<td>et al.</td>
<td>et altera / and others</td>
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<tr>
<td>DLQ</td>
<td>Daily Living Questionnaire</td>
</tr>
<tr>
<td>FES-I</td>
<td>Falls Efficacy Scale – International Version</td>
</tr>
<tr>
<td>g</td>
<td>Unit of measurement for gravitational acceleration (9.81 m/s^2)</td>
</tr>
<tr>
<td>GDS</td>
<td>Geriatric Depression Scale</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>IADL</td>
<td>Instrumental Activities of Daily Living</td>
</tr>
<tr>
<td>ICF</td>
<td>International Classification of Function Disability and Health</td>
</tr>
<tr>
<td>ICD 10</td>
<td>International Classification of Diseases – Version 10</td>
</tr>
<tr>
<td>IGF-1</td>
<td>insulin-like growth factor</td>
</tr>
<tr>
<td>M.</td>
<td>Muscle</td>
</tr>
<tr>
<td>Mean</td>
<td>Average</td>
</tr>
<tr>
<td>MLDL</td>
<td>Munich Life Quality Dimension List</td>
</tr>
<tr>
<td>MFR</td>
<td>Modified Functional Reach Test</td>
</tr>
<tr>
<td>PICO</td>
<td>Patient-Intervention-Comparison-Outcome</td>
</tr>
<tr>
<td>POMA</td>
<td>Performance Oriented Mobility Assessment</td>
</tr>
<tr>
<td>ProFaNE</td>
<td>Prevention of Falls Network Europe</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized Controlled Trial</td>
</tr>
<tr>
<td>RMS</td>
<td>Root Mean Square - Average</td>
</tr>
<tr>
<td>RPE</td>
<td>Rate of Perceived Exertion – subjective</td>
</tr>
<tr>
<td>S.E.</td>
<td>Standard Error</td>
</tr>
<tr>
<td>TPR</td>
<td>Total Peripheral Resistance</td>
</tr>
<tr>
<td>TVR</td>
<td>Tonic Vibration Reflex</td>
</tr>
<tr>
<td>vs.</td>
<td>versus</td>
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<tr>
<td>SVWVBV</td>
<td>sonic vertical whole-body vibration</td>
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Summary

Introduction
This pilot study examines the question “Does the use of SVWBV training in elderly care facilities lead to changes in activity and participation levels as well as an improvement in mental and emotional health and/or an increase in the quality of life?”

Method
For clarification purposes, nine subjects from two assisted living facilities participated in SVWBV training over a period of 12 weeks with 24 interventions. The mean age (±S.D.) was 82.8 (±5.4) years. The study was conducted using the POMA, FES-I, GDS, MFR as well as the DLQ and MLDL assessments before the first and following the last intervention.

Results
The test results were electronically processed and tested for significant changes (p<0.05) using SPSS 16.0. Whereas the POMA, MFR, GDS as well as the DLQ and MLDL assessments showed significant improvements during the follow-up examination, FES-I showed no significant improvements during the follow-up examination.

Conclusion
Sonic Vertical Whole Body Vibration (SVWBV) training seems to be a viable alternative method used in geriatrics to increase activity and participation levels as well as to improve mental health and quality of life. The easy implementation and the short duration of the training make it advantageous for use with seniors in assisted living facilities. The study design is appropriate for subsequent larger studies with a control group. The positive effects of SVWBV training on the function and structure of the human body and therefore on activities and participation as well as mental health and quality of life are obvious.

Keywords: sonic vertical whole-body vibration, SVWBV, quality of life, participation, activity, ADL, depression, elderly
Chapter 1

1. Introduction

Geriatrics is one of the largest sectors of activity within the field of physiotherapy. The demographic changes that are occurring within German society are often discussed in the media. The steady increase in the population’s mean age as well as the increase in the 65 and older age group makes it necessary to respond to this change in an appropriate manner. In the scope of medical and paramedical care, physiotherapy makes it possible to implement the appropriate amount of preventive and rehabilitative measures in order to respond to the coming changes. After all, the appropriate therapy should result in positive changes at all levels of life. Not only is it necessary to implement structural changes, but improvements in participation in social life, an increase in activities and satisfaction as well as overall quality of life are desirable.

Therefore, this project addresses the largest group of elderly people in our society. This study investigates the effect of whole-body vibration training (SVWBV training) on the quality of life of seniors residing in assisted living facilities. The study illustrates the effect of SVWBV on participation, activities of daily life as well as mental health. A total of nine subjects (1 man/8 women) from two assisted living facilities participated in 24 interventions of whole-body vibration training over a period of 12 weeks. Changes in areas such as quality of life, depression and the risk of falling were investigated using questionnaires and practical tests.

1.1 Relevance

“Seniors” are becoming more and more important in our society. As frequently discussed in recent years, a widespread demographic change has occurred in German society. Being old is no longer an individual fate, but has become a mass phenomenon. The number of people over 80 has increased by 275 percent in recent years [1]. Analyses from the German Federal Statistical Office show that the structure of society will significantly change over the next 50 years. While the overall population will drop from around 82 million in 2005 to approximately 68 million in 2050, the number of people over age 65 will increase from 16 million in 2005 to approximately 23 million in 2050. While the number of persons over the age of 65 was barely 19 percent in 2005, it will be almost 33 percent by the year 2050 [2]. Demographic growth in Germany, as calculated by the German Federal Statistical Office, is illustrated in figure 1 and figure 2 below. Figure 1 shows that the population distribution in 1995 included a broad base in the area of 25-40 year-olds. The number of people age 55 and older declines as their age increases.
The population’s age group is expected to redistribute in 2040. According to calculations, there will be a considerable increase in the number of elderly people among the German population, while there will be a decline in the younger age group. Figure 2 shows the expected growth of the German population.

In addition, according to prognoses, annual life expectancy will increase by three months [3]. As a result, the growth of the entire population adds to increased public attention on the individual. This is also a change that is increasing the above-mentioned redistribution within the German population. Since 1964 the longest life expectancy of 80 years has almost doubled by eight years [4]. While the average life expectancy of women was around 81.5 years in 2002/2004, in 2050, the average woman will reach the average age of 88. A similar picture exists for the life expectancy of men. In 2002/2004, the average was 75.9 years. In 2050, the life expectancy for men will be around 83.5 years [2]. Figure 3 on page 3 shows a graphic representation of the increasing life expectancy of men and women up to the year 2050.
The overall increase in life expectancy increases the significance of degenerative processes [3]. At advanced ages, the appearance of diseases, for example, is characterized by the phenomenon of multi-morbidity, since a third of persons over the age of 70 suffer from five different illnesses, [5] with the risk of being significantly affected in terms of functionality considerably increased. In this perspective, it is clear that especially with seniors with a steadily growing mean age, the primary prevention of diseases of the musculoskeletal system as well as secondary care are becoming more significant.

1.1.1 Activities and Danger of Falling

The main aspect of this study involves the activities of seniors, the corresponding steadily increasing risk of falling and to what extent these two factors can be influenced by means of SVWBV training.

People’s daily habits increasingly change as they age. Most people reduce their level of activity, some people retreat and spend the majority of their free time inside their residence or the nursing home [6]. However, various studies have shown that elderly people attempt to maintain a certain level of activity based on their physical and mental abilities as well as their social environment [7, 8, 9]. In this regard, activity in a social context plays a central role for their physical as well as their mental well-being [10]. Various studies have shown that an elderly
person’s level of activity and performance of tasks is directly connected with this person’s physical and mental satisfaction [10, 11, 12]. In addition, Ditto et al. assert that health problems are negatively evaluated to the extent that they limit the valued activities of the affected person [13]. Hence, an improvement in functional activities can result in an increased number of activity options for seniors and can therefore also mean increased satisfaction and quality of life. Various studies show the positive effects of SVWBV training and the functional performance of elderly people [14, 16]. Increased functional performance results in expanded possibilities for the participants to take part in those activities that are significant to them.

An elderly person’s increased risk of falling is also directly connected with activities. The increased frequency of falling must also be considered with increasing age. Around 30 percent of persons over age 65 fall at least once a year. About 40 percent of people aged 80 and older fall once a year [16]. A ten percent increase per decade of life can be assumed [17]. For persons living in a nursing home or an assisted living facility, the frequency of falling is even higher: around 50 percent of nursing home residents fall at least once a year. Around ten percent of these cases result in injuries that require treatment. Five percent of the cases result in broken bones and one to two percent of the cases involve fractured hips [16].

As a result of falls, the probability of subsequent morbidity [30] and mortality [31] increases. The resulting necessary post-traumatic, medical care results in increasing costs for the healthcare system [32].

Costs for the direct medical treatment of hip fractures alone amount to around one billion euros a year in Germany. The long-term cost of the resulting care as well as the loss of productive time at work for relatives is not considered here. In 50 percent of the cases, the patients do not regain their previous mobility and in 20 percent of the cases, the patients remain in need of care [16].

In addition, in 2006, diseases and the consequences of external causes cost the healthcare system of the Federal Republic of Germany a total of 229,562 million euros for both sexes. Healthcare costs for illnesses and the consequences of external causes in the 65 to 85 age group amounted to 86,597 million euros and therefore, almost 38 percent. The ratio of costs for the treatment of diseases of the musculoskeletal system and connective tissues was similar. For 2006, they totaled around 26,631 million euros. Proportionally, the costs for patients between age 65 and 85 were almost 10,930 million euros or almost 41 percent of the total costs for diseases of the musculoskeletal system. Another cost-intensive factor is problems with the circulatory system. The combined cost for all age groups amounted to 35,179 million euros.
20,094 million euros of these costs were for people age 65 to 85 or about 57 percent. Since the over 65 age group amounts to about 19 percent of the total population, the resulting costs are disproportionately high [33]. An overview of the costs of the healthcare system in the Federal Republic of Germany as a whole and for the 65 to 85 age group is shown in Table 1.

<table>
<thead>
<tr>
<th>ICD 10</th>
<th>Gender</th>
<th>Both Genders</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>All diseases and the consequences of external causes (all age groups)</td>
<td>229,562</td>
<td>97,731</td>
<td>131,831</td>
<td></td>
</tr>
<tr>
<td>All diseases and the consequences of external causes (age 65 to under age 85)</td>
<td>86,597</td>
<td>36,819</td>
<td>49,779</td>
<td></td>
</tr>
<tr>
<td>Diseases of the musculoskeletal system and the connective tissues (all age groups)</td>
<td>26,631</td>
<td>9,607</td>
<td>17,023</td>
<td></td>
</tr>
<tr>
<td>Diseases of the musculoskeletal system and the connective tissues (age 65 to under age 85)</td>
<td>10,930</td>
<td>3,300</td>
<td>7,629</td>
<td></td>
</tr>
<tr>
<td>Diseases of the respiratory system (all age groups)</td>
<td>12,062</td>
<td>6,130</td>
<td>5,932</td>
<td></td>
</tr>
<tr>
<td>Diseases of the respiratory system (age 65 to under age 85)</td>
<td>3,470</td>
<td>1,864</td>
<td>1,606</td>
<td></td>
</tr>
<tr>
<td>Diseases of the circulatory system (all age groups)</td>
<td>35,179</td>
<td>16,879</td>
<td>18,300</td>
<td></td>
</tr>
<tr>
<td>Diseases of the circulatory system (age 65 to under age 85)</td>
<td>20,094</td>
<td>9,636</td>
<td>10,459</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Cost of Diseases in millions of € for Germany arranged according to gender, age and ICD 10 classification in the year 2006 [Calculation of the cost of diseases, German Federal Statistical Office, 2008]

According to Ruberstein et al., there are multiple causes for falls [18]. Thus, falls can be the result of the interaction between an environment and an organism that can no longer optimally react [17].

In other words, the risk of falling is influenced by exogenous and endogenous factors. Examples of exogenous factors are an uneven surface or poor lighting, but also include unsuitable footwear [16]. Endogenous risk factors for falls among seniors are, for example, deficient neuromuscular control [19], reduced muscle strength, a deterioration of balance, but also a fear of falling or a case history of falling [16, 20, 21, 22].
This leads to the question of which risk factors can result in an accumulated occurrence of falls, especially falls resulting in injuries. A summary created by Masdeu et al. [23] of the most significant individual risk factors for falls in seniors is shown in table 2 below. A total of 16 controlled studies were evaluated by Masdeu regarding this subject.

<table>
<thead>
<tr>
<th>Significant Individual Fall Risk Factors</th>
<th>Sign./Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Factor</td>
<td></td>
</tr>
<tr>
<td>Weakness</td>
<td>11/11</td>
</tr>
<tr>
<td>Balance deficit</td>
<td>9/9</td>
</tr>
<tr>
<td>Gait problems</td>
<td>8/9</td>
</tr>
<tr>
<td>Vision problems</td>
<td>5/9</td>
</tr>
<tr>
<td>Reduced mobility</td>
<td>9/9</td>
</tr>
<tr>
<td>Cognitive reduction</td>
<td>4/8</td>
</tr>
<tr>
<td>ADL deficit</td>
<td>5/6</td>
</tr>
<tr>
<td>Orthostatism</td>
<td>2/7</td>
</tr>
</tbody>
</table>

Table 2: Significant Individual Fall Risk Factors: “Number of studies with significant results/total number of studies for this factor [according to Grob D, Fall Assessment: Indications, Tools]

When an elderly person falls, there is frequently a loss of trust in their own abilities, especially with regard to bodily movement and balance [24, 25]. Lost trust in their own abilities and the fear of falling again leads to a further decline in bodily activity and a resulting continued reduction of postural stability and overall quality of life [26]. This connection illustrates the geriatric downward spiral (see figure 4) [27]

Figure 4: Geriatric Downward Spiral

[Püllen R. Introduction to Geriatric Medicine]
Studies show that the risk of falling can be reduced by about 25 percent [28] through targeted interventions with training programs that improve neuromuscular function, especially strength and balance abilities. Since SVWBV training has demonstrated effectiveness in the area of standing and gait performance [29] in a relatively short training time, this suggests that the use of the vibration platform would be beneficial in the field of geriatrics in order to prevent falls in elderly persons.

1.1.2 Depression

A further aspect of this study is the appearance of depression and its proven negative effects on senior participation and activities of daily life (ADL, IADL) [34]. There is no unified definition of depression [35]. Colloquially speaking, the term depression is frequently used to describe a type of depressive mood. In most cases there are several causes. It thus concerns a multi-factor event. Therefore, biological, mental and social components all play a role [36].

As a medical term, depression is a non-specific description for a disruption of emotional and mental life that especially involves mood, diminished motivation and dejection [37]. Depending on the duration, intensity and frequency of the occurrence, it can be considered as an illness that requires treatment [38]. In addition to the above-mentioned main symptoms, a depressive episode is characterized by the loss of interest and enjoyment of almost all activities. Generally, there are also other symptoms, such as pain. These can be disruptions in appetite and sleep, fear, a feeling of guilt as well as thoughts of suicide or suicidal attempts [39]. In general, in comparison to younger patients, the symptoms of depression in elderly people are often blurred and not easily recognizable and hard to diagnose. The cognitive limitations that accompany depression can, for example, also be signs of imminent dementia. Therefore, there are also certain characteristics that appear especially with older patients. In comparison to younger patients, older patients, for example, suffer from an increased number of incidents involving depressive delusions and show a much greater co-morbidity with neurodegenerative ailments [40].

There are various findings regarding the prevalence of depression in the elderly population. In a representative survey, Linden et al. found that 13.2 percent of seniors evaluated their life as being “no longer worth living” [29]. Bickel et al. [41] found that 13.5 percent of elderly people suffer from a pathologically significant depressive disturbance. According to Linden et al, this is 9.8 percent. Around 3 to 4 percent of patients who experience a progression of their illness commit suicide [29].
Chapter 1

Depression has a considerable impact on Germany's healthcare system. In 2004, the cost for healthcare in Germany for patients between the age of 65 and 85 suffering from depression was 1.168 billion euros. In this respect, the cost for women was 917 million euros or about 79 percent and the cost for men was 251 million euros or about 21 percent [33].

The average cost for a nursing home resident in the Federal Republic of Germany is 3,648 euros per month. For a depressed patient, the resulting costs are 5,241 or up to one-third higher when compared directly. An improvement of one point on the Geriatric Depression Scale (GDS) is equal to a savings of 336 euros [42]. Therefore, an improvement of emotional health would have a direct impact on the costs of the healthcare system.

The results of research conducted by Takahashi et al. are crucial for a discussion about depression in this study. This research showed that improved postural stability results in an improved value on the GDS [43]. Since the improvement of the postural stability is a proven effect of SVWBV training [15, 44], this study investigates whether SVWBV training has a positive effect on the mental health of the test subjects.

1.2 The Use of SVWBV Training in Geriatrics

The field of geriatrics has several training programs for the improvement of physical and mental ability. The known forms of geriatric therapy include balance training, strength training and gait exercises [14]. In recent years, whole-body vibration (SVWBV) training has become established in the area of physiotherapy. Since 1996, training devices on which a subject can stand have been available. This enables unified training of the extremities as well as the trunk muscles [45].

As a new therapy option, especially for the improvement of muscle strength, neuromuscular performance and balance, this form of therapy is optimally adapted to the needs of geriatric patents, [46, 47] since the often complicated operation of devices is eliminated and intervention times with an average of 10 minutes are relatively short [48].

With SVWBV training, the subject stands on a platform that is set to vibrate on a special mechanism. The mechanical vibration stimulus is then transferred from the platform to the subject’s feet and distributes its effects to the body. Some studies describe an improvement of strength in the lower extremities following vibration training [44, 46, 49-52], while other studies show improved balance reactions both after extrinsic as well as after intrinsic balance disturbances [15, 44]. An increase in balance as well as reduced danger of falling were also shown [53].
1.3 Physiological Effects of SVWBV Training

The body’s biological response to whole-body vibration depends on the frequency of the vibration, the amplitude, the duration of use and the type of vibration. The frequency of the vibration is measured in hertz (Hz) and indicates the number of vibrations per second that are transferred to the human body. It is the deciding factor when it comes to determining the effect of SVWBV. The amplitude of the vibration can either be given as a speed (for example, g or m/s²) or as a deflection of the platform (for example, mm, cm, m). Finally, the duration of the vibration stimulus must be considered in order to be able to evaluate the possible effects on the human body.

There are several physiological reactions of the human body to vibration stimulus. For example, if the human body is continually or over a longer period of time, i.e. several hours, exposed to a vibration stimulus as a result of professional exposure, such as is the case for example with construction workers or professional drivers, there are several negative effects. In many cases, the exposure to vibration leads to degenerative changes in the spinal column, dislocation of the inter-vertebral disks and osteoarthritis [54].

Medical whole-body vibration training differs significantly from the previously described type of professional forced exposure to vibration. On the one hand, the duration of the training unit is only a few minutes, and on the other hand, the frequency and intensity of the vibration stimulus can be adjusted according to the goal of the treatment.

In order to get a better idea of the effects of medical whole-body vibration training on the human body, the effects of the vibration stimulus on the different body systems and their functions are described below.

1.3.1 Neuromuscular Changes

Starting at age 65, there is a noticeable reduction in basic motor functions such as coordination, endurance and strength [55]. By the third decade of life, there is measurable sarcopenia or loss of muscle mass [56]. Van den Berg and others cite several studies wherein people between the ages of 20 and 70 lose an average of 20-40 percent of their muscle mass. At age 90, the proportion reaches 50 percent [19]. Fast-twitch fibers are especially affected. While young people typically have a muscle mass of 60 percent, this number drops to 30 percent in 80-year old men [57].

FT fibers are a crucial component for standing and gait security. Because of their ability to quickly develop strength and due to the afferent activity of the polysynaptic reflexes generated by the muscle spindles, they are significant in compensating for disturbances (disruptive stimuli) during the gait or standing phase. According to several studies, the lower extremities are
especially affected by the loss of FT fibers [58, 59]. Caused by pre-dominant execution of static muscular work of the lower extremities in increasing age [60], or in order words, a reduced stress of the FT fibers. Because of its high frequency stimulation on the entire body, especially on the lower extremities, SVWBV training seems to be a suitable preventative measure for age-related sacropenia. Wilmore and Costill state that the corresponding training can prevent a loss of FT fibers [61].

Another cause of reduced reflexivity in the elderly is the reduced performance of the corresponding neuronal structures. Granacher and Gollhoffer cite various studies showing the reduction of nerve connection velocity in the case of seniors [62]. The resulting increased latency period causes postural reactions to become uncoordinated with age due to disruptions [19]. In addition, this results in the desensitizing of the muscle spindles. These muscle spindles play a central role for a secure and economic gait wherein the central nervous system is continually supplied with information from the peripheral nervous system. The desensitizing of the muscle spindles with age is caused by several factors. An increase in capsule size was observed while the number of intrafusal fibers as well as nuclear chain fibers generally declined [20]. Through desensitizing, the speed and accuracy, at which the muscle spindles can impact postural control, is reduced. This results in a deterioration of static sensitivity and therefore the ability to correctly perceive and interpret muscle length and the position of a joint. Several studies show that with regular training and the corresponding stimulation the perception sensitivity of the muscle spindles can be increased in elderly people [20, 63, 64]. High-frequency stimulation of the muscle spindles through SVWBV training can be considered a possible explanation for the increased postural stability that follows SVWBV training.

The increased pre-synaptic block, supposedly caused by the degenerative changes of the supraspinal structures [65, 66] on the one hand and the shrinking of the interneural network, caused by an age-related loss of interneurons and dopaminergic neurons on the other hand, can be considered an additional cause for a reduction of polysynaptic reflexes in elderly people [67, 68]. Even here there are indications that sensory-motor training can result in a positive modulation of these structures [69]. However, it is an undisputed fact that sensory-motor training, to which SVWBV training belongs according to Granacher [70], significantly improves daily motor function [63, 71].

For several years now, it was thought that the central nervous system (CNS) is a dominant static organ with a largely fixed number of neurons at birth. However, this idea must be revised as it is becoming increasingly apparent that the CNS is one of the most adaptable organs and has unexpected plasticity even in old age [72].
1.3.2 Cardiovascular Changes

There is an increasing risk of cardiovascular disease and resulting mortality in old age due to the increased occurrence of high blood pressure [99]. Decreased vascular elasticity, especially the Windkessel vessels near the heart, frequently leads to an increase of systolic blood pressure [100].

Whole-body vibration involves a sufficient vibration stimulus that results in different adaptive reactions in the human circulatory system. After vibration training, the middle arterial blood pressure is reduced, while during training, an increase in blood pressure was observed [73]. Various scientific explanations can be cited in order to explain this phenomenon. On the one hand, the muscles are activated by the tonic vibration reflex [74, 75]. This activation leads to a constriction of the intramuscular vessels and therefore to an increase in total peripheral resistance (TPR) and an increase in arterial blood pressure since up to 20 percent of the maximum isometric contraction strength leads to a block of the arterial blood supply and up to 50 percent leads to a complete closure of the vessel [76].

Another possible explanation for increased blood pressure is the direct effect of the vibration stimulus on the blood vessel. The direction of the vibration can be separated into one component parallel to the vessel and a second component perpendicular to the vessel flow. The vibration stimulus leads to a deformation of the vessel walls in muscles, the internal organs and in bone capillaries. Hydrodynamic analyses show that an elliptical-shaped vessel provides better resistance to the fluid (the blood) that is passing through it than a round vessel with the same circumference. In contrast to the longitudinal effect, it has been shown that the lateral effect especially impacts small vessels, or in other words, arterioles, capillaries and venules, which have the greatest effect on TPR. The blood vessel deformations caused by the vibration and the resulting increased flow resistance are responsible for the increased TPR during whole-body vibration training [73].

As a result of a homeostatic adaptive reaction to the maintenance of middle arterial blood pressure and cardiac output, the body subsequently reacts with an increase in blood pressure or a decrease of TPR or a combination of both of these processes.

The fact that TPR is narrower after the vibration than it was before the vibration lends credence to the notion that the existence of the adaptive mechanism results in the reduction of TPR. This method of reducing TPR through vibration would open additional capillaries or increase the vessel diameter of the arteries or both. This process leads to an increase in the surface area of the micro-vessels in the muscles and thus an improved exchange of gas and nutrients between the blood and muscle fibers as well as to any other tissues within the body [72].
SVWBV training can result in a change in the vessel structure by means of the above-mentioned short-term adaptive reaction and therefore appears to be a means to increase resilience in elderly people as well as to prevent serious cardiovascular diseases that appear in connection with high blood pressure. However, subsequent studies must be conducted in order to determine whether these kinds of changes are long-term.

1.3.3 Respiratory Changes
The metabolic activity of an organism can be determined by measuring oxygen intake under constant conditions. If oxygen intake during exercise is subtracted from oxygen intact at rest, the specific energy expenditure of the activity can be determined. Finally, the energy expenditure in connection to the body mass can be established and the individual difference in oxygen intake can be determined. A study conducted by Rittweger et al. [73] showed an increased intake of oxygen during activities on a vibration platform with a frequency of 26 Hz both during the normal upright standing position as well as with static knee bending without stress and active knee bending with added stress.

The fact that electromagnetic discharges show increased muscle activity during SVWBV [101], lends credence to the fact that muscle activity can be activated through vibration. The vibration itself represents an active exercise rather than just a passive process. Another indication is the fact that the subjective rate of perceived exertion (RPE) as well as the heart rate and the available lactate value in the blood increases with vibration training about the same as with moderate exercise such as bicycling or walking. The energy expended through vibration can also be increased through an increase of frequency and amplitude of the vibration [78]. By increasing energy expenditure, SVWBV training leads to an increased demand on the respiratory system in order to balance the oxygen deficit. This can result in the structural adaptation of the respiratory system which can then show improved endurance.

1.3.4 Endocrine and Metabolic Changes
Studies show that vibration training has an impact on the hormonal system of the human body as well as on human metabolism. In a study conducted by Bosco et al. [79] in 2000, it was shown that whole-body vibration training significantly influences the concentration of testosterone, somatotropin and cortisol in blood plasma. Significantly higher values were measured with testosterone \(p=0.026\) and somatotropin \(p=0.014\), while the concentration of cortisol \(p=0.03\) significantly decreased in plasma. According to Bosco, the increased concentration of somatotropin is a result of repeated stimulation of the motor cortex. New
research results [80] confirm the effect of whole-body vibration training on the concentration of the hormone somatotropin and cortisol in the blood of elderly persons. The reduction of cortisol can be ascribed to the effect of insufficient stimulation of the motor cortex on the one hand and to neural feedback from the musculoskeletal system on the other hand. This reaction of testosterone and somatotropin shows a different activation of various neuro-secretory centers and shows differences in the central control of endocrine centers during vibration [79].

The increased distribution of somatotropin not only stimulates intracellular protein synthesis, but also the proliferation of satellite cells. As myogen stem cells, these cells are responsible for the growth as well as the repair mechanism for all kinds of muscle fibers. The proliferative capacity of the satellite cells alone does not essentially decrease later in life (80 year-olds) in comparison to middle age [72]. Therefore, SVWBV training can have a positive effect on the growth of muscles.

1.3.5 Changes in Bone Structures

Various mechanisms are considered in the discussion of the effective function of SVWBV on the human skeletal system. Mechanical bone stress is the essential factor when it comes to changes in bone structure through external influences. Due to the dynamic change between tensile and compressive forces, an anabolic effect is exercised on the bone metabolism which can lead to the preservation or increase in bone mass. [98] The muscle activity caused by the tonic vibration reflex can be one reason for an increase in bone mineral density (BMD) after SVWBV training [44].

In addition, there are links between diseases of the skeletal and blood vessel systems. The bone density as well as the bone circulation in patients suffering from osteoporosis of the proximal femur head were reduced, as opposed to patients without osteoporosis [81]. The impact of a vascular component on the occurrence of osteoporosis was also considered by Shih et al. [82] in the study of BMD of the spinal column and bone perfusion in post-menopausal women.

A presumed underlying mechanism is the blood circulation or capillarization of the skeleton. The blood supply of a bone is connected to its metabolic requirements. The skeletal system's susceptibility to disease increases if the vessel system within the bone lacks the ability to react to necessary metabolic requirements. Under some circumstances, diseases of the vessel systems also lead to the existence of osteoporosis. It could also be said that interventions that improve the blood circulation of the bone have positive effects on the bone structure.
Like the other vessels, they also react to genetic and environmental risk factors. If diseases of the bone vessel system and therefore limitations of bone blood circulation are a reason for the loss of bone mass, the risk factors for arteriosclerosis and the risk of contracting osteoporosis are also increased. In fact, studies show a link between smoking, diabetes mellitus and elevated LDL cholesterol with an increased risk for cardiovascular diseases and reduced bone density [84]. This suggests that increased bone circulation also has an impact on bone density. As indicated in 1.3.2 above, one option to increase circulation is whole-body vibration training. In a study of literature about the bone blood supply and bone density, Stewart et al. [85] came to the conclusion that increased blood flow to the legs and possibly also increased bone blood circulation could lead to an increase in bone mass following whole-body vibration training. In addition to the above-mentioned cardiovascular effects on the structure of blood vessels, the authors attributed the effect to improved micro-vascular filtration through increased filtration pressure as well as to improved lymphatic drainage.
1.4 Main Issue

In summary, it can be said that the above-mentioned aspects, namely the demographic change within German society, the increased risk of falling and the resulting changes in activities and participation as well as the occurrence of depression among seniors, have a significant impact on society. In addition, the above-mentioned positive effects of SVWBV training on bodily function and structure in seniors are already known in the literature.

The main objective of this study is to investigate whether the improvement of functional performance through SVWBV training is reflected at the social level in increased participation and/or at the mental level in the form of increased quality of life/satisfaction.

Therefore, this study is based on the following question:

“Does the use of SVWBV training in elderly care facilities lead to changes in activity and/or participation levels as well as an improvement in mental and emotional health and/or an increase in the quality of life?”

According to Sackett et al [86], it makes sense to use the PICO-plan question formulation. The individual components of the questionnaires are broken down according to this plan.

Patients / Population

The study population consisted of 9 subjects (1 man/8 women) from two institutions known as “assisted living facilities” that had a minimum age of 65 years at the time of the study.

Interventions

The intervention consists of a training program on a whole-body vibration training platform stretched over a period of 12 weeks with a total of 24 training units.

Comparison

This project concerns a pilot study without a control group.

Outcome

The study should provide scientific evidence regarding the impact of whole-body vibration training on changes in the level of activities, participation as well as mental health.
2. Method

The goal of this pilot study is to demonstrate that SVWBV training may have a positive effect on the level of activity and participation as well as the mental health and quality of life of seniors. In addition, the procedure used to conduct this study should be analyzed so that it can later be used as a starting point to implement possible changes before conducting any subsequent studies.

2.1 Hypotheses

The connections described in Chapter 1 give rise to two hypotheses:

\( H_0 \) - Hypothesis = “With regard to the level of activity and participation and the level of satisfaction or mental health, there were no significant changes following SVWBV training.”

\( H_A \) - Hypothesis = “With regard to the level of activity and participation and the level of satisfaction or mental health, there were significant changes following SVWBV training.”

2.2 Literature Research

Literature research was conducted using the PudMed, ScienceDirect and PEDro online databases. A search was conducted using the following keywords: whole-body vibration, SVWBV, vibration, effects, balance, posture, postural control, falls, elderly.

The search results were checked by both authors based on their relevance to this project. If a reference was found to be relevant, the summary was read and then the complete text may also have been searched for the relevant results. In addition, the literature references were considered in the study and any possible relevant literature was used to create the expert opinion.

2.3 Intervention

In this pilot study the intervention group was investigated to determine how SVWBV training affects the level of activity and participation as well as mental health and/or the quality of life. The investigation was conducted using various questionnaires and two practical tests (see also Chapter 2.6). The study included a measurement made before the initial intervention and a measurement at the end of the last intervention. The complete intervention is stretched
over a period of 12 weeks with a total of 24 training units. The implementation protocol for the progressively applied SVWBV training is included in Attachment 1. A description of the “TurboSonic TT 2590” SVWBV platform used in the study is included in Attachment 2 and the initial position used for training on the SVWBV platform is described in Attachment 3.

2.4 Study Participants
The study participants live in two nursing homes in North Rhine-Westphalia, Germany where the seniors live in “assisted living” facilities. Prior to the start of the study it was promoted within the nursing homes. Interested seniors were given information about the content of the study at an information event. The average age of the study participants was 82.8 years. Eligibility for participation in the study was based on the criteria shown in Table 3 below.

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Nursing home resident</td>
<td>• New implants</td>
</tr>
<tr>
<td>• Age &gt; 65 years</td>
<td>• New fractures</td>
</tr>
<tr>
<td></td>
<td>• Epilepsy</td>
</tr>
<tr>
<td></td>
<td>• Malignant tumor</td>
</tr>
<tr>
<td></td>
<td>• Acute thrombosis</td>
</tr>
<tr>
<td></td>
<td>• Kidney stones / gall stones</td>
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<tr>
<td></td>
<td>• Acute tendinopathy</td>
</tr>
<tr>
<td></td>
<td>• Dementia</td>
</tr>
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<td></td>
<td>• Neurological diseases</td>
</tr>
</tbody>
</table>

Table 3: Inclusion and Exclusion Criteria

2.5 Informed Consent from the Study Participant
After establishing the patient's suitability to participate in the study, the potential participants were given an informed consent form. This form was given to the participants to sign in order to confirm their consent. The Informed Consent Form states that patients have been sufficiently informed, both verbally and in writing, about the nature of the scientific research and that they have the right to withdraw from the study at any time without the need to provide reasons. By signing the consent form, the patients also declare that they understand that the study administrators will not assume any responsibility for possible health problems or other damage that could occur as a result of their participation in the study. In addition,
patients grant consent that their personal data will be stored and may be used for the purpose of this study while preserving their anonymity. The form that is used is included in Attachment 4.

A data sheet is used to collect personal data from the study participants. It includes the name, date of birth and gender of the subject as well as their height and weight and any possible pre-existing conditions and medications.

**2.6 Assessments**

In order to analyze the activity and participation level as well as the self-assessed quality of life and mental health factors considered in this study, several measurement tools needed to be used. During the analysis of the study mentioned above we learned that in order to be able to safely conduct the evaluation of the functional activity level, the Performance Oriented Mobility Assessment is used in literature [43]. In addition, the modified Functional Reach Test appears to be a good measurement tool to analyze the IADL and BADL. The quality of life was determined using the DLQ and MLDL which, according to the authors of the questionnaire, complement each other well [87]. Mental condition was indicated using the Geriatric Depression Scale (GDS) and the self-assessed risk of falling was measured using the Falls Efficacy Scale – International Version (FES-I). An overview and an explanation of the assessments used in this study as well as their relationship to the different levels of the ICF are provided below.

**2.6.1 Daily Living Questionnaire (DLQ)**

**ICF-Level**: Personal factors, contextual factors

One of the main objectives of this study was to determine the quality of life in different areas of life. The DLQ is a process to determine the quality of life based on behavioral aspects and specific diseases is based on answers to open questions about the quality of life. The process consists of 42 positively formulated items that are summarized in six subscales (a-f) and then combined to obtain a total score. The subscales of the DLQ concern the following areas:

- a. **Mental condition** (9 items: 4, 13, 31, 32, 33, 34, 35, 38, 39)
- b. **Physical health** (9 items: 1, 2, 5, 7, 10, 14, 21, 26, 28)
- c. **Social life** (9 items: 6, 9, 11, 17, 20, 23, 29 37, 40)
- d. **Daily functional ability** (9 items: 3, 8, 12, 16, 22, 24, 30, 36, 41)
- e. **Vitality** (3 items: 18, 25, 27)
- f. **Medical care** (3 items: 15, 19, 42)
Chapter 2

The questions are answered based on a 5-point Likert scale (1 = not at all, 2 = only with effort, 3 = partially, 4 = very well, 5 = easily). Each item can be assessed a value between 1 and 5. A higher value reflects a higher quality of life. The total value is calculated by adding the individual items. The DLQ provides satisfactory to good results with regard to reliability, validity, sensitivity and discrimination ability. The internal consistency (Cronbach’s $\alpha$) of the subscale is $r > 0.80$ with the exception of the medical care scale. In a healthy population, the sensitivity of the DLQ is somewhat smaller, while in an unhealthy population, it can be assumed that there is good responsiveness [87]. The test manual for the DLQ is included in Attachment 5.

2.6.2 Munich Life-Quality Dimension List (MLDL)

ICF-Level: Personal factors, contextual factors

The MLDL is a dimensional tool that can be used with all diseases to determine the level of satisfaction with individual quality of life areas with respect to bio-psycho-social aspects. The MLDL questionnaire consists of a total of 20 items, 19 of which are grouped into four subscales (a-d) which can be combined to obtain a total score. In addition, one item (number 20: overall life) evaluates the quality of life as an overall value. The 19 items can also be used separately to determine the importance of the desire for change and belief in changes with respect to individual life areas. The evaluation uses a Likert scale of 0 to 10 (0 = very unsatisfied to 10 = very satisfied).

A high score reflects a high satisfaction with life. The subscales of the MLDL include the following areas:

a. Physical (5 items: 1, 2, 3, 18, 19)
b. Mental (4 items: 4, 5, 6, 7)
c. Daily life (5 items: 8, 10, 11, 12, 13)
d. Social life (5 items: 9, 14, 15, 16, 17)

According to the author, psychometrics provides satisfactory internal consistency of the subscales: the physical scale showed internal consistency in various studies with healthy and sick subjects (Cronbach’s $\alpha$) between 0.63 and 0.92; the mental scale was between 0.82 and 0.91; the social life scale was between 0.69 and 0.92; the daily life scale was between 0.66 and 0.87; and the total score for all the subscales varied between 0.85 and 0.96 [87]. The test manual for the MLDL is included in Attachment 6.
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2.6.3 Performance Oriented Mobility Assessment (POMA)

ICF-Level: Bodily function, activities

The POMA is a functional assessment tool used to determine the risk of falling in older people. The evaluation incorporates behaviors and movement activities during sitting, standing up, walking and sitting down. The version used in the study consists of 20 items with two subscales for balance and gait. The individual items were evaluated with 0, 1 or 2 points. The maximum point score is 28 points. The quality criteria used for the POMA is moderate to good. According to Behrmann et al. [88], the intra-test reliability is \( r=0.95 \). In other words, several researchers obtained the same results with a high probability. According to Tinetti et al. [89], the risk of falling is significantly higher for patients who obtain a score of 20 points. Raiche et al. [90] reported a sensitivity of 70 percent and a specificity of 50 percent for the POMA. In order words, seven out of ten people at risk of falling were recognized as such, while at the same time every second person not at risk of falling also showed an apparently increased risk of falling. Because of the relatively small specificity, it is recommended that an additional multi-factor assessment be used in order to determine the risk of falling.

Therefore, in order to obtain more precise information, in addition to the POMA, we used the FES-I scale as a screening test for the further determination of risk factors.

The test manual for the POMA is included in Attachment 7.

2.6.4 Falls Efficacy Scale – International Version (FES-I)

ICF Level: bodily function, activities

The international version of the Falls Efficacy Scale was used in this study as an additional multi-factor assessment tool to determine the risk of falling. This questionnaire is used to determine self-efficacy in elderly people with respect to falling. It was developed in the scope of an expert network for the prevention of falls (Prevention of Falls Network Europe ProFaNE). The FES-I expands on the Falls Efficacy Scale (FES) which helps determine complex functional activities and other social aspects of self-efficacy. The FES-I questionnaire consists of 16 items taking into consideration several activities and falls. It also comprises social aspects as well as complex functional activities. There are four possible responses to the questions (1 = not at all concerned, 2 = somewhat concerned, 3 = fairly concerned, 4 = very concerned). The FES-I has very good reliability coefficients with high internal consistency (Cronbach's \( \alpha = 0.96 \)) and a high retest reliability (\( r = 0.96 \)) [91]. The German language version of the test manual of the FES-I is included in attachment 8.
2.6.5 Geriatric Depression Scale (GDS)

ICF-Level: Personal factors

In order to determine the subject’s level of depression, the Geriatric Depression Scale was used. This scale was also used in the study conducted by Takahashi [43]. The GDS is a measurement tool to evaluate mental and emotional health. It consists of a total of 30 items with YES or NO answers. If an answer points to the existence of depression, it is given a score of zero points. Otherwise, it is given a score of one. At the end of the evaluation, the total of all 30 items is calculated. With a critical value of 17 points (or a total of 13 NO answers), the GDS showed high sensitivity (84.0 percent) and specificity (88.9 percent). The high internal consistency (Cronbach’s $\alpha=0.91$) and the low inter-item correlation show that on the whole, the GDS is a questionnaire with good psychometric qualities [92]. The GDS was especially used in this study in order to determine the effect of whole-body vibration on mental health and to verify correlations with the MFR. The GDS test manual is included in Attachment 9.

2.6.6 Modified Functional Reach Test (MFR)

ICF Level: Bodily function, activities

The Modified Functional Reach Test according to Takahashi et al. [43] is another tool used to determine the ability to conduct functional activities. The modified Functional Reach Test is an adaptation of the original Functional Reach Test. Using the modified administration method, if need be, the reliability and validity of the original version of the Functional Reach Test can be assessed. Takahashi et al. determined that there was no significant relationship between the previous FR and the MR (ICC=0.32; CI=0.22 - 0.41). Neither the original Functional Reach Test ($p=0.79$) nor the modified Functional Reach Test ($p=0.62$) correlate with the number of falls in the measured population. The ability to conduct functional activities, however, correlates significantly with the modified lateral Functional Reach Test. Individuals with an MFR $\geq 20$ cm had a higher BADL score ($p=0.039$) and IADL score ($p=0.0016$) in comparison to individuals with an MFR $< 20$ cm. With regard to the relationship between the previous FR and the BADL and/or IADL score, there were no differences found between a larger previous FR $\geq 30$ cm and a smaller previous FR $< 30$ cm with regard to the execution of BADL ($p=0.76$) and IADL ($p=0.36$). [43] Because of the test-retest reliability of the MFR, good to very good scores were obtained (ICC=0.90; CI=0.89 - 0.96). In summary, it can be said that the MFR can be used as a measurement tool that is independent from the
previous FR in order to determine activity level. However, the MFR cannot be used to determine the risk of falling. [43]

This project used the process described by Takahashi et al. The MFR is the maximum distance that someone with their arm stretched out and abducted 90° with a secure stance can reach to the side without losing contact with the floor. For this purpose, the patient is standing with their legs spread. The maximum distance from the starting to the end point is measured from the tip of the middle finder using a measuring tape placed on the wall at a height of 150 cm. The measurement is conducted for the right and left sides. In order to evaluate the results of the measurements, the sum of the measurements from the right and lefts sides is calculated.
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3. Results

In the beginning, the study population consisted of 12 subjects (11 women/1 men) with an average age of 82.8 ± 5.4 years. During the study, the population shrank to nine subjects. The drop-out rate was thus 25 percent. Measurement data was collected in the scope of the initial findings before the first and after the last of a total of 24 interventions with SVWBV training that were administered over a period of 3 months. The measurements were taken using the above-mentioned measurement tools (DLQ, MLDL, POMA, FES-I, GDS as well as the MFR). The DLQ, MLDL, FES-I and GDS questionnaires were distributed to the test subjects during a preliminary meeting. The MFR as well as the POMA were conducted before the first and after the last intervention, as described above.

The results of the questionnaires and assessments were collected electronically and then processed and evaluated using the SPSS 16.0 statistical program. The variation between the preliminary measurement and the re-measurement was statistically significant with a value of \( p = 0.05 \) or more. Since it can be assumed that the same patient groups were treated in the study during the preliminary measurement and re-measurement, the significance level was determined using the \( T \)-Tests for paired samples. SPSS was used to conduct the necessary procedure. The following chapter describes the statistical evaluation and presents the measurement results in the form of graphs.

3.1 Daily Living Questionnaire (DLQ)

The “Daily Living Questionnaire” was used to determine the behavior-related quality of life. A high total point score indicates a correspondingly high satisfaction with life. It is advantageous to divide the questionnaire into different subscales that can also be evaluated separately from each other and provide valid results.

The total point score, when the scores of all subscales were combined, was 134.4 ± 15.7 for the preliminary measurement. The total point score increased by 19.7 points during re-measurement for a total score of 154.1 ± 14.4. With a \( p \)-value of \( p = 0.002 \), the changes in the total point score are considered significant in this case.

Analyzing the results of corresponding subscales also resulted in a significant improvement for the “physical health” subscale with a score of 27.6 ± 3.9 during the preliminary measurement and a value of 32.1 ± 5.2 for the re-measurement (\( p = 0.016 \)). For the “mental condition” subscale, there was an average improvement of 3.7 points with a score of 31.7 ± 3.9 for the preliminary measurement and 35.4 ± 3.7 for the re-measurement (\( p = 0.008 \)). Likewise, for the “social life” subscale, there
was an improvement between the preliminary measurement (24.1 ± 4.2) and the re-measurement (27.2 ± 4.1) for an average of 3.1 points ($p=0.007$). In addition, there were significant improvements in the “daily functional ability” subscale with an average variation of 6.4 points with a score of 29.8 ± 3.3 for the preliminary measurement and 36.2 ± 3.3 for the re-measurement ($p=0.001$) as well as for the “vitality” subscale with a score of 10.7 ± 1.6 for the preliminary measurement and 11.9 ± 1.8 for the re-investigation. Therefore, there was an average variation of 1.2 points ($p=0.023$). Only with the “medical care” subscale was there no significant change ($p=0.302$). In this case, the measured point total changed from an average of 0.5 points to a score of 10.7 ± 2.3 for the preliminary investigation and 11.2 ± 6 for the re-investigation. The ‘preliminary measurements” and the “re-measurements” are indicated in Table 4 below. Values of $p < 0.05$ are underlined in the table.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.E.</td>
<td>Mean</td>
</tr>
<tr>
<td>Physical Health</td>
<td>27.6 ± 3.9</td>
<td>1.7</td>
<td>32.1 ± 5.2</td>
</tr>
<tr>
<td>Mental Condition</td>
<td>31.7 ± 3.9</td>
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<td>35.4 ± 3.7</td>
</tr>
<tr>
<td>Social Life</td>
<td>24.1 ± 4.2</td>
<td>1.4</td>
<td>27.2 ± 4.1</td>
</tr>
<tr>
<td>Daily functional ability</td>
<td>29.8 ± 3.3</td>
<td>1.1</td>
<td>36.2 ± 3.3</td>
</tr>
<tr>
<td>Vitality</td>
<td>10.7 ± 1.6</td>
<td>0.5</td>
<td>11.9 ± 1.8</td>
</tr>
<tr>
<td>Medical Care</td>
<td>10.7 ± 2.3</td>
<td>0.8</td>
<td>11.2 ± 1.6</td>
</tr>
<tr>
<td>Total value</td>
<td>134.4 ± 15.7</td>
<td>5.2</td>
<td>154.1 ± 14.4</td>
</tr>
</tbody>
</table>

*Table 4: Daily Living Questionnaire (DLQ) – Results of the preliminary investigation and re-investigation for the total score and the average of all subscales with the standard deviation, standard error and $p$-value*

In order to illustrate the measurement results of the DLQ for the preliminary measurement and re-measurement, the following standardized graphic presentation of the different subscales (Figure 5) is used. The subscales were standardized so that they can be directly compared based on a score of 100 since the four subscales of “function”; “body”; “mental” and “social” each consist of 9 items so that a maximum score of 45 points is possible, while the subscales “vitality” and “medical care” have 3 items each and a maximum total score of 15 points. Figure 5 below shows the results of the preliminary investigation (blue) and the re-investigation (green).
3.2 Munich Life Quality Dimension List (MLDL)

The Munich Life Quality Dimension List (MLDL) was used to supplement the Daily Living Questionnaire (DLQ) and was therefore an additional dimensional measurement tool to determine satisfaction with individual quality of life areas with respect to bio-psycho-social aspects. The measurement results for the four subscales were evaluated, namely “physical”; “mental”; “social life” and “daily living” as well as one item, “vitality”, which was evaluated globally.

The total score for all subscales (without item 20) changed from 98.2 ± 20.7 for the preliminary measurement to a score of 117.7 ± 14.5 for the re-measurement (p=0.001) and
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is therefore statistically significant. The “physical” subscale changed significantly from 28.2 ± 5.5 for the preliminary measurement to 32.6 ± 5.3 for the re-measurement ($p=0.006$). In addition, significant improvements were obtained with the “mental” subscale where the total point score increased from 21.2 ± 5.7 for the preliminary measurement to a score of 28.3 ± 4.5 for the re-measurement ($p=0.002$). The changes of the “daily living” subscale were also significant with an increase from 25.8 ± 3.9 to 30.2 ± 3.6 ($p=0.008$). The “social life” subscale was not so significant with an increase of 16.2 ± 8.0 from the preliminary measurement to a score of 19.0 ± 4.6 for the re-measurement ($p=0.149$). For the overall evaluation of the quality of life, there was a change of 6.8 ± 1.6 for the preliminary measurement to a score of 7.6 ± 1.3 for the re-measurement ($p=0.193$). Table 5 below summarizes the statistical analyses for the MLDL. The table shows the average results obtained for the individual subscales as well as for the total value, adding items 1-19, along with the standard deviation, the standard error as well as the corresponding $p$-value as a measurement of significance.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
<th>$p$ value</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Mean ± S.E.</td>
<td>Mean ± S.E.</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>28.2 ± 5.5</td>
<td>32.6 ± 5.3</td>
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</tr>
<tr>
<td>Mental</td>
<td>21.2 ± 5.7</td>
<td>28.3 ± 4.5</td>
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</tr>
<tr>
<td>Social Life</td>
<td>16.2 ± 8.0</td>
<td>19.0 ± 4.6</td>
<td>0.149</td>
</tr>
<tr>
<td>Daily life</td>
<td>25.8 ± 3.9</td>
<td>30.2 ± 3.6</td>
<td>0.008</td>
</tr>
<tr>
<td>Vitality</td>
<td>6.8 ± 1.6</td>
<td>7.6 ± 1.3</td>
<td>0.193</td>
</tr>
<tr>
<td>Total value</td>
<td>98.2 ± 20.7</td>
<td>117.7 ± 14.5</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 5: Munich Life Quality Dimension List (MLDL) – Results of the preliminary investigation and re-investigation for the total value and the average of all subscales with the standard deviation, standard error and $p$-value

Figure 6 illustrates the measurement results of the MLDL. The bar graph shows the measurement results of the four subscales “daily living”, “body”, “mental” and “social” for the preliminary investigation (blue) and the re-investigation (green). The total value of the individual subscales was standardized so that they could be directly compared to each other using a score of 100, since the “daily living”, “body” and “social” subscales consist of 5 items with a possible maximum total score of 50 points, while the “mental” subscale only includes 4 items with a maximum total score of 40 points.
Chapter 3

3.3 Performance Oriented Mobility Assessment (POMA)

The analysis of the measurement results from the Performance Oriented Mobility Assessment showed significant changes in the “gait” subscale ($p=0.016$) and the “balance” subscale ($p=0.008$). The results obtained for the “gait” subscale increased on average from $9.3 \pm 2.7$ to $11.3 \pm 1.0$. The target point value for the “balance” subscale changed from $13.6 \pm 1.9$ to $15.6 \pm 0.7$. The total score obtained changed from $22.9 \pm 4.2$ for the preliminary investigation to $26.9 \pm 1.3$ for the re-investigation with a significance value of $p=0.004$. 

Figure 6: Munich Life Quality Dimension List (MLDL) – Graphic representation of the subscale percentages for the preliminary measurement (blue) and the re-measurement (green)
Chapter 3

Table 6 below shows the average score for both subscales and the total score obtained from the statistical analysis as well as the corresponding standard deviations, the standard error and the corresponding $p$ value. Significant results are underlined in the $p = \ldots$ column.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± S.E.</td>
<td>Mean ± S.E.</td>
<td></td>
</tr>
<tr>
<td>Gait</td>
<td>9.3 ± 2.7</td>
<td>11.3 ± 1.0</td>
<td>0.016</td>
</tr>
<tr>
<td>Balance</td>
<td>13.6 ± 1.9</td>
<td>15.6 ± 0.7</td>
<td>0.008</td>
</tr>
<tr>
<td>Total Value</td>
<td>22.9 ± 4.2</td>
<td>26.9 ± 1.3</td>
<td>0.004</td>
</tr>
</tbody>
</table>

**Table 6**: Performance Oriented Mobility Assessment (POMA) – Results of the preliminary investigation and re-investigation for the total value and the average of all subscales with the standard deviation, standard error and $p$-value

Figure 7 is a graphic representation of the measurement results of the individual subscales. For the purpose of better comparison, the balance and gait subscales as well as the total score are standardized at a score of 100. The graph shows the results of the preliminary investigation (blue) and the re-investigation (green).

**Figure 7**: Performance Oriented Mobility Assessment (POMA) - Graphic representation of the subscale percentages for the preliminary measurement (blue) and the re-measurement (green)
3.4 Falls Efficacy Scale – International Version (FES-I)

The evaluation of the measurement results of the Falls Efficacy Scale – International Version (FES-I) showed no significant improvement in the resulting total score \( (p=0.436) \). The point value of \( 28.1 \pm 9.6 \) for the preliminary measurement only fell to a score of \( 26.2 \pm 9.0 \) for the re-measurement. Table 7 shows the average total score obtained during the “preliminary measurement” and during the “re-measurement” as well as the standard deviation, the standard error and the corresponding \( p \) value.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean - S.E.</td>
<td>Mean - S.E.</td>
<td></td>
</tr>
<tr>
<td>Total Value</td>
<td>28.1 ± 9.6  3.2</td>
<td>26.2 ± 9.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Table 7: Falls Efficacy Scale – International Version (FES-I) – Results of the preliminary investigation and re-investigation for the total value and the average of all subscales with the standard deviation, standard error and \( p \)-value

Figure 8 is a graphic representation of the measurement results and compares the total scores obtained for the preliminary investigation (blue) and the re-investigation (green). The results are standardized at a score of 100.

Figure 8: Falls Efficacy Scale – International Version (FES-I) - Graphic representation of the percentages of the total score for the preliminary investigation (blue) and the re-investigation (green)
3.5 Geriatric Depression Scale (GDS)

The analysis of the measurement results of the Geriatric Depression Scale showed significant improvement in the obtained point value ($p=0.012$). A positive YES answer resulted in the addition of 1 point to the total value, while a negative NO answer, indicating the existence of depression, was counted as a point value of 0. The average number of points obtained during the preliminary measurement was $18.2 \pm 4.9$ and increased to $20.6 \pm 4.6$ during re-measurement. The measurement results are shown in Table 8.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean - S.E.</td>
<td>Mean - S.E.</td>
</tr>
<tr>
<td>Total Value</td>
<td>18.2 ± 4.9 - 1.6</td>
<td>20.6 ± 4.6 - 1.5</td>
</tr>
</tbody>
</table>

*Table 8: Geriatric Depression Scale – Average results of the preliminary investigation and re-investigation with standard deviation, standard error and $p$-value*

Figure 9 illustrates the measurement results. The bar graph shows the average total point score obtained on the GDS during the preliminary investigation (blue) and the re-investigation (green).

*Figure 9: Geriatric Depression Scale (GDS) - Graphic representation of the percentages of the total score for the preliminary measurement (blue) and the re-measurement (green)*
3.6 Modified Functional Reach Test (MFR)

According to Takahashi, statistical analyses of the measurement results show a significant ($p=0.001$) increase in the score obtained on the modified Functional Reach Test. An increase in the measured distance of $27.7 \pm 9.9$ cm during the preliminary measurement compared to $36.6 \pm 8.9$ cm for the re-measurement was observed. The results show that postural control could be improved with SVWBV training since it enables the test subject to overcome the greater distance. Table 9 shows a summary of the measurement results.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Preliminary Measurement</th>
<th>Re-measurement</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean - S.E.</td>
<td>Mean - S.E.</td>
<td></td>
</tr>
<tr>
<td>Total Value</td>
<td>$27.7 \pm 9.9$ - 3.3</td>
<td>$36.6 \pm 8.9$ - 3.0</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Table 9: Modified Functional Reach Test (MFR) – – Average results of the preliminary measurement and re-measurement with standard deviation, standard error and $p$-value*

Figure 10 illustrates the measurement results. The bar graph shows the average total point score obtained on the MFR for the preliminary measurement (blue) and the re-measurement (green).

*Figure 10: Modified Functional Reach Test (MFR) - Graphic representation of the percentages of the total score for the preliminary measurement (blue) and the re-measurement (green)*
4. Discussion

Based on the data collected and analyzed in the scope of this study, the $H_0$-hypothesis described under point 2.1 was discarded in favor of the $H_A$-hypothesis.

$$H_A\ -\ \text{Hypothesis} = \ "At\ the\ level\ of\ activity\ and\ participation\ and\ the\ level\ of\ satisfaction\ or\ mental\ health,\ there\ were\ significant\ changes\ following\ SVWBV\ training."$$

Therefore, the question formulated in Chapter 1.5 - “Does the use of SVWBV training in elderly care facilities lead to changes in activity and participation levels as well as an improvement in mental and emotional health and an increase in the quality of life?” - can be answered with a “Yes”.

This is the first study to research the effects of SVWBV training on the mental and social level of seniors. A total of twelve seniors residing in an assisting living facility participated in this study. The relatively high drop-out rate was due to the fact that a high average age of around 83 can result in several co-morbidities [5], which may ultimately have led to the drop-out of 25 percent of the subjects. The reasons for abandoning the study (stomach ulcer, fever of unknown origin, carpal tunnel syndrome) were present in this study with no recognizable connection to SVWBV training. In addition, the participation of each individual subject was cleared in advance by the treating doctor. Because of the small intervention group, it was certainly difficult to generalize the results, however, it was established that SVWBV training did produce a measurable positive effect on the activity level, mental condition as well as the quality of life of the subjects.

Positive results from the DLQ and MLDL questionnaires show a clear improvement in the quality of life and the ability to cope with daily life. The results of the DLQ and MLDL are congruent except for the “social life” aspect. Unlike the DLQ, there were no significant improvements obtained in this MLDL subscale. However, it must be considered that two of the five items on the MLDL “social life” subscale were not answered by 90 percent of the subjects. These items refer to the areas of “marriage/partnership (item 10) and “sex life” (item 11). The questions were apparently not suitable for the average age group of the subjects. The authors do not know if there are corresponding assessments available in German that were created and validated especially for people in this age group. Subsequent
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studies may wish to find corresponding assessments outside the German language area and translate them or design and validate new assessments that would better correspond to the living conditions of seniors.

The supposed connection between increased functional performance and an improved MFR and/or an improvement in the GDS was confirmed in this project. Therefore, it can be assumed that an increased functional ability in daily life accompanies an improvement of mental condition. However, the lack of agreement between the POMA and the MFR and FES-I can be problematic. While the POMA and MFR scores significantly improved, this effect was absent from the FES-I. One explanation for this could be that the POMA assessment was not discerning enough for the subjects in this study or that the self-assessment of the subjects did not change during the study period.

The issue is which factors can be attributed to the measurable effects of the SVWBV training. The known positive effects of SVWBV training on muscle strength as well as standing and gait security [14, 15] could have resulted in an increase in activities and participation due to an improved self-confidence in the subject's own abilities [24, 25].

The interaction between the patient and therapists during the intervention and/or between the subject before and after the intervention must also be taken into consideration. A feeling of social benefit and increased satisfaction could materialize in a person in direct connection to the above-mentioned interaction of the participant. Bogaerts et al. described similar effects from satisfaction and the physical and social benefit during and after a similar intervention [15].

An additional supposition suggests that SVWBV training influences perception as well as cognitive processes. The majority of the subjects reported an improved bodily feeling and an increased self-perception in connection with the SVWBV training. One possible explanation for the increased bodily feeling could be the increased afferent activity of the proprioceptive peripheral receptors which, as shown previously in other studies, reacts to sensory-motor training and whose structure can be improved [20, 63, 64]. Ultimately, physical activity could also have had an impact on the cognitive process and therefore, on perception, as previously described in the literature [96]. Finally, improved self-perception could have resulted in an increased trust in the patient’s own abilities and, as described above, this leads to increased participation in activities.

It must be mentioned that one difficulty with conducting this study was that the assessments used to verify the activities and participation of the subjects were filled out by the subjects themselves. The distorted self-perception and self-assessment of some subjects hindered
the objective collection and evaluation of the measurement parameters. Test subject 2 can be used as an example. She was a very depressed woman who was withdrawn and reclusive before the intervention (confirmed by the doctor), but she showed positive changes during the intervention, according to the perception of the directors of the assisted living facility, her co-residents and the researcher. She resumed her participation in various group activities, began to groom herself better and sought additional contact with the other residents. However, almost no changes were observed on the DLQ and MLDL assessments. Decreased memory capacity is supposedly a related factor, however, this distortion of self-perception is potentially and among other things caused by the fact that elderly people have often lived in unchanging situations for many years. The accompanied habituation could hinder the determination of the gradual appearance of a change. Especially residents of assisted living facilities already have a strict routine life with definitive constants that no longer change, according to their subjective perception.

In addition, because of the SQL and MLDL assessments that were used, it was not possible to evaluate in which areas the increased participation was expressed. In both cases, it would be a good idea to allow the relatives of seniors as well as healthcare personnel to participate in the evaluation for the purpose of better objectivity.

In the area of activities, it would make sense for future studies to incorporate an analysis of functional abilities. As previously described in the literature, the standing pattern and gait of elderly people changes to a posture [93] that is focused on safety and stability and on an even gait, for example, with smaller steps [94]. In other words, value is placed on confirmed postural stability. It has been shown that this is improved through SVWBV training [14, 15]. The proven significant function of trunk stability while maintaining postural control [95] and the ability to influence these through SVWBV training would be important for future studies. An exact analysis of postural organization during the standing and gait phases before and after SVWBV training through the video control of reference points would lead to a more precise understanding of the functional changes. In addition, EMG measurements, for example, would make the changes in the postural stability of crucial muscle tissues/loops during the gait and standing phases more visible (see [93, 102]).
5. Conclusion

SVWBV training is an alternative training method used in the field of geriatrics to improve activity and participation levels as well as mental health. The easy implementation and the short duration of the training process make it advantageous for use in senior assisted living facilities. The positive effects of SVWBV training are especially significant at the level of bodily function and structure. Body destabilization, a frequent occurrence in old age as a result of inactivity, simultaneously leads to reductions in participation. SVWBV training can offer a suitable method to counteract this negative consequence without much effort. The noticeable positive results of this pilot study suggest the need to conduct a large applied RCT in this area. As already observed at other locations, seniors seemed to enjoy SVWBV training and its acceptance was consistently positive.

Future studies are necessary in order to be able to declare which areas show improved participation. An evaluation of the long-term effects of SVWBV training on the participation and mental health of seniors is also necessary. This would also involve a corresponding questionnaire for relatives and nursing home administrators since it is feared that the new social pattern established among the participants months ago will no longer be assessed as extraordinary.

In this area, it would be recommendable to compare SVWBV training with other forms of therapy within a controlled study that should have a larger pool of subjects so that the available results could be generalized. In this regard, it would also be sensible to make better use of custom-made measurement instruments to analyze the procedures.

The quality of life of seniors is becoming more and more important in our society as a result of imminent changes. Research in the area of assessing findings and conducting comparative studies make sense in each area in order to be able to better understand connections and to be able to provide elderly people with the best possible care.
6. Literature References


Chapter 6


[38] Fakten zur Depression. BKK. 2008 [online] Available from: http://www.barmer.de/barmer/web/Portale/Versichertenportal/Presse-Center/Pressemitteilungen/080520_20depression/fakten,property=Data.pdf [Accessed August 28 2008]


Chapter 6


Chapter 6


Chapter 6


### Attachment 1 – SVWBV Training Implementation Protocol

<table>
<thead>
<tr>
<th>Week</th>
<th>Duration</th>
<th>Frequency (Hz)</th>
<th>Method</th>
<th>Break(s)</th>
<th>Implementation</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>30</td>
<td>11 (a,b,c) 21 (d,e)</td>
<td>manual</td>
<td>45</td>
<td>static</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>4-6</td>
<td>45</td>
<td>11 (a,b,c) 21 (d,e)</td>
<td>manual</td>
<td>30</td>
<td>dynamic (d) + static</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7-9</td>
<td>60</td>
<td>11 (a,b,c) 21 (d,e)</td>
<td>manual</td>
<td>30</td>
<td>dynamic (d) + static</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10-12</td>
<td>60</td>
<td>11 (a,b,c) 21 (d,e)</td>
<td>manual</td>
<td>15</td>
<td>dynamic (d) + static</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 10: SVWBV Training Implementation Protocol**

**Explanation:**

- Letters “a-e” refer to positions “a-e”.
- The frequency of 11 Hz was selected for position 1-3 since it provokes a strong response on the trunk, extremities and thigh muscles.
- The frequency of 21 Hz was selected for positions 4-5 since it mainly activates the leg muscles.
- The “manual” method describes a special possible setting for the use of the TurboSonic device.
- The “TurboSonic Trainer Model TT2590 Professional” was used as the vibration platform.
Attachment 2

**Attachment 2 – Operating Instructions for “TurboSonic TT 2590”**

The TurboSonic TT 2590 device from the Swiss company known as Imporex AG was used in this study. Unlike similar machines, this device does not use a mechanical eccentric component to provide the vibration stimulus. The vibration is generated by means of a system similar to a loudspeaker. This produces a sinusoidal, vertical vibration of the platform by means of two electric coils and magnets (Figure 11). The frequency of the vibration can be continually adjusted based on the design within a frequency range of 3 Hz to 25 Hz. Many types of sports, for example, produce vibrations in the body at a frequency less than 10 Hz. An additional advantage of the continuous controllability of the frequency and the intensity of the vibration is the ability to target the stimulation to individual muscle groups. Depending on the frequency, a different increase of activity in electromyographic discharge occurs in different muscle groups.

![Figure 11: Schematic Design of the TurboSonic TT 2590](image)

[Imporex AG, 2008]

**EMG Activity during Vibration Training**

Electromyographic discharge is especially suitable to illustrate the effect of whole-body vibration. In this regard, the activity of an individual muscle in a muscle group or of individual fibers can be measured using electrodes. By analyzing muscle activity with and without vibration stimulus, conclusions can be drawn about the effectiveness of the administered training stimulus. Two frequencies were selected for this study that are targeted to strengthen the lower extremities and the trunk. The following four graphics are used to illustrate the effect of whole-body vibration at different frequency ranges on the human muscular system. Two diagrams show the average (root mean square RMS) of the increased muscle activity using the electromyographic discharge of the individual muscle groups at training frequencies of 8 Hz and 24 Hz (see figure 12 and figure 13). Two body charts illustrate the quantitative activation of the muscles of the entire human kinetic system and specify the regional and local differences at two different areas of frequency (see figure 14 and figure 15).
The following figures illustrate the electromyographic discharge for the frequency ranges of 8-11 Hz and 21-25 Hz. In figures 12 and 13, the orange curve represents the EMG discharge while standing without vibration and the red curve represents the increase in EMG activity during vibration at a frequency of 8 Hz and 21 Hz.

At a training frequency of 8 Hz, there is an average increase in muscle activity of 30-40 percent at a position without vibration compared to a position with vibration stimulus and an above average increase in the activity of the M.trapezius, M.glutaeus maximus and M.vastus medialis of an average of 40-60 percent (see figure 12).

![Figure 12: EMG Activity without vibration compared to vibration at a frequency of 8 Hz](Source: Imporex AG, 2008)

When compared to training without vibration, training with vibration at a frequency of 24 Hz resulted in increased activation of the M.rectus abdominis as well as M.glutaeus maximus and M.vastus medialis. The average increase in activity is around 30 percent. Figure 13 provides a graphic representation of this activity.

![Figure 13: EMG Activity without vibration compared to vibration at a frequency of 24 Hz](Source: Imporex AG, 2008)
The quantitative analysis of the activated muscle groups shows different activation patterns at the different vibration frequencies. By continually adjusting the frequency, it was possible to easily switch between the training frequencies.

Vibration at a frequency of 8 Hz especially activates the trunk muscles as well as the proximal muscle groups of the lower extremities with an effectiveness of 80-100 percent – illustrated in the following figure using the color red. Both the upper distal as well as the lower distal extremities are activated with an effectiveness of 80-100 percent. Figure 14 presents a schematic representation of human muscles and their activation through whole-body vibration at a frequency of 8 Hz.

![Figure 14: Schematic representation of muscle activity during whole-body vibration at a frequency of 8 Hz](Source: Imporex AG, 2008)

Vibration training at a frequency of 24 Hz results in a modified activity pattern when compared to a frequency of 8 Hz. With an effectiveness of 80-100 percent, the trunk muscles of the M.rectus abdominis as well as parts of the lower extremities, especially the Mm.ischiocrales are affected. The upper muscles of the lower extremities were activated with an effectiveness of 50-80 percent, while the trunk muscles as well as the muscle group of the upper extremities were activated with an effectiveness of 20-50 percent. Figure 15 presents a schematic view of the activation of the muscles groups at a training frequency of 24 Hz.

![Figure 15: Schematic representation of muscle activity during whole-body vibration at a frequency of 24 Hz](Source: Imporex AG, 2008)
Attachment 3 – Exercises

**Position A:**

**INITIAL POSITION:**

- **Feet:** parallel, shoulder length
- **Knees:** 5° flexion
- **Hips:** 5° flexion
- **Shoulders:** 85° anteflexion
- **Elbows:** 10° flexion
- **Hands:** neutral position, palms towards the body

Parallel standing position with the arms elevated and the palms pointing toward the body. The purpose of this position is to improve the connection of the upper extremities to the trunk and to strengthen and stabilize the shoulder girdle, the pelvic floor muscles and optimize the legs axes.

*Figure 16: Demonstration of Position A*

**Position B:**

**INITIAL POSITION:**

- **Feet:** shoulder length in stride position
- **Knees:** 5° flexion
- **Hips:** 5° flexion
- **Shoulders:** 85° anteflexion
- **Elbows:** 10° flexion
- **Hands:** neutral position, palm towards the body

Position B is an advanced version of Position A since there is a greater need for stability. The stride position brings the standing position to a functional level.

*Figure 17: Demonstration of Position B*
Position C:

INITIAL POSITION:

Feet: Shoulder length in stride position
Knees: 5° flexion
Hips: 5° flexion
1st Arm: Shoulder: 85° anteflexion
       Elbow: 10° flexion
2nd Arm: Shoulder: 10° anteflexion
       Elbow: 45° flexion
Hand: Hand at the height of the Crista iliaca,
      Palms towards the body
Spinal column: 45° rotation to the left or right.
      Reference point: sternum
Pelvis: aligned to the front

Figure 18: Demonstration of Position C

After the training goals of Position A, the emphasis here is on the rotation and stabilization of the spinal column. The modified arm position places greater demand on the entire organization of the subject's body than in Positions A and B.

Position D:

INITIAL POSITION:

Feet: parallel, shoulder length
Knees: 90° flexion
Hips: 100° flexion
Arms: neutral position, palm towards the body

This position is suitable for the targeted strengthening and stabilization of the bone axes.

Figure 19: Demonstration of Position D
**Position E:**

**INITIAL POSITION:**

*Standing on one leg, the subject holds on to the device with both hands.*

This position is suitable for the targeted stabilization and functional strengthening of the hip muscles.

*Figure 20: Demonstration of Position E*
Attachment 4 – Informed Consent Form

Name
______________________________

Date of Birth
______________________________

I, __________________________________________
(First and last name)

hereby state that I received the test subject information about the study entitled: “Whole-Body Vibration – Assisted Living” and this Informed Consent Form for Study Participants.

Furthermore, I declare the following:

I was sufficiently informed, both verbally and in writing, about this scientific investigation.

I know that I may withdraw my consent at any time without the need to provide a reason and without this resulting in any disadvantages to me.

I know that the study administrators bear no responsibility for any possible health damage or any other damage that could occur as a result of this study. I am solely responsible for my participation in this study.

I agree that during this scientific investigation, information about my medical problems and illnesses as well as specific personal data about me related to this study will be recorded. It is guaranteed that my personal data will not be distributed to third parties. If this study is published in a scientific journal, this data cannot be used to determine who participated in this study. My personal data is protected by the German Data Protection Act.

I agree with the procedures described above and I confirm by signing below.

_______________________________________
(Place, date, subject)

__________________________________________
(Place, date, therapist)
Attachment 5 – Daily Living Questionnaire (DLQ)  
(according to Bullinger et al. [87])

The following questions concern your activities during the past week. Please mark an X in the corresponding box next to each question.

During the past week, I was able to:

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Get my body to do what I wanted?</td>
<td>□</td>
</tr>
<tr>
<td>2. Concentrate on a specific task for an extended period of time?</td>
<td>□</td>
</tr>
<tr>
<td>3. Engage in a normal professional/household activity?</td>
<td>□</td>
</tr>
<tr>
<td>4. Accomplish what I had planned?</td>
<td>□</td>
</tr>
<tr>
<td>5. Sleep enough so that I feel fresh and rested?</td>
<td>□</td>
</tr>
<tr>
<td>6. Have contact with other people (visitors, telephone calls)?</td>
<td>□</td>
</tr>
<tr>
<td>7. Remember some things and facts?</td>
<td>□</td>
</tr>
<tr>
<td>8. Do something with my spare time?</td>
<td>□</td>
</tr>
<tr>
<td>9. Feel understood/supported by my family?</td>
<td>□</td>
</tr>
<tr>
<td>10. Eat with an appetite?</td>
<td>□</td>
</tr>
<tr>
<td>11. Participate in family life?</td>
<td>□</td>
</tr>
<tr>
<td>12. Dress, bathe and use the bathroom by myself?</td>
<td>□</td>
</tr>
<tr>
<td>13. Manage my illnesses?</td>
<td>□</td>
</tr>
<tr>
<td>14. Physically exert myself (running, carry, lifting)?</td>
<td>□</td>
</tr>
<tr>
<td>15. Believe in the meaning and success of my treatment?</td>
<td>□</td>
</tr>
<tr>
<td>16. Perform my household chores?</td>
<td>□</td>
</tr>
<tr>
<td>17. Feel good in the presence of others?</td>
<td>□</td>
</tr>
<tr>
<td>18. Enjoy life?</td>
<td>□</td>
</tr>
</tbody>
</table>
19. Feel like I am receiving good medical care? □ □ □ □ □ □
20. Do something together with other people? □ □ □ □ □ □
21. Make myself comfortable or relax? □ □ □ □ □ □
22. Overcome daily problems/conflicts? □ □ □ □ □ □
23. Be with my partner sexually? □ □ □ □ □ □
24. Go shopping and run errands outside the house? □ □ □ □ □ □
25. Be confident about the future? □ □ □ □ □ □
26. Move my body unhindered and without pain? □ □ □ □ □ □
27. Do something nice and enjoy it? □ □ □ □ □ □
28. Think clearly when planning or solving problems? □ □ □ □ □ □
29. Feel good about my family, get along with them? □ □ □ □ □ □
30. Engage in spare time activities? □ □ □ □ □ □
31. Groom myself? □ □ □ □ □ □
32. Be interested in something? □ □ □ □ □ □
33. Like/accept myself? □ □ □ □ □ □
34. Do something good for myself? □ □ □ □ □ □
35. Accomplish something I attempted? □ □ □ □ □ □
36. Pursue my hobbies and favorite activities? □ □ □ □ □ □
37. Talk with my partner about something that interests me? □ □ □ □ □ □
38. Arrange my life according to my own ideas and wishes? □ □ □ □ □ □
39. Feel self-confident? □ □ □ □ □ □
40. Rely on the help and understanding of my partner? □ □ □ □ □ □
41. Fulfill my obligations to my satisfaction? □ □ □ □ □ □
42. Feel like my doctor listened to my concerns? □ □ □ □ □ □
Attachment 6 – Munich Life-Quality Dimensions List (MLDL) (according to Bullinger et al. [87])

Instructions: The purpose of the following questionnaire is to determine how **satisfied** you were with different areas of your life **during the past week, including today**. Mark the number that best corresponds to you with an X.

<table>
<thead>
<tr>
<th>How satisfied are you with the following:</th>
<th>Very dissatisfied</th>
<th>Very satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. your health condition</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
<td></td>
</tr>
<tr>
<td>2. your physical ability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. your mental ability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. your personal well-being</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. your self-esteem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. your ability to relax</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. your success and recognition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. the support and security you receive from others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. your level of independence in daily life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. your marriage / partnership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. your sex life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. your family life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. your friendships / acquaintances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. your work situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. your financial situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. your living situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. your spare time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. your medical care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. the treatment of your illness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Performance Oriented Mobility Assessment (POMA) (according to D. Marks [97])

### Test form

<table>
<thead>
<tr>
<th>Tinetti Test</th>
<th>Step length and height, left swing foot</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sitting balance</em></td>
<td>Left foot does not pass right stance foot with step</td>
</tr>
<tr>
<td>0 Lean or slides in chair</td>
<td>Left foot passes right stance foot</td>
</tr>
<tr>
<td>1 Sits stably and safely on the chair</td>
<td>Left foot does not completely clear the floor</td>
</tr>
<tr>
<td>1 Sits stably and safely on the chair</td>
<td>Left foot completely clears the floor</td>
</tr>
<tr>
<td><em>Standing Up</em></td>
<td>Gait Symmetry</td>
</tr>
<tr>
<td>0 Unable to stand up without help</td>
<td>Right and left step lengths are not equal</td>
</tr>
<tr>
<td>1 Able to stand up using arms</td>
<td>Right and left step lengths appear equal</td>
</tr>
<tr>
<td>2 Able to stand up without using arms</td>
<td></td>
</tr>
<tr>
<td><em>Attempts to stand up</em></td>
<td>Step Continuity</td>
</tr>
<tr>
<td>0 Unable to stand up without help</td>
<td>Stopping or discontinuity between steps</td>
</tr>
<tr>
<td>1 Able to stand up after several attempts</td>
<td>Steps appear continuous</td>
</tr>
<tr>
<td>2 Able to stand up at first attempt</td>
<td></td>
</tr>
<tr>
<td><em>Immediate standing balance (first 5 seconds)</em></td>
<td>Path Deviation</td>
</tr>
<tr>
<td>0 Unsteady (small steps, marked trunk sway)</td>
<td>Marked deviation</td>
</tr>
<tr>
<td>1 Steady, but uses cane or other object for support</td>
<td>Slight deviation or needs walking aid</td>
</tr>
<tr>
<td>2 Steady without cane or other support</td>
<td>Straight without a walking aid</td>
</tr>
<tr>
<td><em>Standing Balance (wide stance)</em></td>
<td>Trunk Stability</td>
</tr>
<tr>
<td>0 Unsteady</td>
<td>Marked sway or needs walking aid</td>
</tr>
<tr>
<td>1 Steady, but with wide stance (more than 10 cm)</td>
<td>No sway, but leans forward or uses arms for balance</td>
</tr>
<tr>
<td>2 Steady, without cane or other support</td>
<td>No sway, does not lean forward, does not use arms for balance</td>
</tr>
<tr>
<td><em>Nudged (three light pushes on patient’s sternum)</em></td>
<td>Walking Stance</td>
</tr>
<tr>
<td>0 Falls without help</td>
<td>Feet apart while walking (more than 5 cm)</td>
</tr>
<tr>
<td>1 Takes backward steps, needs support, but does not fall</td>
<td>Feet after touching while walking</td>
</tr>
<tr>
<td>2 Steady</td>
<td></td>
</tr>
<tr>
<td><em>Eyes closed (narrowest possible stance)</em></td>
<td>Turing 360°</td>
</tr>
<tr>
<td>0 Unsteady</td>
<td>Discontinuous steps</td>
</tr>
<tr>
<td>1 Steady</td>
<td>Continuous steps</td>
</tr>
<tr>
<td>1 Steady</td>
<td>Unsteady</td>
</tr>
<tr>
<td><em>Initiation of gait (immediately after “go”)</em></td>
<td>Steady</td>
</tr>
<tr>
<td>0 Hesitancy or multiple attempts to start</td>
<td></td>
</tr>
<tr>
<td>1 No hesitancy</td>
<td></td>
</tr>
<tr>
<td>1 No hesitancy</td>
<td></td>
</tr>
<tr>
<td><em>Step length and height, right swing foot</em></td>
<td>Sitting Down</td>
</tr>
<tr>
<td>0 Right foot does not pass left stance foot with step</td>
<td>Unsafe (misjudged distance, falls into chair)</td>
</tr>
<tr>
<td>1 Right foot passes left stance foot</td>
<td>Uses arms or unsmooth motion</td>
</tr>
<tr>
<td>0 Right foot does not completely clear the floor</td>
<td>Safe smooth motion</td>
</tr>
<tr>
<td>1 Right foot completely clears the floor</td>
<td></td>
</tr>
</tbody>
</table>

= Total Balance Score (max. of 16 points)

= Total Gait Score (max. of 12 points)

= Total Score (max. of 28 points)
Now we would like to ask some questions about how concerned you are about the possibility of falling when you do certain activities. For each of the following activities, please consider how you normally do these activities. If you do not do the activity at the moment (for example, if someone does your shopping for you), please answer anyway to show whether you think you would be concerned about falling if you did the activity. Please mark the answer closest to your own opinion in order to show how concerned you are that you might fall if you did this activity.

<table>
<thead>
<tr>
<th></th>
<th>Not at all concerned</th>
<th>Somewhat concerned</th>
<th>Fairly concerned</th>
<th>Very concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cleaning the house (e.g. sweeping, vacuuming or dusting)</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Getting dressed or undressed</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Preparing simple meals</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Taking a bath or shower</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Going shopping</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Getting in or out of a chair</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Going up or down stairs</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Walking around the neighborhood</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Reaching for something above your head or on the ground</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Going to answer the telephone before it stops ringing</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Walking on a slippery surface (e.g. wet or icy)</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Visiting a friend or relative</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Walking in a crowded place</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Walking up or down a slope</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Attending an event (e.g. family gathering, social activity or religious service)</td>
<td>1 □ 2 □ 3 □ 4 □</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Attachment 9 – Geriatric Depression Scale (GDS)

According to S. Gauggel, B. Birkner [92].

For the following questions, please choose the answer that best describes your condition/feeling during the past few weeks.

1. Are you basically satisfied with your life? No
2. Have you dropped many of your activities or interests? Yes
3. Do you feel that your life is empty? Yes
4. Do you often get bored? Yes
5. Are you hopeful about the future? No
6. Are you bothered by thoughts you can’t get out of your head? Yes
7. Are you in good spirits most of the time? No
8. Are you afraid that something bad is going to happen to you? Yes
9. Do you feel happy most of the time? No
10. Do you often feel helpless? Yes
11. Do you often get restless and fidgety? Yes
12. Do you prefer to stay at home, rather than going out and doing new things? Yes
13. Do you frequently worry about the future? Yes
14. Do you feel you have more problems with memory than usually? Yes
15. Do you think it is wonderful to be alive now? No
16. Do you often feel downhearted and blue? Yes
17. Do you feel pretty worthless the way you are now? Yes
18. Do you worry a lot about the past? Yes
19. Do you find life very exciting? No
20. Is it hard for you to get started on new projects? Yes
21. Do you feel full of energy? No
22. Do you feel that your situation is hopeless? Yes
23. Do you think that most people are better off than you are? Yes
24. Do you frequently get upset over little things? Yes
25. Do you frequently feel like crying? Yes
26. Do you have trouble concentrating? Yes
27. Do you enjoy getting up in the morning? No
28. Do you avoid social gatherings? Yes
29. Is it easy for you to make decisions? No
30. Have you been able to think clearly in the past few weeks? No
Acknowledgments

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We wish a heartfelt thanks to all of you.

September 2008