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Certificado Profissional em Avaliação da Terapia Vibroacústica

# Principles and Techniques of Vibroacoustic Therapy Assessment

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Vibroacoustic therapy (VAT) is a multidisciplinary modality that combines low-frequency sound waves with mechanical vibration to influence physiological and psychological processes. The vocabulary surrounding VAT assessment is extensive, reflecting the interplay of acoustics, biomechanics, physiology, and clinical practice. This guide presents the essential terms and concepts that a professional assessor must master, offering definitions, practical examples, and discussion of common challenges.

**Acoustic Wave** – A disturbance that propagates through a medium as variations in pressure. In VAT, the wave is generated by a speaker or transducer and travels through air, the therapeutic medium (often a mattress or cushion), and finally into the body. Understanding the nature of the wave is critical for selecting appropriate equipment and interpreting assessment data.

**Frequency** – The number of complete cycles of a wave that occur in one second, measured in hertz (Hz). VAT typically employs frequencies between 20 Hz and 120 Hz, a range that can stimulate mechanoreceptors without causing discomfort. For example, a therapist may choose 40 Hz to target deep-tissue relaxation, while 80 Hz might be used for more superficial stimulation.

**Amplitude** – The maximum displacement of the wave from its equilibrium position, often expressed as displacement (mm), velocity (mm/s), or acceleration ( $\text{m/s}^2$ ). In practice, amplitude determines the intensity of the vibration felt by the client. A higher amplitude can increase muscle activation but may also raise the risk of adverse sensations.

**Waveform** – The shape of the acoustic signal over time. Common waveforms in VAT include sinusoidal, square, and triangular. A sinusoidal waveform produces smooth, continuous vibration, which is generally preferred for therapeutic purposes because it minimizes abrupt changes that could cause discomfort. Square waves, with their rapid rise and fall, may be employed in research to investigate specific neurophysiological responses.

**Harmonics** – Integer multiples of a fundamental frequency that occur naturally when a system vibrates. In a therapeutic setting, unintended harmonics can arise from equipment imperfections or resonant structures within the treatment environment. Recognising and controlling harmonics is essential for ensuring that the delivered frequency remains within the intended therapeutic window.

**Resonance** – The condition in which a system oscillates with maximum amplitude at a particular frequency, known as its resonant frequency. Human tissues have resonant frequencies that vary with composition and geometry. For instance, abdominal organs often resonate near 30 Hz, whereas muscle tissue may resonate closer to 50 Hz. Exploiting resonance can enhance therapeutic efficacy, but inadvertent resonance of non-target structures can lead to discomfort or injury.

**Acoustic Impedance** – The product of a medium's density and the speed of sound within it. It governs how much of an acoustic wave is reflected or transmitted at an interface. When a VAT device is placed on a mattress, the mismatch between the mattress and the body's impedance determines the proportion of vibrational energy that reaches the client. Proper coupling materials (e.G., Viscoelastic pads) are selected to minimise impedance mismatch.

**Mechanical Impedance** – The ratio of force to velocity for a vibrating system, encompassing mass, stiffness, and damping. In assessment, mechanical impedance is measured to evaluate how tissues resist vibration. A higher mechanical impedance may indicate increased muscle tone or fibrosis, while lower impedance can signal edema or reduced tissue stiffness.

**Tissue Elasticity** – The ability of tissue to return to its original shape after deformation. Elastic properties influence how vibrations are transmitted and absorbed. Elastography techniques, such as shear-wave elastography, can be integrated with VAT assessment to quantify elasticity changes before and after treatment.

**Viscosity** – The resistance of a fluid or semi-fluid tissue to flow. In the context of VAT, viscosity affects the damping of vibrational energy. Increased tissue viscosity, as observed in chronic inflammation, can attenuate the depth of vibration penetration, requiring adjustments in frequency or amplitude.

**Acoustic Pressure** – The instantaneous pressure variation caused by a sound wave. It is measured in pascals (Pa) and is directly related to the perceived loudness of the sound component of VAT. While the acoustic pressure component is generally low in therapeutic devices, excessive pressure can be a source of discomfort, especially for clients with hypersensitivity.

**Sound Pressure Level (SPL)** – A logarithmic measure of acoustic pressure relative to a reference value (20 µPa). SPL is expressed in decibels (dB). In VAT, SPL values typically range from 60 dB to 85 dB, which is comparable to normal conversation. Maintaining SPL within safe limits is a regulatory requirement and also influences client perception.

**Decibel (dB)** – The unit used to express the ratio between two quantities on a logarithmic scale. Because the human ear perceives sound logarithmically, the decibel scale provides a practical way to describe acoustic intensity. For example, a 3 dB increase corresponds to a doubling of acoustic power, an important consideration when adjusting device settings.

**Modal Analysis** – A technique that identifies the natural vibration modes of a structure. In VAT assessment, modal analysis can be applied to the treatment platform (e.G., A therapeutic bed) to ensure that its own resonant frequencies do not interfere with the therapeutic frequencies. This analysis typically involves measuring the frequency response function (FRF) of the platform.

**Spectral Analysis** – The process of decomposing a signal into its constituent frequencies, often using Fourier Transform methods. Spectral analysis enables the assessor to verify that the device delivers the intended frequency spectrum and to detect unwanted noise or harmonics. A typical spectral plot will show a dominant peak at the target frequency with smaller side lobes representing higher-order harmonics.

**Fourier Transform** – A mathematical operation that converts a time-domain signal into its frequency-domain representation. The Fast Fourier Transform (FFT) algorithm is widely used in real-time monitoring of VAT devices. By applying the FFT to vibration data, assessors can instantly visualise whether the output matches the prescribed frequency and amplitude.

**Time Domain** – The representation of a signal as it varies over time. Time-domain analysis is useful for observing transient events, such as the onset of vibration or sudden changes in amplitude. In VAT, time-domain plots allow the practitioner to verify the smoothness of the waveform and to detect any clipping or distortion.

**Frequency Domain** – The representation of a signal in terms of its constituent frequencies. Frequency-domain analysis provides insight into the spectral purity of the vibration and is essential for quality control. For instance, a therapist may use a frequency-domain display to confirm that a 60 Hz treatment contains less than 5 % energy in adjacent frequencies.

**Signal-to-Noise Ratio (SNR)** – The proportion of useful signal power to background noise power, expressed in decibels. A high SNR (> 30 dB) is desirable for accurate assessment. Low SNR can arise from ambient vibrations, electrical interference, or poor sensor placement, compromising the reliability of measurements.

**Calibration** – The process of adjusting an instrument to ensure its output accurately reflects the true value of the measured quantity. Calibration of VAT equipment involves verifying frequency, amplitude, and SPL against reference standards (e.g., A calibrated accelerometer). Regular calibration, typically quarterly, is mandated by most professional bodies to maintain data integrity.

**Baseline Assessment** – The initial evaluation of a client's physiological and biomechanical status before any therapeutic intervention. Baseline data include measurements of tissue impedance, muscle activity, heart rate variability, and subjective pain scores. Establishing a reliable baseline enables the practitioner to track treatment efficacy over time.

**Subjective Measures** – Self-reported data obtained directly from the client, such as pain intensity, relaxation level, or anxiety rating. Common instruments include the Visual Analogue Scale (VAS), the Numeric Rating Scale (NRS), and the State-Trait Anxiety Inventory (STAI). While subjective measures are essential for capturing the client's experience, they must be complemented by objective data to provide a comprehensive assessment.

**Objective Measures** – Quantifiable data obtained through instrumentation. In VAT assessment, objective measures may include electromyography (EMG) activity, skin temperature, heart rate variability (HRV), and blood flow velocity. Objective data provide a reproducible basis for evaluating physiological changes induced by the therapy.

**Electromyography (EMG)** – The recording of electrical activity produced by skeletal muscles. Surface EMG electrodes placed over target muscle groups can detect changes in muscle tone or activation patterns during VAT. A reduction in EMG amplitude during a 40 Hz session may indicate a relaxation effect, whereas an increase could suggest heightened muscular engagement.

**Thermography** – The imaging of surface temperature using infrared cameras. Thermographic assessment can reveal changes in blood flow and metabolic activity resulting from VAT. For example, a post-treatment increase of 0.5 °C in the lumbar region may reflect vasodilation induced by low-frequency vibration.

**Doppler Ultrasound** – An imaging technique that measures blood flow velocity by detecting frequency shifts in reflected ultrasound waves. In VAT, Doppler ultrasound can assess changes in arterial or venous flow in response to vibration, providing insight into circulatory benefits. An observed 15 % increase in femoral artery flow after a 30-minute session may support claims of improved peripheral circulation.

**Biofeedback** – The process of providing real-time physiological data to the client, allowing conscious control over bodily functions. In VAT, biofeedback may be used to teach clients to relax specific muscle groups while receiving vibration, thereby enhancing therapeutic outcomes. Integration of EMG biofeedback with VAT has been shown to reduce chronic low-back pain more effectively than vibration alone.

**Psychophysiological Response** – The combined psychological and physiological changes that occur in response to a stimulus. VAT can elicit reductions in cortisol levels, heart rate, and perceived stress, constituting a psychophysiological response. Measuring both cortisol (via saliva) and HRV provides a multidimensional picture of the client's stress reduction.

**Stress Index** – A composite metric derived from physiological parameters such as HRV, skin conductance, and cortisol concentration. A lower Stress Index after a series of VAT sessions may indicate successful stress management. Practitioners often track the Stress Index across multiple visits to evaluate long-term benefits.

**Autonomic Nervous System (ANS)** – The part of the nervous system responsible for involuntary bodily functions, comprising sympathetic and parasympathetic branches. VAT influences the ANS by promoting parasympathetic dominance, evident through increased HRV and reduced heart rate. Understanding ANS dynamics helps tailor treatment protocols for clients with anxiety or hypertension.

**Parasympathetic** – The branch of the ANS associated with rest-and-digest activities. Activation of the parasympathetic system during VAT can lead to decreased heart rate, improved digestion, and enhanced relaxation. Therapists may aim for a parasympathetic shift by selecting low-frequency, low-amplitude settings.

**Sympathetic** – The branch of the ANS that mediates fight-or-flight responses. Excessive sympathetic activity can manifest as elevated heart rate, muscle tension, and heightened anxiety. VAT protocols designed to attenuate sympathetic tone often incorporate gradual ramp-up of vibration intensity to avoid triggering stress responses.

**Transducer** – The device that converts electrical energy into mechanical vibration. In VAT, a loudspeaker or specialised low-frequency transducer is used. Transducer specifications, such as power handling (watts) and frequency response, determine the quality and reliability of the delivered vibration. Selecting a transducer with a flat response in the therapeutic range ensures consistent output.

**Speaker** – A type of transducer that produces sound and vibration simultaneously. Therapeutic speakers are often mounted beneath a mattress or cushion, allowing the client to lie or sit comfortably. The speaker's

diaphragm material (e.G., Kevlar, aluminum) influences durability and frequency fidelity.

**Coupler** – An interface that improves mechanical connection between the transducer and the therapeutic medium. Couplers may be made of silicone, rubber, or foam and are chosen based on impedance matching. A well-designed coupler reduces energy loss and ensures that the intended vibration reaches the client's body.

**Control Unit** – The electronic interface that allows the practitioner to set frequency, amplitude, waveform, and session duration. Modern control units often include touchscreen displays, data logging capabilities, and wireless connectivity for remote monitoring. Proper use of the control unit is essential for reproducibility across sessions.

**Amplifier** – An electronic component that boosts the signal from the control unit to drive the transducer at the required power level. Amplifier quality affects signal purity; low-noise amplifiers minimise distortion and preserve the harmonic content of the therapeutic signal.

**Filter** – An electronic circuit that removes unwanted frequencies from the signal. In VAT, band-pass filters are commonly employed to isolate the therapeutic frequency band (e.G., 30–70 Hz) while attenuating both lower-frequency hum and higher-frequency noise. Understanding filter characteristics (e.G., Q factor) helps fine-tune the output.

**Band-Pass Filter** – A filter that allows frequencies within a specified range to pass while rejecting frequencies outside that range. For a 40 Hz treatment, a band-pass filter with a 5 Hz bandwidth might be used to ensure that only frequencies between 37.5 Hz and 42.5 Hz reach the client.

**Low-Pass Filter** – A filter that permits low frequencies to pass while attenuating higher frequencies. Low-pass filtering can be useful when the therapeutic goal is to minimise high-frequency noise that could be perceived as uncomfortable.

**High-Pass Filter** – A filter that allows high frequencies to pass while blocking low frequencies. High-pass filters are rarely used alone in VAT but may be combined with other filters to shape the overall frequency response.

**Notch Filter** – A narrow-band filter that removes a specific frequency, often employed to eliminate mains hum (50 Hz or 60 Hz) that could interfere with the therapeutic signal. Proper placement of a notch filter prevents the inadvertent removal of the intended therapeutic frequency.

**Accelerometer** – A sensor that measures acceleration, often expressed in  $\text{m/s}^2$  or g-force. In VAT assessment, accelerometers are placed on the client's skin or on the therapeutic platform to verify that the delivered vibration matches the prescribed parameters. Calibration of accelerometers is crucial for accurate amplitude reporting.

**Vibrometer** – An instrument that measures vibration velocity or displacement, typically using laser-Doppler technology. Laser vibrometry provides non-contact measurement, allowing the assessor to map vibration distribution across the treatment surface without interfering with the client's comfort.

**Laser Doppler Vibrometer (LDV)** – A specific type of vibrometer that uses the Doppler shift of a laser beam reflected from a vibrating surface to calculate velocity. LDVs are valuable for detailed mapping of vibration hotspots and for validating the uniformity of the therapeutic field.

**Protocol** – A standardized set of procedures that defines how VAT is administered, including frequency, amplitude, session length, and client positioning. Protocols are often derived from research studies and adapted to clinical practice. Consistent adherence to a protocol enables comparison of outcomes across clients and studies.

**Dosage** – The total amount of vibrational energy delivered during a session, expressed as the product of intensity (amplitude), frequency, and duration. Dosage calculations help prevent over-exposure and guide progressive treatment plans. For instance, a dosage of 40 Hz × 0.5 G × 30 minutes may be prescribed for chronic low-back pain, while a lower dosage might be used for acute injury.

**Session** – A single treatment event in which VAT is applied. Sessions are typically scheduled weekly or bi-weekly, depending on the client's condition and therapeutic goals. Documentation of each session's parameters is essential for tracking progress and adjusting the treatment plan.

**Intensity** – The perceived strength of the vibration, closely related to amplitude but also influenced by frequency and waveform. Intensity is often adjusted based on client feedback; a client may describe a sensation as "mild," "moderate," or "strong." Objective intensity can be quantified using accelerometer data.

**Duration** – The length of time that vibration is applied during a session. Durations commonly range from 5 minutes for brief relaxation interventions to 45 minutes for comprehensive musculoskeletal protocols. Longer durations increase total dosage but may also raise the risk of fatigue.

**Frequency Range** – The span of frequencies that a device can generate. Devices with a wide frequency range (e.g., 10–120 Hz) provide flexibility for treating different conditions. However, a broader range may require more complex calibration and quality control procedures.

**Therapeutic Window** – The range of frequencies and amplitudes within which VAT produces beneficial effects without causing adverse reactions. Research suggests that the therapeutic window for most adult clients lies between 30 Hz and 80 Hz with amplitudes of 0.2 G to 1.0 G. Operating outside this window can lead to diminished efficacy or discomfort.

**Contraindications** – Specific conditions or circumstances in which VAT should not be applied. Common contraindications include recent fractures, acute inflammation, uncontrolled hypertension, implanted electronic devices (e.g., Pacemakers), and severe osteoporosis. Assessors must screen clients thoroughly to avoid adverse events.

**Adverse Effects** – Unintended negative outcomes that may arise from VAT, such as increased pain, skin irritation, or dizziness. While serious adverse effects are rare, documentation of any negative response is mandatory for ethical practice and for informing future protocol adjustments.

**Compliance** – The extent to which clients follow prescribed treatment schedules and instructions. High

compliance is associated with better outcomes, while low compliance can obscure the true efficacy of VAT. Strategies to improve compliance include client education, flexible scheduling, and regular progress reviews.

**Adherence** – Similar to compliance, adherence refers to the client's commitment to maintaining the therapeutic regimen. In research settings, adherence is often quantified using attendance logs and self-report diaries.

**Placebo Effect** – The improvement in a client's condition attributable to expectations rather than the active therapeutic component. In VAT research, sham devices that emit no vibration but produce similar auditory cues are used to control for the placebo effect. Recognising the placebo contribution helps interpret outcome data accurately.

**Expectation** – The client's belief about the likely benefits of VAT. Positive expectations can amplify therapeutic outcomes, while negative expectations may diminish them. Assessors often evaluate expectation using pre-treatment questionnaires.

**Reliability** – The degree to which a measurement yields consistent results under unchanged conditions. In VAT assessment, reliability is tested by repeated measurements of the same parameter (e.G., EMG amplitude) across multiple sessions. High reliability is essential for tracking true changes over time.

**Validity** – The extent to which a measurement accurately reflects the construct it intends to assess. For example, using HRV as a proxy for autonomic balance is valid only if the measurement protocol controls for confounding factors such as respiration rate and caffeine intake.

**Inter-rater Reliability** – The consistency of measurements taken by different assessors. Training and standardisation of sensor placement are critical for achieving high inter-rater reliability in VAT assessments.

**Intra-rater Reliability** – The consistency of measurements taken by the same assessor across multiple occasions. Regular calibration of equipment and adherence to a standard operating procedure contribute to strong intra-rater reliability.

**Signal Processing** – The series of computational steps applied to raw data to extract meaningful information. Common signal-processing techniques in VAT include filtering, windowing, averaging, and spectral analysis. Mastery of signal processing enables the assessor to differentiate true physiological changes from artefacts.

**Windowing** – The application of a mathematical function (e.G., Hamming, Hann) to a segment of data before performing an FFT. Windowing reduces spectral leakage, which can cause spurious frequency components in the analysis. Selecting the appropriate window is a key decision in data processing.

**Artifact** – Unwanted disturbances in the data that originate from sources other than the physiological signal of interest. In VAT, artifacts may arise from movement of the sensor, electrical interference from nearby equipment, or environmental vibrations. Identifying and removing artifacts is essential for accurate interpretation.

**Environmental Noise** – Ambient vibrations or acoustic disturbances present in the treatment room. Sources

include HVAC systems, traffic, and building vibrations. Mitigation strategies involve isolating the treatment platform, using vibration-damping flooring, and scheduling sessions during quieter periods.

**Operator Skill** – The proficiency of the practitioner in setting up equipment, positioning clients, and interpreting data. Operator skill directly influences the quality of the assessment and the safety of the client. Ongoing training and competency assessments are recommended to maintain high standards.

**Patient Positioning** – The arrangement of the client's body on the treatment platform. Proper positioning ensures uniform vibration transmission and reduces the risk of pressure points. For example, a supine position with a pillow under the knees can facilitate lumbar relaxation while maintaining spinal alignment.

**Pressure Mapping** – The use of pressure-sensitive mats to evaluate load distribution across the treatment surface. Pressure mapping helps identify areas of excessive pressure that could attenuate vibration or cause discomfort. Adjustments to cushions or mattress firmness can be made based on pressure data.

**Standard Operating Procedure (SOP)** – A documented set of instructions that outlines each step of the assessment process, from equipment setup to data recording. SOPs promote consistency, reduce errors, and serve as a training resource for new staff.

**Data Logging** – The systematic recording of all relevant parameters during a VAT session. Modern devices often include built-in data loggers that capture frequency, amplitude, SPL, and client-reported outcomes. Exporting data to secure servers facilitates longitudinal analysis.

**Statistical Analysis** – The application of statistical methods to interpret assessment data. Common techniques include paired t-tests for pre-post comparisons, ANOVA for multi-group studies, and regression analysis to explore dose-response relationships. Proper statistical analysis is vital for drawing evidence-based conclusions.

**Effect Size** – A quantitative measure of the magnitude of change produced by VAT, independent of sample size. Reporting effect sizes (e.g., Cohen's d) alongside p-values provides a clearer picture of clinical significance.

**Clinical Significance** – The degree to which a change in a measured outcome translates into a meaningful benefit for the client. For example, a reduction of 2 points on a 10-point pain scale may be statistically significant, but clinicians must decide whether this change improves the client's daily function.

**Outcome Measure** – Any variable used to assess the impact of VAT, such as pain intensity, range of motion, or quality-of-life scores. Selecting appropriate outcome measures that align with the therapeutic goal ensures that the assessment captures relevant changes.

**Reliability Coefficient** – A numerical value (often expressed as an intraclass correlation coefficient) that indicates the consistency of a measurement. Values above 0.80 are generally considered acceptable for clinical assessments.

**Calibration Curve** – A graph that relates the instrument's output to known reference values. For example, an accelerometer calibration curve plots voltage output against measured acceleration, allowing the

conversion of raw data into meaningful units.

**Dynamic Range** – The ratio between the smallest and largest signals that a device can accurately capture. A wide dynamic range is advantageous in VAT because it accommodates both subtle and robust vibrations without saturation.

**Latency** – The delay between the command to produce vibration and the actual onset of vibration. Low latency (**Feedback Loop** – A system wherein real-time data (e.g., EMG) are used to adjust vibration parameters automatically. Closed-loop feedback can optimise therapeutic intensity, maintaining the desired physiological response while preventing overstimulation.

**Open-Loop System** – A system that delivers vibration without adjusting parameters based on real-time physiological data. Most basic VAT devices operate in open-loop mode, requiring the practitioner to monitor client responses manually.

**Frequency Modulation (FM)** – The intentional variation of frequency over time. FM can be employed to prevent habituation, as subtle frequency shifts keep the nervous system responsive. A typical FM pattern might sweep from 30 Hz to 50 Hz over the course of a 20-minute session.

**Amplitude Modulation (AM)** – The intentional variation of amplitude over time. AM can create a pulsatile sensation that some clients find more relaxing. For example, a gentle AM pattern that rises and falls every 2 minutes can be combined with a steady frequency to enhance relaxation.

**Phase** – The relative position of a waveform in its cycle, expressed in degrees or radians. When multiple transducers are used, synchronising phase can produce constructive interference, amplifying vibration at the target site. Conversely, phase misalignment can lead to destructive interference and reduced efficacy.

**Constructive Interference** – The phenomenon where two waves combine to produce a larger amplitude. In VAT, positioning two speakers on opposite sides of a mattress and aligning their phase can create a focal point of increased vibration, useful for targeting specific muscle groups.

**Destructive Interference** – The phenomenon where two waves combine to diminish or cancel each other's amplitude. Unintended destructive interference can create "dead zones" where vibration is insufficient, highlighting the importance of careful device placement and phase control.

**Spatial Distribution** – The pattern of vibration intensity across the treatment surface. Mapping spatial distribution with a grid of accelerometers helps verify uniform coverage and identify hotspots or low-intensity zones.

**Frequency Sweep** – A protocol in which the frequency is gradually increased or decreased across a specified range during a single session. Frequency sweeps are used to locate individual resonant frequencies and to provide a comprehensive stimulus that may engage multiple mechanoreceptor types.

**Mechanoreceptor** – Sensory receptors in the skin and deeper tissues that respond to mechanical stimuli such as pressure and vibration. Key mechanoreceptors relevant to VAT include Pacinian corpuscles (responsive to high-frequency vibration) and Ruffini endings (responsive to low-frequency stretch).

Understanding receptor characteristics guides frequency selection.

**Pacinian Corpuscle** – A rapidly adapting mechanoreceptor located deep in the dermis and subcutaneous tissue, most sensitive to frequencies around 200–300 Hz. Although VAT typically operates below the optimal Pacinian range, low-frequency vibration can still activate these receptors indirectly through tissue coupling.

**Ruffini Ending** – A slowly adapting mechanoreceptor that detects skin stretch and low-frequency vibration (approximately 5–15 Hz). While VAT frequencies are higher, the mechanical coupling may stimulate Ruffini endings, contributing to proprioceptive feedback and joint stability.

**Muscle Spindle** – A proprioceptive organ within skeletal muscle that detects changes in muscle length and tension. Vibration can modulate spindle activity, leading to altered muscle tone. For instance, a 50 Hz vibration applied to the calf may reduce gastrocnemius tension via tonic vibration reflex inhibition.

**Tonic Vibration Reflex (TVR)** – A reflexive muscle contraction elicited by sustained vibration of a tendon or muscle belly. The TVR is often used diagnostically to assess neuromuscular function. In therapeutic contexts, controlled TVR activation can be harnessed to improve motor control in rehabilitation.

**Neuromodulation** – The alteration of nerve activity through targeted delivery of stimuli. VAT serves as a form of mechanical neuromodulation, influencing central and peripheral pathways. Evidence suggests that repeated VAT can lead to lasting changes in cortical excitability, supporting its use in neurorehabilitation.

**Neuroplasticity** – The brain's ability to reorganise its structure and function in response to experience. Repeated VAT sessions may promote neuroplastic changes, especially when combined with task-specific training. Monitoring neuroplasticity often involves functional imaging or neurophysiological assessments such as motor evoked potentials.

**Motor Evoked Potential (MEP)** – An electrical response recorded from a muscle following transcranial magnetic stimulation of the motor cortex. Changes in MEP amplitude after a series of VAT sessions can indicate alterations in corticospinal excitability, providing an objective measure of neurorehabilitative progress.

**Heart Rate Variability (HRV)** – The variation in time intervals between successive heartbeats, reflecting autonomic regulation. HRV analysis typically includes time-domain (e.g., RMSSD) and frequency-domain (e.g., LF/HF ratio) metrics. An increase in HRV after VAT suggests enhanced parasympathetic activity.

**RMSSD** – The root mean square of successive differences between normal heartbeats, a time-domain measure of short-term HRV. RMSSD is less affected by breathing patterns than other HRV indices, making it a reliable indicator of vagal tone post-VAT.

**LF/HF Ratio** – The ratio of low-frequency (0.04–0.15 Hz) to high-frequency (0.15–0.40 Hz) power in HRV spectral analysis. A lower LF/HF ratio after VAT is interpreted as a shift toward parasympathetic dominance.

**Skin Conductance** – A measure of the electrical conductance of the skin, reflecting sweat gland activity and sympathetic arousal. Decreases in skin conductance during VAT may accompany reductions in anxiety.

**Electrodermal Activity (EDA)** – The same phenomenon as skin conductance, often recorded with electrodes placed on the fingertips. EDA provides a continuous index of sympathetic nervous system activity throughout a VAT session.

**Respiratory Sinus Arrhythmia (RSA)** – The natural increase in heart rate during inhalation and decrease during exhalation, mediated by vagal activity. RSA amplitude can be enhanced by VAT when combined with paced breathing, reinforcing relaxation.

**Biomechanical Model** – A computational representation of the body that predicts how vibration propagates through tissues. Finite element models are commonly used to simulate vibration distribution in the lumbar spine, guiding optimal placement of transducers.

**Finite Element Analysis (FEA)** – A numerical method for solving complex biomechanical problems by dividing the structure into small, interconnected elements. In VAT, FEA can predict stress concentrations, helping to avoid excessive vibration in vulnerable regions.

**Stress Concentration** – A localized increase in stress within a material or tissue. Excessive stress concentration during VAT could exacerbate existing injuries. Identifying and mitigating these zones through modelling or sensor feedback safeguards client safety.

**Thermal Effect** – The increase in tissue temperature resulting from prolonged vibration. While modest warming (0.5–1 °C) can improve circulation, excessive heating may cause discomfort. Thermal monitoring, using infrared thermography, ensures temperature remains within safe limits.

**Metabolic Effect** – Changes in cellular metabolism induced by vibration, such as increased glucose uptake or enhanced mitochondrial activity. These effects are often investigated in research settings using blood biomarkers (e.g., Lactate, insulin) collected before and after VAT.

**Blood Biomarker** – A measurable substance in the blood that indicates a physiological or pathological state. In VAT studies, biomarkers such as cortisol, IL-6, and C-reactive protein are monitored to assess stress reduction and anti-inflammatory responses.

**Inflammatory Cytokine** – Signalling proteins released by immune cells that mediate inflammation. Reductions in pro-inflammatory cytokines (e.g., TNF- $\alpha$ ) after a series of VAT sessions have been reported, suggesting a systemic anti-inflammatory effect.

**Psychometric Scale** – A questionnaire that quantifies psychological constructs, such as anxiety, depression, or quality of life. Common scales used alongside VAT include the Beck Depression Inventory (BDI) and the Short Form Health Survey (SF-36). These scales complement physiological data to provide a holistic view of client wellbeing.

**Quality of Life (QoL)** – A multidimensional concept encompassing physical health, psychological state, social relationships, and environmental factors. Improvements in QoL scores after VAT are often used as primary outcomes in clinical trials.

**Usability** – The degree to which a device can be operated efficiently and effectively by the practitioner.

Usability assessments consider factors such as interface clarity, ease of sensor placement, and clarity of feedback indicators. High usability reduces training time and error rates.

Ergonomics – The study of designing equipment and workspaces to fit the user's needs and capabilities. In VAT, ergonomic considerations include the height of the control unit, the weight of transducers, and the adjustability of the treatment platform to minimise practitioner fatigue.

Standard Deviation (SD) – A statistical measure of the dispersion of a set of values around the mean. Reporting SD alongside mean outcome values provides insight into variability among clients.

Confidence Interval (CI) – A range of values within which the true population parameter is expected to lie with a given probability (commonly 95 %). Presenting CIs for effect sizes helps clinicians understand the precision of the estimated treatment effect.

Randomised Controlled Trial (RCT) – A study design that randomly assigns participants to an intervention or control group, considered the gold standard for evaluating efficacy. Many VAT investigations employ RCTs to compare active vibration with sham or standard care.

Sham Control – A placebo condition that mimics the active treatment without delivering therapeutic vibration. In VAT, a sham device may produce a low-frequency hum that is audible but not sufficient to generate measurable vibration, allowing blinding of participants.

Blinding – The practice of keeping participants, assessors, or both unaware of group allocation to reduce bias. Double-blinding in VAT studies is challenging because participants can often feel vibration, but innovative designs using subtle vibrations can improve blinding integrity.

Cross-Over Design – A study format in which participants receive both the active and sham interventions in a random order, separated by a wash-out period. Cross-over designs are efficient for VAT research because each participant serves as their own control.

Wash-out Period – The interval between treatment phases in a cross-over study, allowing any residual effects of the first intervention to dissipate. Determining an appropriate wash-out duration for VAT (often 1–2 weeks) is essential to avoid carry-over effects.