Hearing in various age groups of orchestral musicians and progression of hearing loss with increased number of years of music exposure

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This project has been reviewed and approved by the Central Regional Ethics Committee- CEN/06/06/048. If you have any concerns about the conduct of this research, please contact Committee Administrator: Ms. Sonia Scott: C/- Ministry of Health, 1-3 The Terrace, POBox-5013, Wellington, T: (04) 4962405. Email to: Sonia_ Scott@moh.govt.nz

Abstract

In Orchestra musicians hearing plays a very important role, and slight alterations in their hearing will have a significant impact on their performance ability as musicians. Although the effect of orchestra music on hearing is documented, existing researches have several drawbacks, and in most studies measurement of musical sound exposure is not linked to audiological test results. Some variables that may have a significant influence on resulting hearing loss are not taken into consideration. The literature review shows a confusing picture, and some studies identify high-frequency notches suggestive of noise induced threshold shift while others suggest musicians' hearing levels are not significantly different from a non-exposed population. There are strict legal requirements for the daily noise exposure a worker can receive in workplace but nothing to regulate non-occupational noise and music exposure.

This research work sets out to study the effects of playing in an orchestra on various age groups of musicians, to identify important variables that may potentially contribute to resulting hearing loss, and how playing in an orchestra or a band affects children in particular. In this study 37 out of 61 adult musicians (61%), 19 out of 85 youth musicians (22%) and six out of 37 children musicians (16%) were found to have a hearing loss. The sound exposure measurements confirm that there is an increased risk for hearing loss of all ages and the majority of musicians are also exposed to high impulse noise with the peak level of above 140dB. There is a broad individual difference in sensitivity and vulnerability. It is often difficult to estimate total sound exposure for every musician. Individual susceptibility seems to depend on known and unknown factors and interaction between intrinsic and extrinsic factors. Personal ear protection devices are seldom used among the musicians. Hence this study stresses the importance of an individualised hearing conservation programme that includes identifying all potential variables/factors that may increase the risk.

This thesis addresses the development of hearing loss in orchestra musicians, audio logical findings among players of different musical instruments, and methods of effective hearing conservation programmes for preventing hearing loss in musicians.

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Glossary

A

Acoustics: The science of sound, including its production transmission, reception and effects.

Audiogram: A standardised template or graph on which the hearing threshold of each ear is separately plotted as a function of frequency. Across the top horizontal axis the audible frequency bands are listed, and on the left axis, hearing threshold levels (in dB) in 10dB increments are listed (-10dB to 120dB hearing loss). The tracing is usually plotted by hand using the following convention: the red circles are joined by solid lines for the right ear and blue crosses are joined by dashed line for the left ear.

Audiologist: An audiologist is a healthcare professional specialising in identifying, diagnosing, treating and monitoring disorders of the auditory and vestibular system portions of the ear. Audiologists are trained to diagnose, manage and/or treat hearing or balance problems. They dispense hearing aids and recommend and map cochlear implants. They counsel families through a new diagnosis of hearing loss in infants, and help teach coping and compensation skills to late-deafened adults.

Audiometry: Pure tone audiometry is the measurement of the hearing threshold level of a person by a bilateral pure tone air conduction threshold test. The preferred method is based on the technique developed by Carthart and Jerker and later modified by Hughson and Westlake. The test is conducted by presenting a series of individual pure tones to the person (usually through headphones) in the audible frequency bands of 250, 500, 1000, 2,000, 4,000 and 8,000Hz. Tones are presented by a standardised procedure to determine the hearing threshold level in the particular frequency band. The results are presented in an audiogram.

Asymmetry in hearing: Significant difference in hearing between ears or significant inter-aural differences in hearing threshold sensitivity.

Aural rehabilitation: The process of identifying and diagnosing a hearing loss, providing different types of therapies to clients who are hearing impaired, and implementing different amplification devices to aid the client's hearing abilities. The goal of rehabilitation is to help the person to overcome the hearing handicap (disability).

A-frequency weighting: A network incorporated into a sound level meter to provide a simple measure of how loud a sound is perceived. A-frequency weighting has the response equal to the inverse of the equal loudness contour that passes through the 1000Hz at 30dB. Other frequency weightings such as B and C were developed, but now by international consensus and standardisation, A-frequency weighting is the weighting almost exclusively used for sound level measurement.

C

Cerumen or earwax: It is a naturally occurring substance found in the human ear. Although there are subtle differences between the terms cerumen and earwax, they are used interchangeably. Specifically, when the ceruminous glands in the external ear secrete oils, the result is cerumen.

D

decibel: The decibel (dB) is a unit used to measure sound intensity and other physical quantities. A decibel is one tenth of a bel (B). Its logarithmic scale is convenient to represent the entire range of human hearing.

Dose: The amount of noise exposure relative to the exposure limit for a working day and is stated as a percentage of the limit. In New Zealand, a noise dose of 100% is equivalent to 1 Pascal squared hour or an A-frequency weighted time-average level of 85dB over an 8-hour working day (LAeq 8h = 85dB).

Dosimeter: An integrating sound level meter of smaller size intended to be carried by the exposed person during the entire noise exposure period.

Daily sound exposure: The amount of sound energy a person receives in a day. For workers in industry it is the time integral of the squared instantaneous frequency weighted sound pressure over an 8-hour working day. The standard units are pascal squared seconds (Pa^2s), but in industry it is more convenient to use pascal squared hours (Pa^2 h).

Dips in the pure tone audiogram: Exposure to broad band, steady noise, or noise with an impulsive component, the first sign was a dip or notch in the audiogram maximal at 4kHz with recovery at 6 and 8kHz. The notch broadens with increasing exposure, and may eventually become indistinguishable from the changes of aging (presbycusis), where the hearing shows a gradual deterioration at the high frequencies. Although 4kHz is the classic frequency affected, the notch may be noted elsewhere because the frequency range of the noise influences where the cochlear damage occurs.

E

Ear Infection: An ear infection is usually defined as an inflammation of the middle ear, caused by bacteria, that occurs when fluid builds up behind the eardrum in the middle ear.

Ear Protection Device (EPD): Personal hearing protection devices are any type of ear protector that reduces the amount of volume perceived by the human ear, thereby preventing hearing damage in a loud environment. The three kinds of hearing protection are ear caps, earmuffs and ear plugs. The management of loud work environments, such as construction sites and shooting ranges, have a responsibility to ensure their employees are equipped with proper ear protection to prevent risk of hearing loss.

F

Frequency of sound: As sound is generated by vibration of some sort, the frequency of sound is its number of vibrations per second. Frequency is measured in cycles per second, or Hertz (Hz). The higher the pitch of the sound, the higher the frequency. A low pitch such as a deep voice or a tuba makes fewer vibrations per second than a high voice or violin. Generally, noise induce hearing loss occurs at a pitch of about 2000-4000Hz.

H

Hair cells are the sensory receptors of both the auditory system and the vestibular system in all vertebrates. In mammals the auditory hair cells are located within the organ of Corti on a thin basilar membrane in the cochlea of the inner ear. In mammals, cochlear hair cells come in two anatomically and functionally distinct types: the outer and inner hair cells. Damage to these hair cells results in decreased hearing sensitivity, which is called sensorineural hearing loss.

Hearing loss: Hearing loss is a reduced ability to hear sounds in comparison to normal hearing. Hearing loss ranges from slight to profound.

Hearing threshold: Hearing threshold is the sound level below which a person's ear is unable to detect any sound. For adults, 0dB is the reference level.

Hearing Conservationist: A certified occupational hearing conservationist "is a person who can conduct the practice of hearing conservation, including a pure–tone air conduction hearing evaluation and other associated duties under appropriate supervision, and who can function with other members of the occupational hearing conservation programme team."

Hearing conservation programme: It is a programme designed to prevent noise induced hearing loss. A written hearing conservation programme is required by New Zealand Health and Safety in employment whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 80 decibels measured on the A scale (slow response) or, equivalently, a dose of 40 percent.

I

Individual susceptibility: the marked variability in the manner in which individuals are affected by the same exposure to a toxic agent.

Impulse Noise: Impulse noise is often defined as noise consisting of single bursts with the duration of less than one tenth of a second.

Integrating-averaging sound level meter: An instrument that is used for measuring sound pressure level with standard frequency weighting components and a standard time averaging facility. These instruments are able to log, integrate and process data collected over a specified time period(s) to give values for a suite of standardised sound descriptors such as time-average level, peak level, maximum sound pressure level (in some instruments, exceedance levels and sound exposure levels depending on usage) for the period sampled. In addition to giving numerical values for these parameters, many modern meters are produced with accompanying software to allow data to be downloaded to a computer for further processing and production of graphics such as time histories.

Intensity of sound: Intensity of sound is measured in decibels (dB). The scale runs from the faintest sound the human ear can detect, which is labelled 0dB, to over 180dB, the noise at a rocket pad during launch. Decibels are measured logarithmically, being 20 times the log of the ratio of a particular sound pressure to a reference value of 20μPa.

ISO (International Organization for Standardization): The world's largest developer and publisher of International Standards. It is a non-governmental organisation that forms a link between the public and private sectors. ISO is a network of the national standards institutes of 162 countries, one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. It enables a consensus to be reached on solutions that meet both the requirements of business and the broader needs of society.

L

Leq: See Time Average Level below.

L_{avg}: A metric for monitoring noise proposed by US Occupational Safety and Health Administration(OSHA) standard. The L_{avg} is based on the premise that damage accrued in the ear during periods of high noise is partially repaired during intermittent low noise periods.

L_{Peak}: peak sound pressure: The level of the highest instantaneous sound pressure, in decibels, that occurs during a given time period.

M

Maximum A-frequency weighted sound pressure level (LAmax): This is 10 times the logarithm to the base 10 of the square of the ratio of the maximum sound pressure, to the reference value 20μPa. This is an RMS value and must not be confused with the peak level (L_{peak}), a non-RMS value.

Mismatch Negativity (MMN): It is defined as a component of the event-related potential (ERP) to an odd stimulus in a sequence of stimuli. It arises from electrical activity in the brain and is studied within the field of cognitive neuroscience and psychology. It can occur in any sensory system, but has frequently been studied for audition and for vision.

Music Induced Hearing loss (MIHL): Hearing loss due to excessive, unprotected exposures to loud music. This includes listening to an MP3 player, attending a rock concert, or playing an instrument in an orchestra or band. Also refers to exposures to high volume of music over time that can cause permanent damage.

N

Noise: In a narrow sense, noise can be considered as unwanted sound and refers to cases where the potentially affected person is not intentionally listening. In a broader sense, noise is often used as a synonym for sound.

Noise Induced Hearing loss: Noise induced hearing loss is a permanent hearing impairment resulting from prolonged exposure to high levels of noise. One in 10 people in New Zealand has a hearing loss that affects his or her ability to understand normal speech. Excessive noise exposure is the most common cause of hearing loss.

O

Occupational Safety and Health Administration (OSHA): OSHA is an agency of the US government (under the Department of Labour) with the responsibility of ensuring safety at work and a healthful work environment.

Octave bands: The division of the audible frequency range into a standardised series of adjacent frequency bands where the upper frequency is twice the lower frequency. Each of these bands can be further divided into one-third octave band frequencies.

Orchestra: Is a group of instrumental ensemble that contains sections of string, brass, woodwind and percussion instruments. The orchestra grew by accretion throughout the 18th and 19th centuries, but changed little in composition during the course of the 20th century.

Orchestra pit: Is the area that is located in a lowered area in front of or under the stage, in which musicians perform. The conductor is typically positioned at the front of the orchestral pit facing the stage.

Oto-acoustic emissions (OAEs): Sounds made by our inner ear as it works to extract the information from sound to pass on to the brain. These biological sounds are a natural by-product of this energetic biological process and their existence provides us with a valuable ‘window’ on the mechanism of hearing, allowing us to detect the first signs of deafness – even in newborn babies. Distortion Product Oto-acoustic Emission or dual-tone evoked distortion product is produced from an ear during the non-linear amplification of sound energy in the cochlea.

Otolaryngology: Study of medical and surgical management and treatment of patients with diseases and disorders of the ear, nose, throat (ENT), and related structures of the head and neck. They are commonly referred to as ENT department.

Otoscopy: It is a visual inspection of the ear drum and the auditory canal.

P

Patho-Pysiology: It is a study of the biological and physical manifestations of disease as they correlate with the underlying abnormalities and physiological disturbances.

Peak level (Lpeak): The peak level, expressed in decibels, is 10 times the logarithm, to base 10 of the square of the ratio of the peak sound pressure to the reference value 20µPa. It is a non-RMS value and should not be confused with LAmax. It has no frequency weighting, but to limit the measurement to sound in the audio-frequency range, a 'Z' weighting is used to provide a cut off at high and at low frequencies. A 'C'weighting is often used if no 'Z' weighting is provided on the sound level meter and is stipulated in some standards. In New Zealand it is measured according to NZS 6801:1999 Acoustics – the measurement of sound.

Perilymph: The fluid between the bony and membranous labyrinths of the ear.

Presbyacusis: The sensorineural hearing deterioration associated with age.

Permanent threshold shift: Permanent threshold shift is a permanent loss of hearing and can occur with regular exposure to excessive noise for long periods of time. It can also occur with exposure to very high sound levels for a short period of time. This type of hearing loss will normally continue to increase for up to five years after exposure to the noise.

S

Signal-to-noise ratio (SNR): The signal level minus the noise level (dB).

Sound exposure: The time integral of the squared instantaneous frequency weighted sound pressure over a specified time interval or event. The standard units are in pascal squared seconds (Pa^2s) but can also be quoted in pascal squared hours (Pa^2h).

Sound level meter: An instrument to measure the sound pressure level in decibels (dB), and complying with either or both IEC 60651 or IEC 61672.

Sound pressure level (L_P): Expressed in decibels is ten times the logarithm of the square of the ratio of the frequency weighted and time weighted sound pressure level to the reference value 20 µPa.

Standard deviation (SD): It is a statistical value used to determine how spread out the data in a sample is, and how close individual data points are to the mean, or average value of the sample.

T

Tone: Sound that has a definite pitch. Any given tone is characterised by length, loudness, timbre, and a characteristic pattern of onset and decay.

Tinnitus: Tinnitus is a condition in which a person hears a ringing, buzzing or hissing sound which is caused by the hearing system itself and not by any external sources. Tinnitus can be temporary or persistent and is relatively widespread. It is often associated with hearing impairment, ageing or exposure to loud sounds, and generally involves the part of the nervous system that deals with hearing.

Threshold of hearing: This is the minimum sound pressure level for a specific sound that can evoke an auditory response.

Time-average level ($L_{Aeq\ t}$): The value of the A-frequency weighted sound pressure level of a continuous steady sound that, within a measurement sample time (t), has the same mean square sound pressure as the sound under investigation whose level varies with time. The time period for every LAeq measurement should be stated.

Temporary threshold shift (TTS): The temporary raising of the hearing threshold level after exposure to loud sound.

Threshold of pain: The minimum sound pressure level of a specified sound, which will give a definite sensation of pain (for a given individual).

Transient oto-acoustic emissions (TOAEs): Sounds emitted in response to an acoustic stimulus of very short duration; usually these are clicks, but they can be tone-bursts.

Tympanometry: A technique designed to measure the response of the middle ear to sound energy and provides quantitative information on the function and presence of fluid in the middle ear.

W

Weighting: This refers to the effect on a signal of electronic circuits that modify the signal in a standardised manner. Frequency weighting refers to modifiers of frequency response. Time weighting refers to modifiers of the integration time.

WHO: The World Health Organization.