Music as an effective intervention to muscle tone

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Abstract: Hypertonia is defined as the abnormal increase in muscle tone as a result of neurological disorders. People with hypertonia may have abnormal movement patterns, muscle contracture. Their activities of daily life, quality of life will be affected seriously. Although pharmaceutical treatment and rehabilitation therapy are the main intervention of hypertonia, pharmaceutical treatment has numerous side effects and rehabilitation therapy are lack of powerful evidence to prove the treatment outcome. Music engaged in a wide spectrum of brain areas and has effects on the autonomic nervous system (ANS) due to the music-neuro entrainment process, it could be a pleasant and convenient intervention for people with hypertonia. Previous studies about music intervention for hypertonia are scarce. In this article, we stated the potential neuro mechanism induced by music and summarized different techniques of music-induced muscle relaxation including music listening intervention (MLI), music assisted relaxation, and vibroacoustic therapy. We also summed up some important considerations in the music intervention process such as music selection, the form of music intervention, and individual differences in response to music. Future research will be needed to dig into the music-induced muscle relaxation field and integrate the standard and unified protocol in clinical practice.

1. Introduction

Hypertonia is one of the most serious impairments following neurological disorders such as stroke, multiple sclerosis, cerebral palsy, and Parkinson's disease [1]. It is defined as an abnormal increase of muscle tone due to upper neuron lesion injuries [2]. Two types of hypertonia should be distinguished: pyramidal or extrapyramidal hypertonia. The first type describes "a velocity-dependent increase in muscle tone as a result hyper excitability of the stretch reflex" [3], which is also known as spasticity, and mostly presented during voluntary movements. While the latter, extrapyramidal hypertonia or rigidity, is happened during slow passive movement. Without effective management, it may lead to abnormal movement patterns, pain, joint deformity, muscle contracture, and imbalance [4] and even cause disabilities and impact a person's activities of daily life and quality of life ultimately [2].

Current treatment of hypertonia consists of pharmaceutical and non-pharmaceutical treatment. Pharmaceutical treatment mainly consists of botulinum neurotoxin (BoNT) therapy and oral anti-spasticity medication (eg. baclofen, benzodiazepines).

It could show recurrence of spasticity yet patients may demand frequent injections to achieve better clinical outcomes [5], and anti-spasticity medication may show adverse effects including vertigo, muscle weakness, and hypotension [6, 7].

Non-pharmaceutical treatment refers primarily to rehabilitation therapy consists of physiotherapy and occupational therapy, and they occupy a large percentage part in the treatment of hypertonia. Splinting, muscle passive stretching, positioning, physical modalities, and functional training are known to be effective for hypertonia. However, powerful evidence related to the treatment outcomes and the wide use of these treatment modalities is lacking [2, 8].

During the last ten years, music-based intervention (MBI) had received a lot of attention, a growing number of studies have addressed its treatment effects. Various health conditions include neurological impairments, cancerous pain, and mental disorders can be the targeted condition and benefit from MBI. MBI operated by health-related staff usually consists of singing, listening, or playing an instrument.

Plenty of researches have examined the benefit of MBI for mood, cognition, speech, and motor performance [9]. Studies also showed the advantage of music as a pleasant modality of improving muscle tone among patients with neurological disorders [1, 10].

The American Music Therapy Association (AMTA) suggested music therapy (MT) is an evidence-based and therapeutic use of music interventions to achieve individualized goals by a credentialed music therapist to address patients' cognitive, physical, social, and emotional needs. The process of MT is more standardized and systematic and provides 4 main methods in clinical practice: listening, recreating, composing, and improvising. In this review, we use the term music-based intervention (MBI) for studies where the intervention is delivered by health-related staff rather than professional music therapists, or their participation remains unclear; for studies where credentialed music therapists were involved, we will use the term music therapy (MT) [11].

In terms of the reasons mentioned above, music might be a great non-pharmacological option for patients with neurological impairments who are suffering from hypertonia or spasticity. In this article, we aimed to investigate whether music is an effective instrument to them.

2. Possible mechanism of music induced muscle relaxation

Music is an intentional auditory stimulus that puts music elements such as beat, rhythm, melody, timbre, harmony, form, and style in an organized way. People in ancient times used music as a therapy method to enhance well-being, reduce pain and suffering. And in modern medicine, it is used as an intervention tool through its effect on physiology and clinical symptoms [12].

Music engaged in a wide spectrum of processes in our brain, not only sensorimotor, but also attentional, memorial, perceptual, emotional, and communicational[13]. When a person listens to music, it activates the brain in cortical, subcortical, paralimbic areas, and also relative biological systems [13]. These areas are also related to a person's emotion and reward, and also regulate cognition and arousal, endocrine and hormonal responses [14]. Besides, strong indications had proved that music has effects on the autonomic nervous system (ANS) [15], and due to the particular specialty of music-neuro entrainment process, the human could respond to the external and internal stimuli synchronically. As a result, music might induce change in one's heart rate (HR), blood pressure (BP), respiration, muscle tension, and biochemical responses [10, 16]. Therefore, music might be a great option to induce muscle relaxation and its pleasant character might lead to better therapy compliance [10].

As Hanser [17] proposed, anxiety could be defined as an observable and physiological change in the sympathetic nervous system. Reduction in the physiological index such as muscular tension had been reported as general indicators of reduced stress and anxiety levels [18-20]. Therefore, it is reasonable for us to speculate that music interventions for anxiety can also play a vital role in decreasing muscle tone.

Bradt, Dileo and Potvin [21] had reported that music could be used to reduce distress and anxiety among people with health issues. They studied individuals with coronary heart disease (CHD) who often suffer from serious stress, investigate the effects of music intervention on the physiological and psychological status of patients. They found that music listening intervention (MLI) has a beneficial effect on the anxiety of patients with CHD, and a greater anxiety-reduced effect had shown in the studies that used patient-selected music; Stanczyk [22] concluded that music listening could help oncology patients cope with high levels of stress, and take their mind away from the undergoing anxiety when they are having a hard time of radiotherapy. Music-assisted relaxation may also assist patients through cancer treatments by guiding them to relax their body and mind, symptoms include anxiety and pain will be further addressed.

In addition to psychological relaxation, these studies also collect data about changes in the physiological parameters. Studies reported changed physiological parameters related to music intervention include muscle tension, heart rate (HR), blood pressure (BP), respiratory rate (RR), oxygen saturation (SpO2), etc [21, 23].

3. History of music-induced muscle relaxation

Due to previous research about the relationship between music and its effect on the human's body, music might have great potential as a tool to affect muscle tone among patients with neurological disorders.

In the 1950s and 1960s, Sears et al had found that muscle tone could be altered by music in predictable ways, and this is the very first study that revealed the relationship between muscle tone and music by the use of surface electromyography (EMG) [10].

Nevertheless, Dainow [24] mentioned that little attention was given to the relationship between music and muscle tone, the studies related to muscle tension or electromyography (EMG) are surprisingly scarce.

Some later studies had mentioned or used music intervention in patients with neurological diseases that had achieved certain effects on their muscle tension. A study in 2019 [25] mentioned decreasing muscle tone and general sedative action when patients with stroke are listening to melodic music with a low volume.

Van Criekinge, D'Août, O'Brien and Coutinho [1] wrote a systematic literature review of randomized control trials (RCTs) to investigate the effect of music listening on hypertonia in neurological impaired people, and the evidence of using music as a tool to reduce hypertonia or spasticity is supportive. The conclusion suggested that MLI could be used during rehabilitation tasks (e.g., physiotherapy) or during the break.

In 2021, the team published another article on the relationship between muscle tone and music, and this time they focused on whether music could induce affective states of relaxation and accelerate the recovery of fatigued muscles for people living with hypertonia. They found that listening to sedative or relaxing music resulted in a faster recovery rate of muscle and improved the motor quality when the participant is performing a drinking task. They speculate that the reduction in muscle fatigue induced by music was due to the neural regulation process, which is. in line with the previous study showing that music listening could positively affect one's neural activity [26].

4. Different techniques of music-induced muscle relaxation

Music-related therapy mainly consists of music listening intervention (MLI), music induced relaxation, vibroacoustic therapy and the others.

4.1 Music listening intervention (MLI)

Music listening is a ubiquitous companion and one of the most popular entertainments in people's daily life, because of its neuro mechanism and physical responses, people nowadays sometimes use it as a clinical intervention tool to induce internal body processes such as heart rate, muscle tone, blood volume and respiration [27], and research had proved listening music is able to provide muscle relaxation for people with neurological disorders [1].

In clinical practice, because it is convenient, inexpensive [28], easy to operate and no professional knowledge required, MLI seems to be the most frequently used method of MBI.

According to the recent work [1], MLI has been presented in various ways. They found the variables of MLI not only include music selection (eg. people who selected the music, self-preferences) and different elements of music (eg. loudness, tempo, and music style) but also include intervention time, space, and equipment. Even some interventions presented music in creative ways, such as Warth, Keßler, Hillecke and Bardenheuer [29] had used voice combined with the instrument—a monochord lived performance to improve relaxation outcome.

4.2 Music assisted relaxation

Music-assisted relaxation is a kind of relaxation technique combined with music, it has been used to decrease muscle tension, fatigue, and anxiety levels in many populations in medical settings [30, 31].

In a music-assisted relaxation or imagery intervention, the patient is aiming to facilitate muscle relaxation successfully, and the therapist will instruct the patient to get into a comfortable position and lead the patients' attention to breathing, then patients begin to relax the body from top to bottom or in the opposite direction. Following the music, visual, and tactile imagery intervention, sensation are encouraged during the task Tamplin and Baker [32].

Robb [33] studied comparison of music assisted progressive muscle relaxation (M + PMR), progressive muscle relaxation, music listening, and silence, and she found although each treatment condition had an equal effect in producing changes in anxiety and perceived relaxation, M + PMR elicited the greatest amount of change including self-relaxation experience, state of mind; in Scartelli [34]'s study, a greater reduction of muscle tone was detected in the relaxation training with sedative instrumental music background group than the relaxation group among cerebral palsy adults.

4.3 Vibroacoustic therapy

In 1980, an intervention named vibroacoustic therapy was devised by Olav Skille in Norway, and it is a low-frequency sound massage. It requires the patient to lie on a bed (or sits on a bench) with 4 or 6 loudspeakers on the side, the sound tends to be a mixture of gentle and rhythmic music, and it will be directly transferred through the cushions or mattress. According to the subjective tests, lower frequencies, 40 to 55 Hz will produce a resonant response in the legs, lower lumbar, and pelvic region. Research demonstrated the quite striking effects of vibroacoustic therapy among patients with wide-ranging problems, such as pulmonary disorders, rheumatoid conditions, and profound physical disabilities. Positive evidence showed patients with severe spasticity had demonstrated lower spasm, and reduction in muscle tone with vibroacoustic therapy [35].

Other MT interventions such as environmental music therapy, music sedation technique (which to improve sleep quality), guided imagery, and meditation were not aimed to reduce muscle tone, nevertheless, they have the effect of reducing muscle tension, so we believe that these techniques also need to be paid attention to, and future research could fill the gap in this direction.

5. Music selection

A lot of studies mentioned the type of music they chose in their intervention, and it could be diverse. Varieties of choices not only include the type of music such as Eastern classical instrumental pieces [36], nature sounds [37], contemporary music with lyrics, religious music, but also include different individual-selected music. Some reported using music chosen from family members, while some used patients' preferences as the first choice [38]. It should be noticed that musical preferences seem to play a major role in the treatment effect. Van Criekinge, D'Août, O'Brien and Coutinho [1] suggested using patients' preferences when selecting songs aiming to influence muscle tone, as they found studies that used self-selected music had achieved the greatest treatment effects. The advice of professional music therapists is also worth considering, Tamplin and Baker [32] suggested that music should be steady and without sudden change (eg. tempo, dynamics, or key), which is a great principle that could be adopted in the music selection process.

6. Active and passive form of music intervention

Warth, Keßler, Hillecke and Bardenheuer [29] employed trained music therapists in their study, whereas a lot of studies did not mention the operator of music intervention. In Davis and Thaut [18]'s study, " the researcher placed the cassette recording of the self-selected music into the tape deck"; Van Criekinge, D'Août, O'Brien and Coutinho [10] described the process as " participants heard an audio message via headphones… after 30s, the music tracks would start..." It should be noticed that medical staff of different specialties (professional music therapists and others) may affect the results of the clinical trial because of their different professional perspectives, and this should also be taken into consideration. The different therapist may also utilize different forms of intervention. A major difference lies in the way patient receives music therapy, passive or active. The aim of passive music

therapy is to guide patients to be in a comfortable position to relax their body and mind or visualize peaceful images, while active music therapy requires patients to participate in the music performance [39]. At present, plenty of music intervention for muscle tone is provided in a passive way, whether active music interventions can also cause the change of the muscle tone is also worthy of study. We assume that maybe music-assisted functional activity can also improve the movement of muscle activity, make movements more coordinated, so as to produce the effect of reducing muscle tone.

7. Individuals differences in responses to music

Individual differences should be taken into account in the process of music intervention. Harrer and Harrer [40] thought the stability of an individual's autonomic regulatory system, emotional reactivity, and individual's attitudes toward the stimulus (music) are the three factors that might be responsible for determining response to music [18]. Therefore, it is unsurprising that different results will be presented among people who intervened with music. In addition to individual responses to music, a crucial point cannot be ignored. Van Criekinge, D'Août, O'Brien and Coutinho [1] concluded that different kinds of hypertonia or spasticity due to different pathologies seem have different effects of music intervention. But those studies they analyzed basically related to upper motor neuron involvement (eg. stroke, traumatic brain injury, cerebral palsy, and decreased conscious state), and all of them had symptoms of pyramidal hypertonia, while did not include patients who had extrapyramidal hypertonia or rigidity (eg. Parkinson's disease). According to Galvan and Wichmann [41], sound-based intervention may not influence extrapyramidal muscle tone because its techniques such as auditory cueing are designed to bypass the involvement of the basal ganglia which is the main structure of extrapyramidal. Therefore, we believe that maybe not all patients with neurological disorders will benefit from music intervention and the type of hypertonia should be assured if further studies want to obtain a desired treatment affects.

8. Conclusion

In recent years, the physiological response caused by music has been widely concerned by health-related staff. People wish that this non-pharmacological, non-invasive, and pleasant means can be more effectively used in clinical treatment. Different studies have confirmed that music does affect muscle tone, diverse techniques can choose to promote muscle relaxation in neurologically impaired patients. In addition, music selection and the way of how music interventions are presented should be taken into account if we try to get a satisfactory outcome. Obviously, in the current practice, it is still lack of standard and unified protocol for music intervention related to muscle tone, several gaps were found in the literature which should be focus on.

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