Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

The Biological basis of Carnatic Music Therapy(CMT): Exploring the links

Saranya Varadarajan[1], Lakshmi Priya Sridhar[2], Aravindhan Thirputkuzhi Ranganathan[3], Rajeswari Ramesh[4], Pearlcid Siroraj. A[5], Swaminathan Rajendiran[6], Raghunathan Jagannathan[7], Thodur Madapusi Balaji[8*]

[1]Senior Lecturer, Department of Oral and Maxillofacial Pathology, Sree Venkateswara Dental College, Chennai.
[2]Reader, Department of Pedodontics, Chettinad Dental College, Chennai.
[3] Professor and Head, Department of Periodontics, Dental College, Azamgarh, Uttar Pradesh.
[4]Consultant Oral and Maxillifacial Pathologist, Siroraj Hospital, Thoothukudi, Tamil Nadu.
[5]Senior Lecturer, Department of Oral and Maxillofacial Surgery, Sri Ramachandra Institute of higher education and research (SRIHER).
[6]Senior Lecturer, Department of Periodontics, Sree Venkateswara Dental College, Chennai.
[7]Senior Lecturer, Department of Periodontics, Tagore Dental College and Hospital, Chennai.
[8*]Adjunct Professor of Research, Tagore Medical and Dental College and Hospital, Chennai.
Email Id: tmbala81@gmail.com

ABSTRACT

Carnatic music as a sound form has been known to be resplendent with beauty, melody and aesthetics. However, this musical form has been known to exert several effects on the human body. Studies on the biological effects of music therapy mostly stem from the Western world. These studies exploring the biological effects of music therapy could be extrapolated and applied in the Carnatic music scenario too. This review explores the biological effects that could be exerted by Carnatic music therapy on the various organ systems of the human body and also arrives at a hypothesis as to why Carnatic music therapy could be beneficial in human disease management.

Keywords: ***Carnatic Music Therapy, Central Nervous System, Pain, Immune System, Cardiovascular System, Antioxidants.***

INTRODUCTION

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

The treatment of diseases affecting the human body has always been based on the ateopathogenesis ie, the cause and course of the disease. Pharmacotherapy, surgery and other modalities of treatment have all been developed and implemented based on methodical research findings. The same is the case with alternative systems of medicine. India is a country with a glorious history and the vedic scriptures have played a major role in the field of medicine. There are many traditional systems of medicine like Ayurveda, Siddha, Unani, Yoga and Naturopathy which have been practiced till date[1]. These systems of therapy have been hailed as Alternative medicine. Music therapy could also be categorized under the same banner as an alternative system of medicine and therapy for disease management.

It has been understood that music therapy has been employed in the management of stress[2], anxiety[3], pain[4], cancer related symptoms[5] and Alzheimer's disease[6]. The studies performed in this connection have used both the Western and Indian systems of music. Whatever be the case, music as a sound form with energy could definitely affect the listener in concern and could exert a biological effect. The form of music, its frequency, style, speed and the listener's previous training and knowledge about the music genre could further exert many other pleiotropic effects. But by and large, the biological effects of Carnatic music could be similar and comparable to other forms of music. The present review analyzes the biological effects of music therapy which could be the basis as to why a music therapy prescription works to alleviate disease symptoms. The findings of the review and its hypothesis could be applied to Carnatic music therapy also as many of the reported studies are based on other musical forms.

The Effects of Music Therapy on The Central Nervous System

The central nervous system composed of the brain, spinal cord and associated structures appears to be the predominant target of music therapy as per published literature. The use of imaging techniques such as functional magnetic resonance tomography (f MRT), positron emission tomography (PET), electroencephalography (EEG) and magnetic encephalography (MEG) have demonstrated the multiple areas in the brain that are activated by music exposure[7]. Other than the auditory cortex, music exposure has been found to activate the frontal, parietal, temporal and subcortical areas of the brain thereby triggering a wide range of emotions. The activation of the above mentioned areas will also lead to increased cognition, attention, enhanced memory and mood elevation[7].

With regard to the spinal cord, it is understood that listening to music and rhythmic sounds can activate muscles through reticulospinal pathways7. This is facilitated by the fact that the auditory system has a widely organized fibre system that connects motor centers from the spinal cord and

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

the brain stem. With regard to brain development, it has been found that music exposure can promote brain growth in experimental animals and could contribute to increased nerve plasticity. The NMDA receptors that are present in the auditory cortex have been regarded pivotal to the pathways that enhance lexical skills and memory. An animal study performed on 2 week old mice demonstrated enhanced expression of NR2B protein and NMDA up regulation in the music treated animals with better hippocampal development compared to the music non exposed animal group[8].

The profound effect of music on elevation of neurochemicals and neurotransmitters such as ACTH, dopamine and cortisol has been demonstrated in male wistar rats exposed to traditional Chinese-5 element music therapy[9]. Earlier studies have shown that dopamine is the major neurotransmitter elevated by music listening that inturn cause's activation of dopaminergic reward areas of the brain[10].

The effects of music therapy on pain Pain is another important physiological phenomenon profoundly affected by music exposure. Pain has been referred to as a psychical adjunct of an imperative protective reflex and has also been defines as an unpleasant sensory and emotional expression associated with actual or potential tissue damage or described in terms of such damage[11]. Pain can be categorized as acute or chronic in nature. Acute pain such as that arising from a dental pathology or middle ear infection is severe in nature, throbbing and lancinating in variety. Chronic pain is typically gnawing, unpleasant dull pain in a region that persists thought the day and produces morbidity to the patient in concern. Pain could also be referred in nature and affect a site distant from its origin.

As earlier described pain is a symptom and associated tenderness is a sign of diseases of inflammatory, infectious, metabolic and malignant ateology and is the most common reason for patients in concern approaching clinicians for treatment. The pharmacotherapy of pain involves the use of steroids, non-steroidal anti-inflammatory drugs and certain other centrally acting drugs which act on the pain pathways. Music therapy can also be used as a therapeutic strategy in pain management. The use of music as a non-drug strategy to control pain is based on the fact that music exposure activates the cerebral cortex and increases the production of neurotransmitters that reduce pain perception. Moreover, music also activates the brain edge and reticular system causing reduction in sympathetic nervous activity and upregulation of parasympathetic activity which in turn reduces the response to stress and pain and reduces blood pressure, heart rate and cortisol levels[12]. Music therapy also enhances and elevates mood and serves as a mode of distraction and emotional stabilization of the patient affected.

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

Studies on palliative care cancer patients with pain[13], postoperative patients subjected to coronary artery bypass graft procedure[14], orthopedic procedures[15] and obstetric procedures[16] have also shown the beneficial effects of music therapy in allaying pain and unpleasant experiences.

The Effects of Music Therapy on The Cardiovascular System

The cardiovascular system is composed of the heart and associated vasculature responsible for maintaining circulation and associated physiological homeostasis. Heart rat, pulse rate, blood pressure, respiratory rate, ventilation and endothelial integrity are vital parameters related to the cardiovascular system evaluated by various studies.

The effects of music therapy on the cardiovascular system have been extensively studied between 1980 to 2020[17]. About 149 full text articles have been published detailing the effects of music therapy on the cardiovascular system. A recently published systematic review has analyzed the findings of these studies. According to this, music therapy and listening are believed to have a positive impact on heart rate variation due to parasympathetic effects[17]. On cardiovascular subjects undergoing hemodialysis and exposed to music therapy, the QT interval in the Electrocardiogram has been found to undergo positive changes, denoting cardiovascular improvement[18]. In a study on 46 mothers of preterm infants, music therapy on a weekly basis was found to reduce depression, anxiety and was found to improve cardiac parameters and circulation[19]. In a study on hypertensive patients, music therapy was found to be an adjunct to the 4 weeks of dietary app to stop hypertension (DASH) diet and been found to significantly lower systolic blood pressure scores[20]. With regard to the cortisol levels in saliva, music therapy has been found to cause significant cortisol reduction in elderly patients with and without myocardial infarction[21].

The Effects of Music Therapy on The Immune System

The human immune system is composed of the white blood cells and associated organs such as the bone marrow and lymphoid tissues responsible for genesis, maintenance and maturation of the white blood cells. It is known that the immune response is the reaction of the human immune system to any foreign body be it bacterial, viral, parasitic or fungal[22]. The immune response of the host can be categorized as the cell mediated and humoral immune response[22]. While the cell mediated immune response is characterized by phagocytosis of pathogens by immune cells, the humoral immune response is based on antibody production and antigen-antibody reactions[22].

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)
CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

It has been observed that music exposure affects both the humoral and cell mediated immune responses. A study on 28 women and 5 male subjects found music exposure to increase salivary IgA levels[23]. Another interesting study on 111 human subjects assessed the effects of exposure to group drumming. In this study, music exposure to percussion drums increased the dehydroepiandroserone –cortisol ratios, enhanced Natural Killer cell activity, lymphokine activated natural killer cell activity and also elevated the levels of IL-2 and interferon gamma[24].

Another interesting study on 40 male wistar rats using an asthma stress model found that music exposure reduced IL-4 cytokine levels and also dramatically decreased eosinophil and total leukocyte numbers[25]. This finding reveals the subtle effects of music on the immune system. With regard to immune mediated cancer development, a study has found that exposure of mice to broadband music for 5 hours daily after injection with carcinoma cell lines reduced the development of metastatic nodules and also caused immunoenhancement. This finding was contrast to the control music unexposed mice which quickly developed metastatic nodules[26].

Effect Of Music Therapy on The Antioxidant-Oxidant System

Free radicals and reactive oxygen species are defined as chemically unstable molecules with an unpaired electron and are generated during various physiological and pathological processes and are countered/ combatted by antioxidants, which are molecules capable of mitigating free radicals. It has been proven beyond doubt that free radicals and reactive oxygen species are elevated in Alzheimer's disease, diabetes mellitus type 2, cardiovascular disease, cancer and arthritis a few conditions to name[27].

It has been demonstrated that music therapy and listening can mitigate and reduce the oxidative stress caused by free radicals. A clinical trial on patients undergoing obstetric procedure found that exposure to Turkish classical music increased the levels of the antioxidant glutathione peroxidase[28]. In an interesting study on depressed mouse model exposed to carcinogens, it was found that traditional Chinese music exposure lowered the incidence of tumorigenesis, reduced the tumor size and also lowered the levels of thioredoxin, an oxidative stress marker[29]. In contrast to this, the study reported that the control depressed mice unexposed to music had higher oxidative stress and quickly developed tumors[29].

A study assessing variable effects of traditional classical Chinese music versus heavy metal music on the growth and oxidative state of HEK293T cells in vitro demonstrated that traditional Chinese

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

5 element music increased glutathione levels and proliferative capacity of the kidney cells while heavy metal music increased the oxidative stress of the cells reducing their viability[30].

Clinical Implications

From all the evidences available, music therapy seems to exert multifaceted effects on various systems and profoundly affects the central nervous system, pain pathways, cardiovascular system, immune and antioxidant system. These effects have been found to be positive in curing ailments and disorders of various organs.

Music therapy has also been compared to other alternative therapies such as acupuncture, reiki, reflexology, geranium aromatherapy, meditation and yoga and is found to be a superior form of alternative medicine. It has also been evidenced that the style , form of music, its frequency and tonality in total influence the biological effects and in turn influence the therapeutic benefits.

Conclusion

The beneficial effects of music therapy on the human body can be extrapolated and applied to the Carnatic scenario also considering that music is a universal healing art. It appears that Carnatic music therapy has not been extensively investigated for its biological effects on various organ systems, barring a few ragas like madhyamavathi, shankarabharanam, bhimplas, thodi , hindolam and Ananda bhairavi which have been demonstrated to have pain allaying , anxiolytic and anti-pyretic effects31. There are hundreds of ragas that need to be tested for their therapeutic effects on various diseases. Research in Carnatic music therapy is still in its infancy and needs a boost and more participation from the music and medical fraternity.

Acknowledgement: The authors humbly thank **Dr. Subhashini Parthasarathy,** senior Carnatic musician, musicologist and music researcher and **Mr. Ashwath Narayanan Rajagopal,** independent Carnatic music performer and researcher for their valuable guidance and support in the preparation of this manuscript.

REFERENCES

1. Rudra S, Kalra A, Kumar A, Joe W. (2017) Utilization of alternative systems of medicine as health care services in India: Evidence on AYUSH care from NSS 2014. *PLoS One*. 12(5): e0176916. Published 2017 May 4. doi: 10.1371/journal.pone.0176916.
2. de Witte M, Lindelauf E, Moonen X, Stams GJ, van Hooren S. (2020) Music Therapy Interventions for Stress Reduction in Adults with Mild Intellectual Disabilities: Perspectives from Clinical

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64

Practice. Front Psychol. Dec 10; 11: 572549. doi: 10.3389/fpsyg.2020.572549. PMID: 33362637; PMCID: PMC7759728.

3. Gutiérrez, Enrique Octavio Flores, and Víctor Andrés Terán Camarena. (2015) "Music therapy in generalized anxiety disorder." The Arts in Psychotherapy 44: 19-24.
4. Santiváñez-Acosta R, Tapia-López ELN, Santero M. (2020) Music Therapy in Pain and Anxiety Management during Labor: A Systematic Review and Meta-Analysis. Medicina (Kaunas). Oct 10; 56(10): 526. doi: 10.3390/medicina56100526. PMID: 33050409; PMCID: PMC7599829.
5. Krishnaswamy, Priyadharshini, and Shoba Nair. (2016) "Effect of music therapy on pain and anxiety levels of cancer patients: A pilot study." Indian journal of palliative care 22.3: 307.
6. Fang, R., Ye, S., Huangfu, J. et al. (2017) Music therapy is a potential intervention for cognition of Alzheimer's Disease: a mini-review. Transl Neurodegener 6, 2. https://doi.org/10.1186/s40035-017-0073-9
7. Wang S, Agius M. (2018) The neuroscience of music; a review and summary. Psychiatr Danub. Nov; 30(Suppl 7): 588-594. PMID: 30439853.
8. Korsos, G., Horvath, K., Lukacs, A., Vezer, T., Glavits, R., Fodor, K., et al. (2018) Effects of Accelerated Human Music on Learning and Memory Performance of Rats. Applied Animal Behaviour Science, 202, 94-99. https://doi.org/10.1016/j.applanim.2018.01.011.
9. Hao J, Jiang K, Wu M, Yu J, Zhang X. (2020) The effects of music therapy on amino acid neurotransmitters: Insights from an animal study. Physiol Behav. Oct 1; 224: 113024. doi: 10.1016/j.physbeh.2020.113024. Epub 2020 Jun 21. PMID: 32579893.
10. Zatorre RJ, Salimpoor VN. (2013) From perception to pleasure: music and its neural substrates. Proc Natl Acad Sci U S A. Jun 18; 110 Suppl 2(Suppl 2): 10430-7. doi: 10.1073/pnas.1301228110. Epub 2013 Jun 10. PMID: 23754373; PMCID: PMC3690607.
11. Lee GI, Neumeister MW. (2020) Pain: Pathways and Physiology. Clin Plast Surg. Apr; 47(2): 173-180. doi: 10.1016/j.cps.2019.11.001. Epub 2020 Jan 7. PMID: 32115044.
12. Lee JH. The Effects of Music on Pain: A Meta-Analysis. J Music Ther. 2016 Winter; 53(4): 430-477. doi: 10.1093/jmt/thw012. Epub 2016 Oct 19. Erratum in: J Music Ther. 2021 Aug 24;58(3):372. PMID: 27760797.
13. Warth M, Keßler J, Hillecke TK, Bardenheuer HJ. (2015) Music Therapy in Palliative Care. Dtsch Arztebl Int. Nov 13; 112(46): 788-94. doi: 10.3238/arztebl.2015.0788. PMID: 26806566; PMCID: PMC4671329.
14. Zimmerman L, Nieveen J, Barnason S, Schmaderer M. The effects of music interventions on postoperative pain and sleep in coronary artery bypass graft (CABG) patients. Sch Inq Nurs Pract. 1996 Summer; 10(2): 153-70; discussion 171-4. PMID: 8826769.
15. Lin CL, Hwang SL, Jiang P, Hsiung NH. (2020) Effect of Music Therapy on Pain After Orthopedic Surgery-A Systematic Review and Meta-Analysis. Pain Pract. Apr; 20(4): 422-436. doi: 10.1111/papr.12864. Epub 2020 Jan 9. PMID: 31785131.
16. Santiváñez-Acosta R, Tapia-López ELN, Santero M. (2020) Music Therapy in Pain and Anxiety Management during Labor: A Systematic Review and Meta-Analysis. Medicina (Kaunas). Oct 10; 56(10): 526. doi: 10.3390/medicina56100526. PMID: 33050409; PMCID: PMC7599829.

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb **Indexed in CAS and CABI, Impact Factor: 0.64**

17. Kulinski J, Ofori EK, Visotcky A, Smith A, Sparapani R, Fleg JL. (2021) Effects of music on the cardiovascular system. Trends Cardiovasc Med. Jul 5: S1050-1738(21)00070-0. doi: 10.1016/j.tcm.2021.06.004. Epub ahead of print. PMID: 34237410; PMCID: PMC8727633.
18. C Hou, YJ Lin, KC Lu, HS Chiang, CC Chang, LK. Yang. (2017) Music therapy-induced changes in salivary cortisol level are predictive of cardiovascular mortality in patients under maintenance hemodialysis Ther Clin Risk Manag, 13, pp. 263-272.
19. MKA Ribeiro, TRM Alcantara-Silva, JCM Oliveira, TC Paula, JBR Dutra, GR Pedrino, et al. (2018) Music therapy intervention in cardiac autonomic modulation, anxiety, and depression in mothers of preterms: randomized controlled trial BMC Psychol, 6 (1), p. 57.
20. IA Mir, M Chowdhury, RM Islam, GY Ling, A Chowdhury, ZM Hasan, et al. (2021) Relaxing music reduces blood pressure and heart rate among pre-hypertensive young adults: A randomized control trial.J Clin Hypertens (Greenwich), 23 (2), pp. 317-322.
21. HJ Trappe, G. Voit. (2016) The cardiovascular effect of musical genres. Dtsch Arztebl Int, 113 (20), pp. 347-352.
22. Toskala E. Immunology. (2014) Int Forum Allergy Rhinol. Sep;4 Suppl 2: S21-7. doi: 10.1002/alr.21380. PMID: 25182350.
23. Kuhn D. The effects of active and passive participation in musical activity on the immune system as measured by salivary immunoglobulin A (SIgA). J Music Ther. 2002 Spring; 39(1): 30-9. doi: 10.1093/jmt/39.1.30. PMID: 12015810.
24. Bittman BB, Berk LS, Felten DL, Westengard J, Simonton OC, Pappas J, Ninehouser M. (2001) Composite effects of group drumming music therapy on modulation of neuroendocrine-immune parameters in normal subjects. Altern Ther Health Med. Jan; 7(1): 38-47. PMID: 11191041.
25. Lu Y, Liu M, Shi S, Jiang H, Yang L, Liu X, Zhang Q, Pan F. (2010) Effects of stress in early life on immune functions in rats with asthma and the effects of music therapy. J Asthma. Jun; 47(5): 526-31. doi: 10.3109/02770901003801964. PMID: 20560827.
26. Núñez MJ, Mañá P, Liñares D, Riveiro MP, Balboa J, Suárez-Quintanilla J, Maracchi M, Méndez MR, López JM, Freire-Garabal M. (2002) Music, immunity and cancer. Life Sci. Jul 19; 71(9): 1047-57. doi: 10.1016/s0024-3205(02)01796-4. PMID: 12088764.
27. Pham-Huy LA, He H, Pham-Huy C. (2008) Free radicals, antioxidants in disease and health. *Int J Biomed Sci*. 4(2): 89-96.
28. Orak Y, Bakacak SM, Yaylali A, Tolun FI, Kiran H, Boran OF, Kurt AH, Doganer A. (2020) Efeitos da musicoterapia sobre dor e estresse oxidativo na aspiração folicular: estudo clínico randomizado [Effects of music therapy on pain and oxidative stress in oocyte pick-up: a randomized clinical trial]. Braz J Anesthesiol. Sep-Oct; 70(5): 491-499. Portuguese. doi: 10.1016/j.bjan.2020.04.015. Epub 2020 Jul 28. PMID: 32829925.
29. Jia, Lei, et al. (2021) "Music Therapy in Traditional Chinese Medicine Attenuates the Depression-Associated Breast Cancer Development in MMTV-PyMT Nice and Clinics." *Int J Med Res Healt Sci* 10.3: 110-21.
30. Feng, Qian, et al. (2022) "Effects of different music on HEK293T cell growth and mitochondrial functions." *Explore*.

Indian Journal of Research in Pharmacy and Biotechnology (IJRPB)
www.ijrpb.com ISSN: 2321-5674 (Print), 2320-3471 (Online)

CrossRef DOI: https://doi.org/10.31426/ijrpb Indexed in CAS and CABI, Impact Factor: 0.64