VIRTUAL REALITY: A PHILANTHROPIST TO YOUNG ASTHMATICS!

Abstract

The chapter opens by outlining the present state of asthma care and the limitations of traditional rehabilitation approaches. It then digs into the theoretical basis for using virtual reality in healthcare, emphasising its ability to engage patients in immersive and interactive environments that mirror real-world scenarios.

Case studies and success stories from real-world uses of virtual reality in asthma rehabilitation are presented, demonstrating the favourable impact on patient involvement, motivation, and self-management skills. The possible obstacles and ethical concerns related with the broad use of VR in healthcare are also discussed.

Moreover, the chapter emphasises the promise use of virtual reality as a supplemental tool in asthma rehabilitation, offering a novel and immersive approach to improving respiratory health outcomes. The incorporation of VR technology into standard care procedures has the potential to transform asthma management, providing a more engaging and effective alternative for individuals looking to better their respiratory health.

Keywords: VR Technology, Asthma Management, healthcare

Authors

Aditi
Assistant Professor
SGT University
Gurugram, Haryana, India

Anushree Rai
Assistant Professor
SGT University
Gurugram, Haryana, India

Asthma is a chronic disease which is outlined by aggravation of airway hypersensitivity, mucus secretion, broncho constriction and inflammation of the airways.[WHO,2022; Mims J. W. 2015] Various trigger factors leads to exacerbation of asthma such as Air that is cold causes narrowing of the lower airways, trapping air, and difficulty exhaling, resulting in ventilation and perfusion imbalance, hypoxia, hypercapnia, and acid-base imbalances, all of which are susceptible to life-threatening problems if not treated promptly [Mims J. W. 2015].

The prevalence of asthma in India is about 3% i.e., 30 million patients are suffering from asthma. Out of which the prevalence is about 2.4% among population of age more than 15 years and between 4% and 20% among children. It is one of the primary reasons of morbidity and death in rural India. One of the studies in 2004 estimated that 57,000 deaths in India were due to asthma. [Agrawal S, 2013]

Exercise training plays a crucial role in the conservative care of adults with chronic pulmonary conditions. It is documented in the literature that exercise training reduces the symptoms severity experienced during daily life such as breathlessness, exhaustion and improve health-related quality of life. Various studies among individuals with COPD suggest that High intensity training for exercise, as opposed to low intensity exercise, may be helpful in the context of triggering a physiological training response. [Sawyer, A.,2020] High-Intensity interval training (HIIT) definition varies across different studies. One of the reviews elaborates during High-intensity interval exercising with active rest intervals, you can maintain 95% of your peak heart rate. is defined as high-intensity exercise combined with aerobic periods. along with target intensity existing in sub- maximal VO2 max i.e., between 85% and 95% of the peak heart rate. It incorporates quick spurts of high-intensity activity (less than VO2 peak but mostly involve less than cent percent i.e., between 70 % and 90% of VO2 peak or between 85% and HIIT is referred to as aerobic sub- maximal VO2 max intensity. SIT's peak power output (PPO) is approximately 350% of its total power generation at VO2max. [Sawyer A., 2020]

Subjects dealing with chronic cardiovascular and pulmonary diseases find difficulties in changing behavior to a more active and healthier lifestyle, Proposals from the healthcare field to engage in hospital-based rehabilitation programmes are practical and increase quality of life and exercise ability. All the patients cannot participate in these recovery programmes because of weakness and long distance to the hospital. Augmented Reality systems are currently being employed in a variety of rehabilitation procedures. However, science is still in its early stages and requires further research. A consistent definition of Augmented Reality must be developed, and additional research is needed to figure out the potential of using Augmented Reality to encourage occupation practice in a more contextually appropriate environment in order to improve motor learning and generalization to other tasks [Madison D.,2018]. In specific areas of patient health, the application of Augmented Reality in rehabilitation has demonstrated advantages. However, these benefits have not been studied. A recent systematic review conducted by Ertuk G et al., 2021 evaluated the impact of HIIT/SIT protocols on asthmatic subjects. The result of the review concluded that patients suffering from the condition benefit from HIIT/SIT treatments.

While virtual reality offers a novel and fun method of physical activity, it is critical to determine if the bodily and therapeutic consequences are comparable to traditional exercise

training. In this chapter, we will try to understand if Virtual reality can be a benefactor to the patients of asthma.

I. ASTHMA DEFINITION

Francis M. Rachemann in 1918 proposed the medical concepts as "allergic asthma" or "intrinsic asthma". This paradigm has been supplanted by biomarker-based asthma characterization. This is gradually being superseded in the twenty-first century by biomarker-based profiling of asthma for focused therapy of certain subdivisions. Asthma is an ongoing inflammatory condition of the bronchi where mast cells, eosinophils, T lymphocytes, macrophages, neutrophils, and epithelial cells all serve a role. (The 1991, 1997, and 2007 National Institute of Health Guidelines on Asthma). Adult bronchial asthma clinically presented with airway narrowing which is derived from airway inflammation and hyper responsiveness resulting in wheezing, dyspnea and cough (Yanagisawa S., 2018). Long-term inflammation damages the airways and causes airway remodeling, which includes subepithelial fibrosis under the subsurface membrane, smooth muscle hypertrophy, and submucosal gland hyperplasia. As a consequence, intractable asthma develops, with irreversible airway limitation and persistent airway hyper responsiveness (James W. Mims., 2015).

1. **Definition of Severe Asthma** (according to ERS/ATS 2014) (Lommatzsch M & Virchow J. C., 2014)

   During Therapy with

   - Corticosteroid inhalation at high doses plus at least one additional controller (LABA, montelukast, or theophylline) or
   - corticosteroids taken orally for more than 6 months annually
   - If therapy is lowered, at least one of the following occurs or would occur:
   - ACT < 20 or ACQ >1.5 ACT 20 or ACQ >1.5
   - Minimum of 2 aggravation within preceding 12 months
   - ACT <20 or ACQ >1.5 with minimum of 1 outbreak cured in medical centre or involving mechanical ventilation in the previous year
   - FEV1 80% (if FEV1/FVC is less than the typical lower cutoff)

2. **Etiology and Prevalence of Asthma:** The etiology of asthma is idiopathic, gene-environment interaction is an important risk factor. Genetic play major role in asthma ranging from 35% to 95%. A review was conducted by Stern J., 2020 listed various determinants for asthma which include Vitamin D deprivation contributed to enhanced Eosinophilia on bronchial lavage, airway remodelling, decreased T regulatory cells, raised NF-KB expression, and raised proinflammatory cytokines, tobacco smoking during pregnancy increases risk of asthma in the offspring, air pollution, pre- natal and early life stress, allergen exposure also exacerbate asthma. The European Community Respiratory Health Survey (ECRHS) and ISAAC have a major role in the development of estimation of asthma prevalence globally. The prevalence in wheeze from Indian centers ranged from 4.1 to 9.7% and 23.2 to 32% in centers from Denmark, UK, US, Estonia, Sweden, Australia, New Zealand, and Ireland. Asthma widespread presence ranged from 2 to 3.3% in sites in Germany, Spain, Greece, Austria, Italy, and Algeria to 8 to 11.9% in areas in

the United Kingdom, New Zealand, and Australia and prevalence of asthma symptoms is high among centers with English speaking which may be due to westernization which increases the risk of asthma associated symptoms.

II. HIGH- INTENSITY INTERVAL TRAINING (HIIT)

HIIT is distinguished by quick, alternating bouts of intensive exercise followed by intervals of relaxation or low-intensity exercise in between. HIIT model with submaximal efforts that elicit ≥90% of VO_{2max} or >75% of maximal power (Buchheit, M.; Laursen, P.B., 2013; MacInnis, M.J.; Gibala, M.J. P., 2016). HIIT results in similar or even superior effects on corporeal, execution and fitness related on diseased as well as healthy population, serves as an alternative to traditional endurance training. HIIT helps in improving cardiorespiratory fitness among cardiovascular impairments, heart failure, insulin resistance syndrome and overweight subjects. It is more effective than moderate-intensity training for exercise as improvement in function vascular lining evaluated via flow-oriented widening of the brachial artery increased more after HIIT than after moderate intensity exercise. (Wisloff et al. 2007; Tjonna et al. 2008, 2009; Moholdt et al. 2009).

III. ROLE OF HIIT IN ASTHMA PATIENTS

Regimen in exercise is essential in the treatment of people with chronic lung diseases. Among asthma patient physical exercise improved maximal oxygen uptake significantly, according to a systematic Cochrane review (Carson K V et al., 2013). Indoor cycling high-intensity interval training enhances VO2 max in untrained asthma patients irrespective of asthma control level, airway inflammation and airway hyper-responsiveness (Toennesen L L et al., 2018). Winn. C. O. N et al., 2019 compared efficacy of a 6-month on-site HIIT exercise in asthmatic teenagers to that of their healthy peers. In teenagers, HIIT resulted in significant gains in cardiorespiratory fitness and weight maintenance. This bigger rise could be attributed to individuals with asthma having poorer baseline fitness, as baseline fitness has been shown to have an effect of extent of variation triggered by an intercession in adolescents.

IV. ROLE OF AUGMENTED REALITY IN CARDIOPULMONARY REHABILITATION

Virtual Reality (VR) defined as realistic, immersive simulation of 3D environment using interactive software and hardware which is controlled by movement of the body. Calculation by software, sensory feedback, immersion and human machine interaction are four cardinal elements of virtual reality. Nowadays virtual reality is implemented in cardiopulmonary rehabilitation. A systematic review was conducted by Penn I- Wen et al., 2018 reviewed studies combining the effect of virtual reality and cardiopulmonary rehabilitation. It was concluded that for successful application of virtual reality requires virtual environment which can provide attention, memory, physical strength and daily living activities, quantitative and qualitative method of evaluation. Virtual reality increases motivation and adherence to cardiac rehabilitation program (Penn I- Wen et al., 2018).

Virtual reality is also beneficial in delivering pulmonary rehabilitation program via Kinect system in patients with COPD (Rutkowsk S et al., 2020). It was concluded from this systematic review that virtual reality improved physical fitness in COPD patients. The

Nintendo Wii and the Xbox 360 Kinect are the most popular gaming systems. [Sween J, 2014] Movement recognition equipment is used in these systems to simulate the motions of the players, which are projected on-screen. Wii Fit activities, for example, are designed expressly to increase your level of fitness and include muscular strengthening, cardio (jogging/kickboxing), and stability games (yogic movements, skiing, snowmobiling). [Bonnechère B, 2016] Additional recreations, such as Wii Sports and Kinect Sports, encourage active exercise via having fun while being involved in virtual sports solo or against a fellow contestant. [Butler et al., 2019]

Systemic review done by Butler et al. gathered studies on chronic respiratory disease that incorporated an active video game element as a kind of fitness training & a comparative group in 2019. Although the number of included studies in this review were less but it showed that Peak rhythms and levels of dyspnea were increased by playing intensive arcade games. which were significantly comparable with traditional exercise training. Butler also mentioned that to determine the impact of training with video games on persons with chronic respiratory disorders, more comprehensive and over time randomised controlled trials are required.

Whenever a person starts enjoying his task no matter how difficult or tedious it is, it becomes easy and provides a sense of relaxation. Thus, it is more important to enjoy the process of healing in the case of Pulmonary patients as well. Condon et al. recently assessed the enjoyment in their systemic review and meta-analysis and found that patients with impaired respiratory health enjoyed the intervention provided through virtual reality and the results were statistically significant. Exercise gaming and/or virtual reality gameplay treatment effectiveness was frequently measured using The rhythm of the heart (peak and average), breathing difficulties and breathing efficiency (SpO2 and VO2) are all measured.

VRS are entire-body workouts with no predetermined routine that mirror daily actions such as side-steppage movement (e.g., balance maintenance) and bending in front (e.g., achieve a goal) and are performed by devoted individuals. It may be due to VRS's inability to achieve peak exercise intensity, as it was a sort of complete-body workout intended for amusement with integrated break times (activation time for the game). While contrasting treadmill and stationary bike workouts, a recent study found that only maximal exercise produced a comparable degree of oxygen saturation. [LeGear T, et al., 2016]

REFERENCES

[1] https://www.who.int/news/item/20-05-2022-world-health-statistics-2022
[2] Mims J. W. (2015). Asthma: definitions and pathophysiology. *International forum of allergy & rhinology*, *5 Suppl 1*, S2–S6. https://doi.org/10.1002/alr.21609
[3] Agrawal, S., Pearce, N., & Ebrahim, S. (2013). Prevalence and risk factors for self-reported asthma in an adult Indian population: a cross-sectional survey. *The international journal of tuberculosis and lung disease: the official journal of the International Union against Tuberculosis and Lung Disease*, *17*(2), 275–282. https://doi.org/10.5588/ijtld.12.0438
[4] Sawyer, A., Cavalheri, V., & Hill, K. (2020). Effects of high intensity interval training on exercise capacity in people with chronic pulmonary conditions: a narrative review. *BMC sports science, medicine & rehabilitation*, *12*, 22. https://doi.org/10.1186/s13102-020-00167-y
[5] https://www.nhlbi.nih.gov/sites/default/files/media/docs/EPR 3_Asthma_Full_Report_2007.pdf
[6] Yanagisawa, S., & Ichinose, M. (2018). Definition and diagnosis of asthma-COPD overlap (ACO). *Allergology international : official journal of the Japanese Society of Allergology*, *67*(2), 172–178. https://doi.org/10.1016/j.alit.2018.01.002

[7] Boonbrahm, Poonpong & Kaewrat, Charlee & Boonbrahm, Salin. (2019). Interactive Marker-based Augmented Reality for CPR Training. International Journal of Technology. 10. 1326. 10.14716/ijtech.v10i7.3267.
[8] Ertürk, G., Günday, Ç., Evrendilek, H., Sağır, K., & Aslan, G. K. (2022). Effects of high intensity interval training and sprint interval training in patients with asthma: a systematic review. *The Journal of asthma : official journal of the Association for the Care of Asthma*, *59*(11), 2292–2304. https://doi.org/10.1080/02770903.2021.1999470
[9] Mims J. W. (2015). Asthma: definitions and pathophysiology. *International forum of allergy & rhinology*, *5 Suppl 1*, S2–S6. https://doi.org/10.1002/alr.21609
[10] Lommatzsch, M., & Virchow, J. C. (2014). Severe asthma: definition, diagnosis and treatment. *Deutsches Arzteblatt international*, *111*(50), 847–855. https://doi.org/10.3238/arztebl.2014.0847 https://erj.ersjournals.com/content/43/2/343
[11] Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. *Sports medicine (Auckland, N.Z.)*, *43*(5), 313–338. https://doi.org/10.1007/s40279-013-0029-x
[12] MacInnis, M. J., & Gibala, M. J. (2017). Physiological adaptations to interval training and the role of exercise intensity. *The Journal of physiology*, *595*(9), 2915–2930. https://doi.org/10.1113/JP273196
[13] Wisløff, U., Støylen, A., Loennechen, J. P., Bruvold, M., Rognmo, Ø., Haram, P. M., Tjønna, A. E., Helgerud, J., Slørdahl, S. A., Lee, S. J., Videm, V., Bye, A., Smith, G. L., Najjar, S. M., Ellingsen, Ø., & Skjaerpe, T. (2007). Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. *Circulation*, *115*(24), 3086–3094. https://doi.org/10.1161/CIRCULATIONAHA.106.675041
[14] Tjønna, A. E., Lee, S. J., Rognmo, Ø., Stølen, T. O., Bye, A., Haram, P. M., Loennechen, J. P., Al-Share, Q. Y., Skogvoll, E., Slørdahl, S. A., Kemi, O. J., Najjar, S. M., & Wisløff, U. (2008). Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome: a pilot study. *Circulation*, *118*(4), 346–354. https://doi.org/10.1161/CIRCULATIONAHA.108.772822
[15] Moholdt, T. T., Amundsen, B. H., Rustad, L. A., Wahba, A., Løvø, K. T., Gullikstad, L. R., Bye, A., Skogvoll, E., Wisløff, U., & Slørdahl, S. A. (2009). Aerobic interval training versus continuous moderate exercise after coronary artery bypass surgery: a randomized study of cardiovascular effects and quality of life. *American heart journal*, *158*(6), 1031–1037. https://doi.org/10.1016/j.ahj.2009.10.003
[16] Carson, K. V., Chandratilleke, M. G., Picot, J., Brinn, M. P., Esterman, A. J., & Smith, B. J. (2013). Physical training for asthma. *The Cochrane database of systematic reviews*, (9), CD001116. https://doi.org/10.1002/14651858.CD001116.pub4
[17] Toennesen, L. L., Meteran, H., Hostrup, M., Wium Geiker, N. R., Jensen, C. B., Porsbjerg, C., Astrup, A., Bangsbo, J., Parker, D., & Backer, V. (2018). Effects of Exercise and Diet in Nonobese Asthma Patients-A Randomized Controlled Trial. *The journal of allergy and clinical immunology. In practice*, *6*(3), 803–811. https://doi.org/10.1016/j.jaip.2017.09.028
[18] Winn CON, Mackintosh KA, Eddolls WTB, Stratton G, Wilson AM, McNarry MA, Davies GA. Effect of high-intensity interval training in adolescents with asthma: The eXercise for Asthma with Commando Joe's® (X4ACJ) trial. J Sport Health Sci. 2021 Jul;10(4):488-498. doi: 10.1016/j.jshs.2019.05.009. Epub 2019 May 30. PMID: 34304826; PMCID: PMC8343006.
[19] Penn, I-Wen & Chuang, Eric & Chuang, Tien-Yow & Yang, Chen-Ya. (2018). Effects of Virtual-Reality-Augmented Cardiopulmonary Rehabilitation Programs for Patients with Cardiovascular Diseases: A Systemic Review. Neuropsychiatry. 08. 10.4172/Neuropsychiatry.1000499.
[20] Rutkowski, S., Rutkowska, A., Kiper, P., Jastrzebski, D., Racheniuk, H., Turolla, A., Szczegielniak, J., & Casaburi, R. (2020). Virtual Reality Rehabilitation in Patients with Chronic Obstructive Pulmonary Disease: A Randomized Controlled Trial. *International journal of chronic obstructive pulmonary disease*, *15*, 117–124. https://doi.org/10.2147/COPD.S223592
[21] Sween, J., Wallington, S. F., Sheppard, V., Taylor, T., Llanos, A. A., & Adams-Campbell, L. L. (2014). The role of exergaming in improving physical activity: a review. *Journal of physical activity & health*, *11*(4), 864–870. https://doi.org/10.1123/jpah.2011-0425
[22] Bonnechère, B., Jansen, B., Omelina, L., & Van Sint Jan, S. (2016). The use of commercial video games in rehabilitation: a systematic review. *International journal of rehabilitation research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue internationale de recherches de readaptation*, *39*(4), 277–290. https://doi.org/10.1097/MRR.0000000000000190
[23] Butler SJ, Lee AL, Goldstein RS, Brooks D. Active Video Games as a Training Tool for Individuals With Chronic Respiratory Diseases: A SYSTEMATIC REVIEW. J Cardiopulm Rehabil Prev. 2019 Mar;39(2):85-90. doi: 10.1097/HCR.0000000000000320. PMID: 29485524; PMCID: PMC6407826.

