Efficacy Of Home Based Via Video Conferencing Versus Centre Based Exercise Training On Quality Of Life, Exercise Capacity And Sleep Quality Index In Children With Asthma

Alpna Ahuja[1*], Navkaran Singh[2]

[1*]Research Scholar, RIMT University,Mandi Gobindgarh,Punjab, Email: alpna02@gmail.com
[2]Assistant professor, RIMT University,Mandi Gobindgarh,Punjab.

***Corresponding author**: Alpna Ahuja
*Research Scholar, RIMT University,Mandi Gobindgarh,Punjab, Email: alpna02@gmail.com

ABSTRACT
Background: Exercise Training has proven to be very effective in improving functional capacity, in reducing dyspnoea and improving quality of life However, from healthcare perspectives, in low income countries like India, there are various barriers to attending such programs like low awareness, less recognition of physiotherapy services, covid 19 and access cost like transport etc.Novel strategies such as tele-rehabilitation are of great interest as they increase convenience and reduce barriers which are associated with centre based programs. We seek to compare the effects of home based exercise training program via video-conferencing with centre based training program on health related quality of life (HRQOL),exercise capacity, and sleep quality index in children with asthma.
Methods: Participants diagnosed with persistent asthma were randomized to either a home based exercise training group (HG) supervised via video-conferencing or a centre based exercise training group (CG). Both the groups received aerobic exercises training using step aerobics three times per week for eight weeks.
Results: Sixty-two out of 76 participants completed the study i.e 31 in each group .There was no statistically significant between group differences for health related quality of life (t=.495, p=.622), Exercise capacity (t=.183, p=.855)and sleep quality index (t=.615, p=.541)between the two groups. However both the groups achieved significant improvement in all the parameters after 8 weeks of training.
Conclusion: Home-based exercise training via video-conferencing achieved equivalent improvement as compared to centre based exercise training. This innovative model has the potential to revolutionize healthcare delivery in countries like India where accessibility and reach are significant challenges, thereby increasing access to quality care for a larger population.

Key Words: Aerobic exercises, Children, Asthma, exercise capacity, video-conferencing, 6MST.

Introduction: Paediatric asthma is the most common chronic paediatric lung disease that has traditionally been defined as a syndrome of airway inflammation characterized by clinical symptoms of cough and wheeze[1].It is a major global public health problem which is ruining the quality of life of Children and their families. Worldwide, asthma symptoms are increasing at a rapid pace especially in the second half of the last century[2].There is a substantial burden of asthma symptoms in school aged children; around 1 in 20 school-aged children have asthma symptoms which are severe[3]. In developing country like India, there is a 14 fold increase in the asthma symptoms in the last five decades[4]. Exercise training has been widely used as a complimentary therapeutic approach in the management of Asthma. It is safe and well tolerated in patients with asthma and should be prescribed for overall improvement in general and respiratory health[5] . An individualized exercise training program in children with asthma improves cardiopulmonary fitness and has the capacity to improve exercise induced bronchoconstriction[6].
Regular physical exercise can significantly improve lung function, body composition, exercise ability, systemic inflammation and quality of life in children with bronchial asthma[7, 8,9,10]. As asthmatic children has lower aerobic capacity so it is recommended that cardiopulmonary exercise and lower limb muscle endurance should be given due consideration during physical training programs in children with asthma[11, 12]. Various aerobic training programs have been suggested in the literature but there is no agreement for the same. Literature shows that 6-12 weeks of training programs is efficient in improving HRQOL and improving asthma symptoms.
A recent review on exercise and lifestyle changes in paediatric asthma recommends that training programs should have an intensity goal of a ventilator threshold or 80% of maximal heart rate[13].
In children with asthma, pulmonary rehabilitation has proven to be very effective in improving functional capacity, in reducing dyspnea and improving quality of life[14]. However, from healthcare perspectives, in low income countries like India, there are various barriers to attending such programs like low awareness, less recognition of physiotherapy services, covid 19 and access cost like transport etc.These barriers are both at the interpersonal and community levels and prevent children and young people with asthma from accomplishing benefits of physical fitness [15,16].

Novel strategies such as tele-rehabilitation are of great interest as they increase convenience and reduce barriers which are associated with centre based programs. A scoping review on tele-rehabilitation in subjects with respiratory disease concluded tele-rehabilitation to be safe, feasible and a viable first line option for patients with respiratory disease[17]. In covid 19 pandemic, it was well accepted by patients and it improved their clinical outcomes [18].
Previous studies have demonstrated the usage of tele-rehabilitation in COPD with a variety of protocols and have showed equivalent improvement as compared to centre based program[19].However, none of the study has compared home based and centre based exercise training program in children with asthma. Home based exercise training via video-conferencing has the potential to overcome various barriers of pulmonary rehabilitation participation. So, this study has been designed to compare the effects of home based exercise training program via video-conferencing with centre based training program on quality of life , exercise capacity, sleep quality index in children with asthma.

Methods:

Design

A randomized, parallel group trial was conducted at civil hospital, Panchkula. Ethical approval was taken from The Ethical Committee of RIMT University. After the approval, trial was registered with Clinical Trials Registry-India. (CTRI/2024/02/063306)

- **Participants**: Patients diagnosed with persistent asthma was taken from paediatric outpatient department of civil hospital Sec 6, Panchkula as per the inclusion and exclusion criteria. Ethical approval was taken from The Ethical Committee of RIMT University. Inclusion criteria decided was: Children of age group 7-17 years diagnosed with asthma according to GINA guidelines, Children with stable persistent asthma controlled by low or moderate doses of inhaled corticosteroid for at least 6 months, Absence of any acute exacerbation or change of medication in the preceding one month, Children having smart phones or laptops at home. Participants will be excluded if they are suffering from any other lung disorder, cardiovascular or any other musculoskeletal condition, Involvement in any other exercise training program, Participation in any other research studies or has language difficulties and Children who are unable to follow verbal instructions and suffer from cognitive impairment.

Exercise Capacity

Six minute step test (6MST) was performed as mentioned in earlier studies [20, 21]. Subjects were familiarized with the stepper prior to the test. A 20cm step (with non-slip rubber surface) was used. Cadence was free and the patient had to target maximum number of steps. There was no upper-limb support. Oxygen saturation, heart rate, dyspnea and fatigue of lower limbs was assessed after every 2 minutes. Blood pressure and Respiratory rate was assessed before and immediately after the test. The total no of steps during the six minutes was used for analysis. A 10-point Borg scale was used to assess perceived dyspnea and fatigue of lower limbs. Heart rate and SpO2 was assessed using pulse oximeter and blood pressure was assessed using sphygmomanometer.

Quality of Life

Quality of life was assessed by Paediatric Asthma quality of life questionnaire (PAQLQ) [22]. It has 3 domains (symptoms, activity & emotional function). The questionnaire contains 13 questions of symptoms (such as wheezing & cough), 5 questions of activity limitation (such as play, sport) and the 8 questions of emotional function (such as frightened, frustrated). Permission has been taken to use this questionnaire in both English and Hindi language.

Sleep Quality

Assessment of child's sleep quality was done by Sleep disturbance scale for Children (SDSC). It is a 27 item scale which is useful in determining sleep disturbances in clinical and non-clinical population [23]. It helps in evaluating sleep of children aged 3–18 years. This questionnaire was developed by Olivier Bruni. Permission has been taken to use this questionnaire.

Procedure: After comprehensive description of the study, any one parent of the child was asked to sign a consent form and child signed the assent form.
Baseline evaluation at the hospital: All the children were evaluated for height, body weight and body mass index (BMI) using weight & height scale. Exercise capacity, sleep quality and Quality Of Life were evaluated before the start of the intervention (pre-program) and at the end of 8 weeks of intervention (post program).
At the commencement of the study, all the children were instructed about the methods, procedure and benefits of the study. Participants were randomized using sealed envelopes by an investigator who was not

involved in the assessment, diagnosis and treatment. Randomization was done into a home based exercise training group (HG) and a centre based group (CG) .

Home based Group (HG)

During initial visit by the therapist, a smart phone or laptop with inbuilt camera was positioned at an appropriate place where therapist could see the participant exercising. Remotely supervised exercise training at home was conducted thrice a week for 8 weeks, in the groups of 4-6 participants at a time supervised by the therapist using real time video-conferencing using zoom. Participants were able to see and talk to both the therapist and other participants.

The aerobic training program consisted of 3 parts: warm up/stretching, aerobic training and cool down.

Warm up/stretching: The warm up was of 5 minutes and consisted of active exercises of upper limb & lower limb. Stretching was also of 5 minutes and included self-stretching of quadriceps, hamstrings, pectoralis major and trapezius muscles .Stretch was held for 30sec.

Aerobic Training:

The training protocol was designed in accordance with the guidelines recommended by the American College Sports Medicine[24].Aerobic training consisted of step aerobics.

Step Aerobics was performed according to previous studies [25, 26]. Step aerobics training consisted of 3 sessions per week, 30-60 minutes per session for 8 weeks. Step aerobics training was performed using the low-impact version, in which 1 foot remained in contact with the floor at all times, so not allowing any hopping movements. The SA included patterns such as the basic step; “A” step; “L” step; “V” step to both the right and left side; alternating step knee-lift sequences; alternating leg up, up, down, down patterns; and step kicks. Arm movements such as biceps curls and arm raises at the shoulder level and above the head was incorporated simultaneously with some steps. Subjectsreceived a sound track with music cadence between 120 and 126 foot strikes per minute. At the beginning of the first exercise session, the resting HR of subjects was measured by a HR monitor (Polar Electro™,). Heart rate was measured every 5 minutes of each session.

During training session, intensity was controlled by maintaining HR between 70%-80% of the predicted maximum heart rate with reference values calculated according to karnoven’s formula[27]. Dyspnea and/or fatigue was maintained between 4 and 6 on the modified Borg scale. The participants were instructed to take bronchodilators prior to or during the exercise if required.

After completion of eight weeks, Participants were evaluated for the same parameters at the hospital.

Centre Based Group

Aerobic Training was exactly same as stated in Home based group but was conducted in rehabilitation centre.

Data Analysis: Statistical Analysis was done using SPSS software. A total of 62 participants were randomly allocated to home based exercise training group (HG) and centre based exercise training group (CG) i.e. 31 in each group. Data normality was assessed using Kolmogorov-Smirnov test. Data was presented as mean± standard deviation. Between groups comparisons was done using non paired t test and paired t-test was used to evaluate differences with-in the groups. The level of statistical significance was set at 5% for all the tests. ($p \leq 0.05$)

Results:

Movement of participants throughout the study is illustrated in fig.1.

There were 85 eligible patients. Five of them refused to participate so total 80 asthmatic patients were randomized into two equal groups. 40 in home based group (HG) and 40 in centre based group (CG). In the home based group, 9 participants dropped out in the first week due to internet issues. In the centre based group, 5 participants dropped out because of lack of family support and 4 left due to transfer problems. So 31 participants in each group finally completed the study.

Baseline characteristics

Baseline characteristics of 62 participants who completed the study are shown in Table 1. As demonstrated in Table 1 , there were no significant differences between the Group HG and Group CG at the beginning of the study with regard to their age, BMI, , 6MST, and PAQLQ ($p>0.05$). All the participants included in the study had comparable levels ofPAQLQ, SDSC and 6MST baseline scores . Table 2. Depicts the normality analysis of the data according to one sample Kolmogorov –Smirnov test. The p value decided was 0.05. As the p value for the above shown variables is more than 0.05. Hence data is normal and parametric test is applied for analysis.

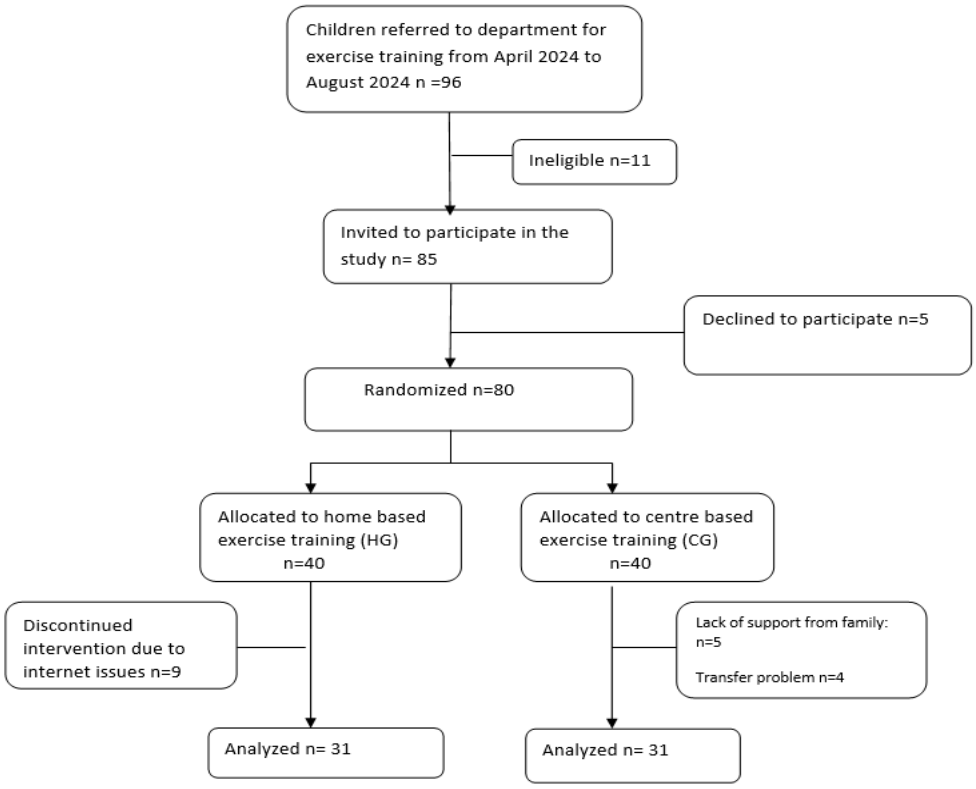

Fig :1 Movement of participants throughout the study .

Table 1 Baseline characteristics of subjects:

Characteristics	Group HG	Group CG	p-value
	Mean ±S.D	Mean ±S.D	
N	31	31	
Age	12.74±3.36	11.81±3.29	0.272
BMI	20.05±4	19.85±2.68	0.809
FEV1	66.39±6.58	67.48±6.52	.512
FVC	80.68±6.33	79.71±4.95	.505
FEV1/FVC	82.55±6.3	84.61±5.74	.183
PEFR	67.13±7.79	69.36±5.19	.191
PAQLO-Total	3.91±0.38	3.96±0.41	.607
PAQLQ symptom	3.96±0.45	3.99±0.45	.655
PAQLQ Activity	3.82±0.45	3.88±0.53	.606
PAQLQ-Emotion	3.95±0.30	3.98±0.34	.692
SDSC	70.58±12.31	68.61±12.51	.535
6MST	139.07±6.41	141.10±6.83	.232

Note:Significant at p<0.05

Abbreviations: HG: Home based group, CG: Centre based group,BMI: Body Mass Index,FVC:Forced Vital Capacity,FEV_1: Forced Expiratory Volume in 1sec,PEFR:Peak Expiratory Flow Rate,PAQLQ: Pediatric asthma quality of life Questionairre, SDSC: Sleep disturbance scale for children, 6MST: 6-minute step test.

Table 2: Normality Analysis

Group	Group HG			Group CG		
	N	Kolmogorov-Smirnov Z	p-value	N	Kolmogorov-Smirnov Z	p-value
PAQLQ(Total)	31	.698	.715	31	.758	.614
PAQLQ(Symptom)	31	.834	.490	31	.694	.721
PAQLQ(Activity)	31	.724	.671	31	.861	.449
PAQLQ(Emotion)	31	.791	.559	31	.752	.624
SDSC	31	.898	.396	31	.914	.374

6MST	31	.656	.783	31	.748	.631

Abbreviations: HG: Home based group, CG: Centre based groupPAQLQ: Pediatric asthma quality of life Questionnaire, SDSC: Sleep disturbance scale for children, 6MST: 6-minute step test.

Comparison of study variables:

Table 3: Pre and post treatment of HRQOL, exercise capacity and sleep quality index within each group

	HG Group			CG group		
GROUP A	Pre	Post	p-value	Pre	Post	p-value
PAQLQ						
PAQLO-Total	3.91±0.38	5.27±0.50	.0001*	3.96±0.41	5.34±0.52	.0001*
PAQLQ symptom	3.94±0.45	5.25±0.62	.0001*	3.99±0.45	5.37±0.63	.0001*
PAQLQ Activity	3.82±0.45	5.12±0.39	.0001*	3.89±0.53	5.17±0.46	.0001*
PAQLQ-Emotion	3.95±0.30	5.35±0.51	.0001*	3.98±0.33	5.42±0.52	.0001*
SDSC	70.58±12.31	48.71±6.38	.0001*	68.61±12.51	47.68±6.82	.0001*
6MST	139.07±6.41	168.58±14.26	.0001*	141.1±6.83	167.90±14.82	.0001*

Note:Significant at p<0.05

Abbreviations: HG: Home based group, CG: Centre based group, PAQLQ: Pediatric asthma quality of life Questionairre, SDSC: Sleep disturbance scale for children, 6MST: 6-minute step test.

Pediatric Asthma Quality of life questionnaire:

As demonstrated in table 3, Pre post treatment comparison with in the groups indicated significant differences in all the measures of quality of life such as symptoms,activity,emotion and overall scores in both home based as well as centre based group.However as shown in table 4 , between group comparison showed no significant difference (p>0.05) in all the measures of quality of life indicating similar improvement of quality of life in home based as well as centre based groups.

Exercise capacity:

As represented in table 1, comparison of mean pre-treatment values of 6MSTbetween home based and centre based group indicated non-significant differences (p>0.05). At the completion of the study, both the groups showed significant improvement in exercise capacity as shown in table 3 (p<0.05).Moreover as shown in Table 4 , the between-group comparison revealed no significant difference in the 6 minute step test, indicating comparable improvements in exercise capacity for both home based and centre based groups.

Sleep Quality Index

Table 1 shows that the mean pre-treatment values of sleep disturbance scale for children were similar for both home based and centre based groups with no significant differences. By the end of the study, both the groups demonstrated significant improvements in sleep quality (Table 3). Furthermore, as shown in Table 4, the between group comparison revealed no significant difference in sleep disturbance scores, indicating equivalent improvements in sleepquality for both the groups.

Table 4 : PAQOL, exercise capacity and sleep quality index between the two groups post treatment

	Post 8weeks exercise training		
	HG group	CG group	p-value
	Mean±S.D	Mean±S.D	p-value
PAQLO-Total	5.271±0.503	5.335±0.523	.622
PAQLQ symptom	5.252±0.616	5.365±0.632	.479
PAQLQ Activity	5.123±0.385	5.174±0.464	.635
PAQLQ-Emotion	5.345±0.505	5.419±0.521	.571
SDSC	48.710	47.677	.541
6MST	168.581±14.261	167.903±14.820	.855

Note:Significant at p<0.05

Abbreviations: HG: Home based group, CG: Centre based group, PAQLQ: Pediatric asthma quality of life Questionnaire, SDSC: Sleep disturbance scale for children, 6MST: 6-minute step test.

Discussion:

The present study was done to compare the efficacy of home based and centre based exercise training in children with asthma. The outcome measures were Pediatric asthma quality of life questionnaire, six minute step test and Sleep disturbance scale for children. This is the first study which used home based exercise training with supervision of all exercise sessions using virtual web meetings via zoom and compared it with centre based exercise training.

The study population who completed the study were divided into two groups, Home based group (Group HG) and centre based group (Group CG) each consisting of 31 participants. Mean age of 31 participants in group A was 12.74 years where as mean age of 31 participants in Group B was 11.81 years. There was no significant difference between the groups signifying the groups were matched.

The major findings of this study showed that asthmatic children in both the groups showed improved exercise capacity, sleep quality and quality of life. These findings were obtained through a program involving moderate-intensity exercise using step aerobics. The asthmatic children had a satisfied participation program without asthma restrictions or attack.

Quality of life:

Health-related Quality of Life has emerged as a crucial outcome measurein the management and assessment of chronic disorders[28]. Beyond experiencing reduced exercise capacity and symptoms like dyspnoea,cough and wheezing, children with this condition also face significant physical,social,educational and emotional challenges that impact their overall well-being[29].The current study showed significant improvement of Health related quality of life evidenced by both overall PAQLQ scores, as well as specific scores of the activity limitation domain, symptoms, and emotional function in both Group HG and Group CG. The observed improvements in quality of life may be attributed to enhanced cardiopulmonary endurance[30], improved lung function[31] and the positive psychosocial benefits associated with participating in a structured exercise program.Our results align with existing research done by Basaran, which demonstrated that an 8 week sub maximal exercise intervention yielded significant quality of life improvements in paediatric patients with asthma[32].

Exercise capacity

The reduction in physical fitness resulting from decreased physical activity in children with bronchial asthma plays a significant role in compromising their quality of life and control ofdisease[33]. Muscle impairments are often linked to long-term use of corticosteroids, sedentary life style and decreased aerobic capacity. Therefore, enhancing exercise ability and improving quality of life can significantly alleviate asthma symptoms.While exercise has long been recognised as a crucial component in managing childhood asthma,exercise induced asthma remains a concern, often discouraging parents from encouraging physical activity in their children.

The results of present study demonstrated that an 8-week program of aerobic exercise training improved exercise capacity in children with asthma in both the groups. Theimprovement in exercise capacity is inconsistent with a study done by sanz-santiago etal that demonstrated significant gains in cardiorepiratory fitness in children and adolescents with asthma[30].

Our results are further supported by a meta-analysis conducted by Liu Y etal which revealed a significant enhancement in exercise capacity following physical exercise[34]. The improved exercise capacity in this study suggests enhanced ventilator efficiency among participants, potentially leading to reduced breathlessness, improved sub maximal exercise capacity and enhanced overall well being during daily activities[35].Despite variations in training programs for individuals with asthma, aerobic training is consistently the most widely recommended and utilized approach for children with asthma.This study pioneers the use of Step Aerobics (SA) as a modality for aerobic training in asthmatic patients. The key factors contributing to enhanced effectiveness of our physical training protocol on cardiovascular fitness appear to be the selection of appropriate training modes, precise training prescription (established at the ventilatory threshold) and optimal frequency and duration of training sessions. Step aerobic training has been shown to have a positive impact on body composition in various populations, including older adults[36], postmenopausal women[37]and patients with chronic heart failure[38].Additionally, step aerobics has been found to improve lower body strength in older adults, likely due to repetitive stepping motion. So, the beneficial effects of step aerobic exercise may be attributed to improvements in either cardiopulmonary fitness or peripheral muscle strength or both.

Sleep Quality

Sleep is a crucial consideration in the care of patients with asthma. Children with asthma often experience night-time awakenings and poor sleep quality due to their condition. These sleep disturbances can have far-reaching consequences, negatively impacting the quality of life of the children as well as their parents.

Furthermore, sleep disturbances can affect academic performance, cognitive function and mental health highlighting the importance of addressing sleep issues in asthma management[39].
A review conducted by Francisco etal investigated the impact of physical exercise on nocturnal symptoms in asthma. The findings suggest that regular physical activity may alleviate nocturnal symptoms by reducing their prevalence and frequency. However, the underlying mechanism responsible for this improvement remains unclear warranting further research to elucidate the relationship between exercise and nocturnal asthma symtomatlogy[40].This study reveals a significant enhancement in sleep qualityas assessed by sleep disturbance scale for children, following an 8 week aerobic exercise training program in both the groups. The observed improvement in sleep quality may be attributed to various factors including better asthma control, reduced nocturnal symptoms[40], improved lung function and decreased anxiety related to their condition all of which promote relaxation[41] and contribute to enhanced sleep quality.

Between the group differences:
This pioneering study is the first to compare home based exercise training using video conferencing with centre based exercise training in children with asthma. This study demonstrated that a home-based exercise training model yields comparable improvement in quality of life, exercise capacity and sleep quality in children with asthma suggesting its potential as an effective and accessible alternative to traditional centre based programs. While the traditional centre-based pulmonary rehabilitation models have demonstrated efficacy in clinical trials[8,27], their real-world impact is often limited by poor participation and adherence rates,highlighting the need for alternative ,more accessible approach. The barriers to accessing rehabilitation services are complex and multifaceted, including low referral rates, patient related challenges such as access constraints, health complexities like co morbidities and the need for family support, which collectively hinder uptake and adherence to these services. This novel telerehabilitation model revolutionizes asthma care by delivering exercise training services in the comfort of their own homes, seamlessly bypassing obstacles such as transportation Hassels, costly commutes and weather related disruptions. Unlike previous studies, this research explores a rehabilitation model that leverages familiar, user friendly technology eliminating the need for extensive technical support making it highly suitable for implementation in real world clinical settings. Home based programs show great promise in addressing the limitations offering a practical and effective solution. So this practical approach demonstrates significant potential for seamless integration into real-world clinical settings, addressing existing limitations and paving the way for effective, home based intervention.

References:
1. Conrad, L. A., Cabana, M. D., & Rastogi, D. (2021). Defining pediatric asthma: phenotypes to endotypes and beyond. *Pediatric research*, *90*(1), 45–51. https://doi.org/10.1038/s41390-020-01231-6
2. Stern, J., Pier, J., &Litonjua, A. A. (2020). Asthma epidemiology and risk factors. *Seminars in immunopathology*, *42*(1), 5–15. https://doi.org/10.1007/s00281-020-00785-1
3. Asher, M. I., Rutter, C. E., Bissell, K., Chiang, C. Y., El Sony, A., Ellwood, E., Ellwood, P., García-Marcos, L., Marks, G. B., Morales, E., Mortimer, K., Pérez-Fernández, V., Robertson, S., Silverwood, R. J., Strachan, D. P., Pearce, N., & Global Asthma Network Phase I Study Group (2021). Worldwide trends in the burden of asthma symptoms in school-aged children: Global Asthma Network Phase I cross-sectional study. *Lancet (London, England)*, *398*(10311), 1569–1580. https://doi.org/10.1016/S0140-6736(21)01450-1
4. Patra, P. K., Bhattarai, D., Prasad, A., Jain, H., Ranjan, S., & Ranjan, A. (2021). Prevalence and risk factors of asthma among school going children in urban area of North India. *Journal of family medicine and primary care*, *10*(1), 421–426. https://doi.org/10.4103/jfmpc.jfmpc_1517_20
5. Lang J. E. (2019). The impact of exercise on asthma. *Current opinion in allergy and clinical immunology*, *19*(2), 118–125. https://doi.org/10.1097/ACI.0000000000000510
6. Wanrooij, V. H., Willeboordse, M., Dompeling, E., & van de Kant, K. D. (2014). Exercise training in children with asthma: a systematic review. *British journal of sports medicine*, *48*(13), 1024–1031. https://doi.org/10.1136/bjsports-2012-091347
7. Liu, Y., Zhao, Y., Liu, F., & Liu, L. (2021). Effects of Physical Exercises on Pulmonary Rehabilitation, Exercise Capacity, and Quality of Life in Children with Asthma: A Meta-Analysis. *Evidence-based complementary and alternative medicine :eCAM*, *2021*, 5104102. https://doi.org/10.1155/2021/5104102
8. Abdelbasset, W. K., Alsubaie, S. F., Tantawy, S. A., Abo Elyazed, T. I., &Kamel, D. M. (2018). Evaluating pulmonary function, aerobic capacity, and pediatric quality of life following a 10-week aerobic exercise training in school-aged asthmatics: a randomized controlled trial. *Patient preference and adherence*, *12*, 1015–1023. https://doi.org/10.2147/PPA.S159622
9. Latorre-Román, P. Á., Navarro-Martínez, A. V., & García-Pinillos, F. (2014). The effectiveness of an indoor intermittent training program for improving lung function, physical capacity, body composition and

quality of life in children with asthma. *The Journal of asthma: official journal of the Association for the Care of Asthma*, *51*(5), 544–551. https://doi.org/10.3109/02770903.2014.888573
10. Khodashenas, E., Bakhtiari, E., Sohrabi, M., Mozayani, A., Arabi, M., ValayatiHaghighi, V., MotevalliHaghi, N., &Ahanchian, H. (2019). The Effect of a Selective Exercise Program on Motor Competence and Pulmonary Function of Asthmatic Children: A Randomized Clinical Trial. *International Journal of Pediatrics*, *7*(7), 9711-9717.doi: 10.22038/ijp.2019.37253.3243
11. Lochte, L., Angermann, M., & Larsson, B. (2009). Cardiorespiratory fitness of asthmatic children and validation of predicted aerobic capacity. *The clinical respiratory journal*, *3*(1), 42–50. https://doi.org/10.1111/j.1752-699X.2008.00107.x
12. Villa, F., Castro, A. P., Pastorino, A. C., Santarém, J. M., Martins, M. A., Jacob, C. M., & Carvalho, C. R. (2011). Aerobic capacity and skeletal muscle function in children with asthma. *Archives of disease in childhood*, *96*(6), 554–559. https://doi.org/10.1136/adc.2011.212431
13. Lu, K. D., &Forno, E. (2020). Exercise and lifestyle changes in pediatric asthma. *Current opinion in pulmonary medicine*, *26*(1), 103–111. https://doi.org/10.1097/MCP.0000000000000636
14. Reimberg, M. M., Castro, R. A., Selman, J. P., Meneses, A. S., Politti, F., Mallozi, M. C., Wandalsen, G. F., Solé, D., De Angelis, K., Dal Corso, S., & Lanza, F. C. (2015). Effects of a pulmonary rehabilitation program on physical capacity, peripheral muscle function and inflammatory markers in asthmatic children and adolescents: study protocol for a randomized controlled trial. *Trials*, *16*, 346. https://doi.org/10.1186/s13063-015-0876-x
15. Kornblit, A., Cain, A., Bauman, L. J., Brown, N. M., & Reznik, M. (2018). Parental Perspectives of Barriers to Physical Activity in Urban Schoolchildren With Asthma. *Academic pediatrics*, *18*(3), 310–316. https://doi.org/10.1016/j.acap.2017.12.011
16. Augustine, A., Bhat, A., Vaishali, K., & Magazine, R. (2021). Barriers to pulmonary rehabilitation - A narrative review and perspectives from a few stakeholders. *Lung India : official organ of Indian Chest Society*, *38*(1), 59–63. https://doi.org/10.4103/lungindia.lungindia_116_20
17. Taito, S., Yamauchi, K., & Kataoka, Y. (2021). Telerehabilitation in Subjects With Respiratory Disease: A Scoping Review. *Respiratory care*, *66*(4), 686–698. https://doi.org/10.4187/respcare.08365
18. Lewis, A., Knight, E., Bland, M., Middleton, J., Mitchell, E., McCrum, K., Conway, J., & Bevan-Smith, E. (2021). Feasibility of an online platform delivery of pulmonary rehabilitation for individuals with chronic respiratory disease. *BMJ open respiratory research*, *8*(1), e000880. https://doi.org/10.1136/bmjresp-2021-000880
19. Cox, N. S., McDonald, C. F., Alison, J. A., Mahal, A., Wootton, R., Hill, C. J., Bondarenko, J., Macdonald, H., O'Halloran, P., Zanaboni, P., Clarke, K., Rennick, D., Borgelt, K., Burge, A. T., Lahham, A., Wageck, B., Crute, H., Czupryn, P., Nichols, A., & Holland, A. E. (2018). Telerehabilitation versus traditional centre-based pulmonary rehabilitation for people with chronic respiratory disease: protocol for a randomised controlled trial. *BMC pulmonary medicine*, *18*(1), 71. https://doi.org/10.1186/s12890-018-0646-0
20. Munari, A. B., Venâncio, R. S., Klein, S. R., Gulart, A. A., Silva, I. J. C. S., Sonza, A., Dal Lago, P., & Mayer, A. F. (2020). Physiological Responses to the 6-min Step Test in Patients With Chronic Obstructive Pulmonary Disease. *Journal of cardiopulmonary rehabilitation and prevention*, *40*(1), 55–61. https://doi.org/10.1097/HCR.0000000000000469
21. Reychler, G., Audag, N., Dewulf, S., Morale Mestre, N., & Caty, G. (2018). Validation of 6 min step test and 4-m gait speed in children: A randomized cross-over study. *Gait & posture*, *61*, 19–24. https://doi.org/10.1016/j.gaitpost.2017.12.011
22. Juniper, E. F., Guyatt, G. H., Feeny, D. H., Ferrie, P. J., Griffith, L. E., & Townsend, M. (1996). Measuring quality of life in children with asthma. *Quality of life research: an international journal of quality of life aspects of treatment, care and rehabilitation*, *5*(1), 35–46. https://doi.org/10.1007/BF00435967
23. Bruni, O., Ottaviano, S., Guidetti, V., Romoli, M., Innocenzi, M., Cortesi, F., & Giannotti, F. (1996). The Sleep Disturbance Scale for Children (SDSC) Construct ion and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *Journal of sleep research*, *5*(4), 251-261.https://doi.org/10.1111/j.1365-2869.1996.00251.x
24. Ferguson B. (2014). ACSM's Guidelines for Exercise Testing and Prescription 9th Ed. 2014. *The Journal of the Canadian Chiropractic Association*, *58*(3), 328.
25. Hallage, T., Krause, M. P., Haile, L., Miculis, C. P., Nagle, E. F., Reis, R. S., & Da Silva, S. G. (2010). The effects of 12 weeks of step aerobics training on functional fitness of elderly women. *Journal of strength and conditioning research*, *24*(8), 2261–2266. https://doi.org/10.1519/JSC.0b013e3181ddacc6
26. Cai, Z. Y., Wen-Chyuan Chen, K., & Wen, H. J. (2014). Effects of a group-based step aerobics training on sleep quality and melatonin levels in sleep-impaired postmenopausal women. *Journal of strength and conditioning research*, *28*(9), 2597–2603. https://doi.org/10.1519/JSC.0000000000000428

27. de Andrade, L. B., Britto, M. C., Lucena-Silva, N., Gomes, R. G., & Figueroa, J. N. (2014). The efficacy of aerobic training in improving the inflammatory component of asthmatic children. Randomized trial. *Respiratory medicine*, *108*(10), 1438-1445.
28. Rutishauser, C., Sawyer, S. M., & Bowes, G. (1998). Quality-of-life assessment in children and adolescents with asthma. *European Respiratory Journal*, *12*(2), 486-494.
29. Juniper, E. F., Guyatt, G. H., Feeny, D. H., Ferrie, P. J., Griffith, L. E., & Townsend, M. (1996). Measuring quality of life in children with asthma. *Quality of life research*, *5*, 35-46.
30. Sanz-Santiago, V., Diez-Vega, I., Santana-Sosa, E., Lopez Nuevo, C., Iturriaga Ramirez, T., Vendrusculo, F. M., ... & Pérez-Ruiz, M. (2020). Effect of a combined exercise program on physical fitness, lung function, and quality of life in patients with controlled asthma and exercise symptoms: A randomized controlled trial. *Pediatric Pulmonology*, *55*(7), 1608-1616.
31. Jing, Z., Wang, X., Zhang, P., Huang, J., Jia, Y., Zhang, J., ... & Sun, X. (2023). Effects of physical activity on lung function and quality of life in asthmatic children: An updated systematic review and meta-analysis. *Frontiers in Pediatrics*, *11*, 1074429.
32. Basaran, S., Guler-Uysal, F., Ergen, N., Seydaoglu, G. Ü. L. Ş. A. H., Bingol-Karakoç, G., & ALTINTAS, D. (2006). Effects of physical exercise on quality of life, exercise capacity and pulmonary function in children with asthma. *Journal of rehabilitation medicine*, *38*(2).
33. McNarry, M. A., Boddy, L. M., & Stratton, G. S. (2014). The relationship between body mass index, aerobic performance and asthma in a pre-pubertal, population-level cohort. *European journal of applied physiology*, *114*, 243-249.
34. Liu, Y., Zhao, Y., Liu, F., & Liu, L. (2021). Effects of Physical Exercises on Pulmonary Rehabilitation, Exercise Capacity, and Quality of Life in Children with Asthma: A Meta-Analysis. *Evidence-based complementary and alternative medicine :eCAM*, *2021*, 5104102. https://doi.org/10.1155/2021/5104102
35. Meyer, T., Lucia, A., Earnest, C. P., & Kindermann, W. (2005). A conceptual framework for performance diagnosis and training prescription from submaximal gas exchange parameters-theory and application. *International journal of sports medicine*, *26*(S 1), S38-S48.
36. Mori, Y, Ayabe, M, Yahiro, T, Tobina, T, Kiyonaga, A, Shindo, M, Yamada, T, and Tanaka, H. The effects of home-based bench step exercise on aerobic capacity, lower extremity power and static balance in older adults. *Int J Sport Health Sci* 4: 570-576, 2006.
37. Chien, WY, Wu, YT, Hsu, AT, Yang, RS, and Lai, JS. Efficacy of a 24-week aerobic exercise program for osteopenic postmenopausal women. *Calcif Tissue Int* 67: 443-448, 2000.
38. Sturm, B., Quittan, M., Wiesinger, G. F., Stanek, B., Frey, B., & Pacher, R. (1999). Moderate-intensity exercise training with elements of step aerobics in patients with severe chronic heart failure. *Archives of physical medicine and rehabilitation*, *80*(7), 746-750.
39. Banasiak, N. C. (2016). Understanding the relationship between asthma and sleep in the pediatric population. *Journal of Pediatric Health Care*, *30*(6), 546-550.
40. Francisco, C. D. O., Bhatawadekar, S. A., Babineau, J., Reid, W. D., & Yadollahi, A. (2018). Effects of physical exercise training on nocturnal symptoms in asthma: Systematic review. *PLoS One*, *13*(10), e0204953.
41. Mendes, F. A., Gonçalves, R. C., Nunes, M. P., Saraiva-Romanholo, B. M., Cukier, A., Stelmach, R., ... & Carvalho, C. R. (2010). Effects of aerobic training on psychosocial morbidity and symptoms in patients with asthma: a randomized clinical trial. *Chest*, *138*(2), 331-337.