Active Video Games as a Training Tool for Individuals With Chronic Respiratory Diseases

A SYSTEMATIC REVIEW

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Purpose: Exercise is an effective treatment for reducing symptom severity and improving quality of life for patients with chronic respiratory diseases. Active video games offer a new and enjoyable way to exercise and have gained popularity in a rehabilitation setting. However, it is unclear whether they achieve comparable physiological and clinical effects as traditional exercise training.

Methods: A systematic literature search was performed to identify studies that included an active video game component as a form of exercise training and a comparator group in chronic respiratory disease. Two assessors independently reviewed study quality using the Cochrane risk of bias tool and extracted data for exercise capacity, quality of life, and preference of exercise model.

Results: Six studies were included in this review. Because of the heterogeneity of the populations, study designs, length of intervention, and outcome measures, meta-analysis could not be performed. Active video game training resulted in comparable training maximal heart rate and dyspnea levels to those achieved when exercising using a treadmill or cycle (n = 5). There was insufficient evidence (n = 3) to determine whether active video game training improved exercise capacity as measured by 6-min walk test or treadmill endurance walking.

Conclusions: Although the quality of evidence was low, in a small number of studies active video games induced peak heart rates and dyspnea levels comparable with traditional exercise training. Larger and longer-term randomized controlled trials are needed to establish the impact of video game training for individuals with chronic respiratory diseases.

Key Words: active video games • exercise training • exergames • respiratory disease

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METHODS

DATABASES

Five electronic databases (MEDLINE, Excerpta Medica dataBASE [EMBASE], Cumulative Index to Nursing and Allied Health Literature [CINAHL], PubMed, and Physiotherapy Evidence Database [PEDro]) were searched in June of 2016. The searches consisted of combinations of terminology related to video games and chronic respiratory diseases and were adapted for each database. A detailed search strategy is included as Supplemental Digital Content 1, available at: http://links.lww.com/JCRP/A67.
identified articles and previous reviews were hand-searched for additional data sources. Both conference abstracts and peer-reviewed research articles were included. The search was updated on February 17, 2017.

**INCLUSION AND EXCLUSION CRITERIA**

One researcher (S.J.B.) performed the initial search. Abstracts were independently reviewed for inclusion by 2 researchers (S.J.B. and A.L.L.). Inclusion criteria consisted of (1) clinical trials with an active video game (exergame) or virtual exercise training intervention; (2) participants with chronic respiratory diseases (asthma, bronchiectasis, chronic obstructive pulmonary disease [COPD], cystic fibrosis [CF], interstitial lung disease [ILD], lung cancer); (3) a comparator group performing traditional exercise modalities; and (4) information for at least 1 quantitative outcome related to exercise capacity. Conference abstracts were included and any duplicate articles were removed following the preliminary search.

Studies were excluded for the following reasons: (1) no comparison group; (2) qualitative studies; and (3) written in a language other than English.

**QUALITY ASSESSMENT**

Two members of the research team (S.J.B. and A.L.L.) independently assessed the studies using the risk of bias tool from Cochrane, with studies rated as unclear, low risk, or high risk. Any discrepancies were resolved by the researchers.

**DATA EXTRACTION AND ANALYSIS**

Field walking test results, treadmill time and duration, ergometry, and maximal heart rate (HR) were included to reflect exercise capacity. Secondary outcomes included measures of dyspnea and perceived exertion to reflect breathlessness and fatigue, oxygen saturation ($\text{SpO}_2$) indicating gas exchange, energy expenditure, measures of health status and HRQOL, and activity enjoyment.

Data extraction was performed by 1 member of the research team (S.J.B.) and verified by a second team member (A.L.L.). The type of data extracted included the disease population, type of intervention, frequency and duration of the intervention sessions, comparator method, outcome measures, and key findings. Because of population variation, study design, and outcome measures, meta-analysis was not possible. Study findings were reported in a narrative format.

**RESULTS**

**SEARCH RESULTS**

As outlined in the Figure, the literature search identified 976 records. After duplicates were removed, 552 abstracts were screened for eligibility and 36 full-text articles and conference abstracts were included for full-text review. An additional 133 records were identified in the updated search following duplicate removal. Abstracts identified in the updated search were screened for eligibility and did not meet the inclusion criteria. Five research articles, and 1 conference abstract met the inclusion criteria for individuals with asthma, CF, COPD, ILD, bronchiectasis, or restrictive chest disease. A summary of the included studies is provided in Table 1. Three randomized controlled trials and 3 crossover studies were identified. The comparator groups completed exercise sessions using treadmill training and cycling training, or completed a standard PR program consisting of both aerobic and strength training.

Results of the risk of bias assessment are provided in Table 2. The conference abstract by Makhabah et al. was unclear in all categories of bias assessment, with no further information obtained from the authors. Of the remaining 5 studies, 4 were determined to be unclear in the blinding of study participants. Other sources of bias included limited washout periods and short exercise sessions in crossover trials. The majority of studies used appropriate randomization and reported all outcomes.

**INTERVENTION**

Table 3 describes the characteristics of the active video games discussed in this review. Four studies used Nintendo Wii and 2 used the Xbox Kinect gaming consoles. Wii Fit, a game consisting of yoga, strength, and aerobic exercises, was used in 2 studies for participants with COPD or mixed respiratory diseases. Two crossover studies for

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**Figure.** Study flow diagram from identification of studies to final inclusion.

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**Table 1.** Characteristics of the included studies.

| Study | Participants | Intervention | Comparator | Outcome Measures |
|-------|--------------|--------------|------------|-----------------|
| Study 1 | Asthma patients | Active video game | Treadmill training | Exercise capacity, dyspnea, heart rate |
| Study 2 | COPD patients | Exergame training | Cycling training | Oxygen saturation, energy expenditure |
| Study 3 | CF patients | Virtual reality | Standard PR program | HRQOL, activity enjoyment |

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**Table 2.** Risk of bias assessment.

| Study | Randomization | Allocation concealment | Blinding of participants | Blinding of outcome assessment | Free of residual confounding |
|-------|-------------|------------------------|--------------------------|-------------------------------|----------------------------|
| Study 1 | Clear | Clear | Clear | Clear | Clear |
| Study 2 | Yes | Clear | Clear | Clear | Clear |
| Study 3 | Yes | Clear | Clear | Clear | Clear |

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**Table 3.** Characteristics of the active video games.

| Game | Platform | Description |
|------|---------|-------------|
| Wii Fit | Wii | Yoga, strength, aerobic exercises |
| Nintendo Wii | Wii | Exergame training |
| Xbox Kinect | Xbox | Exergame training |

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**Figure.** Study flow diagram from identification of studies to final inclusion.
participants with COPD28 or CF25 used the EA Sports Wii Active game, consisting of jogging on the spot, dance, boxing, and other sports. Both studies using the Xbox system chose a mini-game from the Xbox Kinect Adventures game.

Of the randomized controlled trials, 2 studies delivered the video game intervention twice weekly for a period of 6 to 8 wk, and 1 study delivered the intervention once daily for 1/wk for 6 wk (40-min sessions). The third being a single 20-min session.28 From the 3 crossover studies, 2 of which included only a single 15-min session,25,26 the third being a single 20-min session.28

**PRIMARY OUTCOME-EXERCISE CAPACITY**

All 6 studies included outcome measures related to exercise capacity (Table 1). These included constant treadmill time and distance,24 6-min walk distance (6MWD),27,29 cycle ergometry,15 and measures of HR.24,26,28 Treadmill time and distance were compared for children with moderate to severe asthma following 8 wk of training using a treadmill or the “Reflex Ridge” mini-game.24 Both groups showed significant improvement in treadmill time and distance. Between-group differences favored the conventional training group ($P < .05$).

The addition of Wii Fit training to the final week of a standard PR program was associated with significant improvements in 6MWD compared with control ($P = .028$) but no difference in measures of incremental arm ($P = .36$) or leg cycle ergometry ($P = .77$) between groups.27 Another study using Wii Fit noted significant improvements in 6MWD from baseline to end of program in both groups,29 with no between-group differences reported.

Maximal HR levels during active video game training were comparable to or higher than those achieved by the control group in all studies.24,26,28 Kuys et al25 reported significantly higher minimum and maximal training HR in the video game group, although there was no difference in average HR between groups ($95\% CI: 3-15$). The addition of Wii Fit training to the final week of a standard PR program was associated with significant improvements in 6MWD compared with control ($P = .028$) but no difference in measures of incremental arm ($P = .36$) or leg cycle ergometry ($P = .77$) between groups.27 Another study using Wii Fit noted significant improvements in 6MWD from baseline to end of program in both groups,29 with no between-group differences reported.
**SECONDARY OUTCOME MEASURES**

Secondary outcome measures included measures of $SpO_2$, dyspnea rating, rating of perceived exertion, energy expenditure, HRQOL, enjoyment, and preference for exercise modality.

**SECONDARY OUTCOME MEASURES: TRAINING**

$SpO_2$ was similar during training between all intervention and control groups and remained $>90\%$, or was maintained with supplemental oxygen at safe levels during training. Dyspnea levels were recorded during training using the Borg scale and a visual analog scale in the crossover studies. The Transition Dyspnea Index and the Medical Research Council dyspnea scale were used for the randomized controlled trials. Dyspnea levels and rating of perceived exertion between groups were comparable in all studies. Fatigue was measured in 2 studies using a visual analog scale; in 1 study, Wii training resulted in similar fatigue levels compared with control; in a second study, Xbox Kinect training was associated with significantly lower fatigue levels during training ($P < .001$).

Total energy expenditure, as measured continuously during training by a portable activity monitor, was higher than conventional exercise training only when playing the Xbox Kinect Adventure “Reflex Ridge” mini-game than during treadmill training ($P < .01$), with no differences noted with EA Sports Wii Active training.

**SECONDARY OUTCOME MEASURES: CLINICAL**

Only 1 study reported significant differences in dyspnea rating using the Transition Dyspnea Index, with the video game group reporting less breathlessness than the control group ($P < .001$). Two studies measured HRQOL using the St George’s Respiratory Questionnaire. Both groups had significant improvement in their St George’s Respiratory Questionnaire scores only from baseline to the end of the study.

Enjoyment and preference for exercise modality were reported in the 3 crossover studies. Adults with CF expressed higher levels of enjoyment for the EA Wii Sports Active games compared with treadmill exercise (95% CI, 1.6-3.6). Children and adolescents with CF preferred

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### Table 2

| Studies                  | Randomization | Allocation | Blinding | Participants and Personnel | Outcome Assessor | Incomplete Outcome Data | Selective Reporting | Other Bias                  |
|-------------------------|---------------|------------|----------|---------------------------|-----------------|-------------------------|---------------------|----------------------------|
| Gomes et al (2015)      | Low           | Low        | Low      | Unclear                   | Low             | High                    | Low                 | None                        |
| Kuys et al (2011)       | Low           | Low        | Low      | High                      | Low             | High                    | Low                 | Low: Exercises on separate days |
| Legear et al (2016)     | Low           | Unclear    | Unclear  | Unclear                   | Unclear         | Unclear                 | Low                 | Low: 15 min washout period |
| Makhabah et al (2015)   | Unclear       | Unclear    | Unclear  | Unclear                   | Unclear         | Unclear                 | Low                 | Low                        |
| Mazzoleni et al (2014)  | Unclear       | Unclear    | Unclear  | Low                       | Low             | None                    | None                |                            |
| Salonini et al (2015)   | Low           | Unclear    | Unclear  | Low                       | Low             | Low                     | Low                 | Low: Exercises on separate days |

### Table 3

| Studies                  | Game                      | Experiences                                                                 | Exercise Type          | Exercise Intensity                                                                 |
|-------------------------|---------------------------|------------------------------------------------------------------------------|------------------------|----------------------------------------------------------------------------------|
| Gomes et al (2015)      | Xbox Kinect Adventures     | Jumps, squats, perform lateral and arm movements to dodge obstacles and collect points | Aerobic lower body     | 90.5% of predicted maximum HR Meets recommendations of >80% predicted maximum HR for children with respiratory disorders |
|                         | mini-game “Reflex Ridge”  | 10×3-min rounds with a 30-sec rest interval between rounds                    |                        |                                                                                  |
| Kuys et al (2011)       | EA Sports Wii Active      | Boxing, running/track, dancing tailored to each participants preferences and limitations | Aerobic upper body     | 73% of predicted maximum HR Meets recommendations for those with low to average fitness levels |
| Legear et al (2016)     | EA Sports Wii Active      | “Run (medium)” — marching on the spot “Dance basic 1” — Basic arm movements “Heavy” bag-repeated punching on-screen punching bag “Targets 1” — air punching targets on-screen | Aerobic upper body     | Participants self-adjusted to maintain Borg dyspnea scale of 3-5                   |
| Makhabah et al (2015)   | Wii Fit                   | Yoga, strength training, aerobic                                             | Aerobic strength       | No guidelines for intensity reported                                               |
| Mazzoleni et al (2014)  | Wii Fit                   | 5 min of “Yoga” (stretch and deep breathing) at the beginning and end as a warm-up/cooldown “ Jogging Plus” — 10-min running on the spot “Twisting and squat” — 10-min twisting trunk and leg squatting as directed | Aerobic lower body     | No guidelines for intensity reported                                               |
| Salonini et al (2015)   | Xbox Kinect Adventures     | Stand on a virtual raft, jump or step left or right to dodge obstacles and collect points | Aerobic lower body     | Aim of >80% of predicted maximum HR Achieved by 40% of participants                |
|                         | mini-game “River Rush”    | 3 levels, each lasts 6 min with a 1-min rest in-between levels                |                        |                                                                                  |

Abbreviation: HR, heart rate.
and the Xbox Kinect Adventures mini-game “River Rush” to stationary cycle exercise (P < .001) while individuals with COPD equally enjoyed treadmill/cycle training and Nintendo Wii training.

DISCUSSION

A variety of active video games and gaming systems were used in the studies included in this review. These games varied in their exercise intensity, as reflected by the percent predicted maximum HR determined for each population. Compared with treadmill or cycling training, active video games induced similar maximal HR and dyspnea levels. Although 1 study reported between-group differences in 6MWD in favor of the video game intervention, the short (1 wk) intervention period limits any meaningful interpretation of the result beyond a 3-wk inpatient PR program.

The longest duration of active video game training was 8 wk with training twice weekly, the minimum time generally recommended for exercising populations. Only 2 of the 3 randomized controlled trials reported 6 to 8 wk of active video games versus the alternative traditional exercise training. The third randomized controlled trial had only a 1-wk add-on to a short (3-wk) PR program. Other studies varied in intervention length, the shortest 2 being a single 15-min session.

Both active video games such as Nintendo Wii EA Sports Active and the Xbox Kinect Adventures “Refl ex Ridge” and “River Rush” mini-games can achieve exercise intensities similar to those achieved using treadmill or cycle training. These findings are consistent with the recent review of active video game training in patients with CF. The style of video game training, using short, 3–5 min mini-games, with approximately 15–30 sec rest while the next game loads, is similar to interval training, an approach used for patients with chronic respiratory diseases who may be unable to tolerate continuous exercise. Further information is required regarding the relative intensity of exercise prescription for this approach due to the variation of games used in this review.

The specificity of training within the active video game may influence outcome measures. For example, one would not expect changes in arm cycle ergometry from a video game that was predominantly focused on lower limb training. Similarly, the improvement in treadmill time in the control group in the study by Gomes et al is not surprising, despite the higher training energy expenditure and HR in the video game group, as the latter involved a program of jumps, squats, and arm movements to avoid obstacles whereas the former used treadmill training. In addition, the study by Mazzaoloni et al included a measurement of HRQOL after a 1-wk long trial. This highlights the importance of evaluation studies selecting outcomes appropriate to the intervention. In addition, the comparator exercise was variable between studies both in duration and intensity and did not reflect the interval style of the video games.

The majority of active video games on the market are designed to appeal to children and young adults, but studies with older adults have demonstrated that they too can enjoy these games. In this review, children and adults with asthma or CF clearly preferred video game training whereas adults with COPD enjoyed both training modalities. Active video games are a unique exercise training option as they offer the enjoyment and competitive aspect of video games but are controlled by the player’s movement and, therefore, are also a form of physical activity. By immersing the player in a virtual reality, active video games also serve to distract the player from symptoms such as fatigue or dyspnea, common among the respiratory population.

While the collective results demonstrating similar training maximal HR, dyspnea levels and positive enjoyment are encouraging, longer-term studies, with a consistent intervention in a homogeneous population, are required to establish the clinical impact of active video game training. In addition, personnel should be blinded to group allocation when evaluating outcome measures to reduce the risk of bias in future studies. Given the nature of the intervention, it would be difficult to blind participants. An important limitation of this review is the small number of studies identified, which reflects the novelty of video game training in respiratory rehabilitation. Had this review been expanded to include a cardiac population, there would have been more studies included; however, a comprehensive review of “exergames” in cardiac rehabilitation has been previously published. The small number of studies identified included methodological limitations relating to the small sample size, heterogeneity, and duration of exercise training. Such variations in the study design, population, intervention, and outcome measures prevented grouping of data in a meta-analysis. Therefore, current evidence is insufficient to establish the role of active video game training for individuals with chronic respiratory diseases. However, this review will help inform further studies in this area. If shown to be a clinically useful component of exercise, active video games could provide additional variety to standard PR exercise training, increasing motivation and promoting adherence both in a hospital setting and at home.

CONCLUSION

Active video games can induce similar physiological demands such as maximal HR, dyspnea levels, and energy expenditure during training as traditional exercise modalities. The evidence of enhanced clinical outcomes provided in this review is of low quality with small sample sizes and brief intervention periods. Larger randomized controlled trials of homogeneous design and longer-term follow-up will determine whether active video game training can result in long-term improvements in exercise capacity and HRQOL among those with chronic respiratory conditions.

REFERENCES

1. Bateman ED, Hurd SS, Barnes PJ, et al. Global strategy for asthma management and prevention: GINA executive summary. Eur Respir J. 2008;31:143-178.
2. Sawicki GS, Sellers DE, Robinson WM. Self-reported physical and psychological symptom burden in adults with cystic fibrosis. J Pain Symptom Manage. 2008;35:372-380.
3. Vestbo J, Hurd SS, Agusti AG, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2013;187:347-365.
4. Carson KV, Chandratilleke MG, Picot J, Brinn MP, Esterman AJ, Smith BJ. Physical training for asthma. Cochrane Database Syst Rev. 2013;9:CD001116.
5. Fanelli A, Cabral ALB, Neder JA, Martins MA, Carvalho CRF. Exercise training on disease control and quality of life in asthmatic children. Med Sci Sports Exerc. 2007;39:1474-1480.
6. Lacasse Y, Martin S, Lasserson TJ, Goldstein RS. Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. Cochrane systematic review. Eur Respir Physiol. 2007;43:475-485.
7. Selvadurai HC, Bliimc CJ, Meyers N, Mellis CM, Cooper PJ, Van Asperen PP. Randomized controlled study of in-hospital exercise training programs in children with cystic fibrosis. Pediatr Pulmonol. 2002;33:194-200.
9. Foster S, Thomas IHM. Pulmonary rehabilitation in lung disease other than chronic obstructive pulmonary disease. Am Rev Respir Dis. 1990;141:601-604.

10. Ries AL, Bauldoff GS, Carlin BW, et al. Pulmonary rehabilitation: joint ACCP/AACVPR evidence-based clinical practice guidelines. Chest. 2007;131:45-42S.

11. Molina K, Ricci NA, de Moraes SA, Perracini MR. Virtual reality using games for improving physical functioning in older adults: a systematic review. J Neuroeng Rehabil. 2014;11:1-20.

12. Sween J, Wallington SF, Sheppard V, Taylor T, Llanos AA, Adams-Campbell LL. The role of exergaming in improving physical activity: a review. J Phys Act Health. 2014;11:864-870.

13. Bonnehère B, Jansen B, Omelina L, Van Sint Jan S. The use of commercial video games in rehabilitation: a systematic review. Int J Rehabil Res. 2016;39:277-290.

14. Albores J, Marolda C, Haggerty M, Gerstenhaber M, Zuwallack R. The use of a home exercise program based on a computer system in patients with chronic obstructive pulmonary disease. J Cardiopulm Rehabil Prev. 2013;33:47-52.

15. Albores J, Normandin E, Marolda C, ZuWallack R, Lahiri B. Physiologic variables observed in COPD patients while exercising with an interactive activity-promoting video game. Am J Respir Crit Care Med. 2011;183:A3969. Abstract.

16. del Corral T, Percegon J, Seborga M, Rabinovich RA, Vilaro J. Physiological response during activity programs using Wii-based video games in patients with cystic fibrosis (CF). J Cyst Fibros. 2014;13:706-711.

17. Hoffman AJ, Brintnall RA, Brown JK, et al. Too sick not to exercise: using a 6-week, home-based exercise intervention for cancer-related fatigue self-management for postsurgical non-small cell lung cancer patients. Cancer Nurs. 2013;36:175-188.

18. Hoffman AJ, Brintnall RA, Brown JK, et al. Virtual reality bringing a new reality to postthoracotomy lung cancer patients via a home-based exercise intervention targeting fatigue while undergoing adjuvant treatment. Cancer Nurs. 2014;37:23-33.

19. Griffiths TL, Burr ML, Campbell IA, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. Lancet. 2000;355:362-368.

20. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:81.

21. Higgins JPT, Altman DG, Gortzke PC, et al. The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928. doi:https://doi.org/10.1136/bmj.d5928.

22. Gomes EL, Carvalho CR, Peixoto-Souza FS, et al. Active video game exercise training improves the clinical control of asthma in children: randomized controlled trial. PLoS One. 2015;10(8):e0135433.

23. Kuys SS, Hall K, Peacey M, Wood M, Cobb R, Bell SC. Gaming console exercise and cycle or treadmill exercise provide similar cardiovascular demand in adults with cystic fibrosis: a randomised cross-over trial. J Physiother. 2011;57:35-40.

24. Legear T, Legear M, Preradovic D, Wilson G, Kirkham A, Camp PG. Does a Nintendo Wii exercise program provide similar exercise demands as a traditional pulmonary rehabilitation program in adults with COPD? Clin Respir J. 2016;10:303-310.

25. Mazzoleni S, Montagnani G, Veghieggiin G, et al. Interactive videogame as rehabilitation tool of patients with chronic respiratory diseases: preliminary results of a feasibility study. Respir Med. 2014;108:1516-1524.

26. Salonini E, Gambazza S, Meneghelli I, et al. Active video game playing in children and adolescents with cystic fibrosis: exercise or just fun? Respir Care. 2015;60:1172-1179.

27. Makhabah D, Suradi S, Doewes M. The role of interactive game-based system in pulmonary rehabilitation of patients with COPD. Eur Respir J. 2015;46:PA549. Abstract.

28. Baquet G, Gamelin FX, Muccio P, Thevenet D, Van Praagh E, Berthoin S. Continuous vs. interval aerobic training in 8- to 11-year-old children. J Strength Cond Res. 2010;24:1381-1388.

29. American College of Sports Medicine. ACSM’s Guidelines for Exercise Testing and Prescription. Baltimore, MD: Lippincott Williams & Wilkins; 2010.

30. Williams C, Benden C, Stevens D, Radtke T. Exercise training in children and adolescents with cystic fibrosis: theory into practice. Int J Pediatr. 2010;670640. doi: 10.1155/2010/670640.

31. Carbonera LP, Vendruscolo JM, Donadio MV. Physiologic responses during exercise with video games in patients with cystic fibrosis: a systematic review. Respir Med. 2016;119:63-69.

32. Beauchamp MK, Goldstein RS, Hill K, Dolmage TE, Mathur S, Brooks D. Interval versus continuous training in individuals with chronic obstructive pulmonary disease—a systematic review. Thorax. 2010;65:157-164.

33. Ruivo JA. Exergames and cardiac rehabilitation: a review. J Cardiopulm Rehabil Prev. 2014;34:2-20.