

Research Article

Feasibility of Flying Disc Game for Patients with Oxygen Therapy

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Keywords

- Physical activity
- COPD
- Exercise training
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Abstract

Background: Flying disc (FD) game might improve the physical activity (PA) in patients with long-term oxygen therapy (LTOT). However, the objectively-measured intensity and the safety of FD game have not been evaluated. In order to apply the FD game to LTOT patients, we evaluated the intensity, feasibility and continuity of the FD game.

Methods: The PA during the FD game and that of daily living were measured with a triaxial accelerometer. SpO₂, heart rate (HR), and modified Borg scale during the FD game were measured and a questionnaire survey was performed.

Results: Fourteen LTOT patients, cumulative total of 18 cases were included. The % duration of PA during the FD game was significantly higher than that of daily living at the intensity ≥ 2.0 METs ($p=0.001$), ≥ 2.5 METs ($p=0.016$), but not at ≥ 3.0 METs and ≥ 3.5 METs. The lowest SpO₂ was 88%, highest HR was 130/min, and highest Borg scale was 7 points. Patients enjoyed and desired to participate in the FD game again.

Conclusion: As the FD game was mild activity, was feasible, and gave patients motivation to continue, this could become a candidate of effective intervention for improving PA in LTOT patients.

ABBREVIATIONS

FD: Flying Disc; PA: Physical Activity; LTOT: Long-Term Oxygen Therapy; COPD: Chronic Obstructive Pulmonary Disease; SpO₂: Percutaneous Oxygen Saturation By Pulse Oximetry; HR: Heart Rate; mBorg Scale: Modified Borg Scale; BP: Blood Pressure; Mets: Metabolic Equivalents; FEV_{1.0}: Forced Expiratory Volume In One Second; FVC: Forced Vital Capacity

INTRODUCTION

Long-term oxygen therapy (LTOT) has been recommended for patients with hypoxemia. In patients with LTOT, exercise capacity, activity of daily living (ADL), QOL and also physical activity (PA) were reduced compared to those without LTOT [1, 2]. PA is reduced [3, 4] and is the strongest predictor of all-cause mortality [5] in patients with chronic obstructive pulmonary disease (COPD) which is the most common disease requiring

LTOT. The improvement and maintenance of PA could be one of the most important issues for the management of patients with LTOT.

The effect of bronchodilators on PA in COPD is still controversial [6-8]. Rehabilitation is useful for improving exercise tolerance, ADL and QOL in patients with COPD [9-11] and could be useful for PA. However, these effects can easily diminish after discontinuing rehabilitation. In order to maintain the PA, the development of interventions that patients enjoy and are motivated to continue is required.

The flying disc (FD) game for disabled subjects has been held in several parts in Japan and is one of the official events of Paralympic Games. A FD is a disc-shaped gliding object that is generally plastic and roughly 20 to 25 cm in diameter with a lip, thrown and caught for recreation. The Japan FD Federation for the Disabled was formally established in 1998 and, since then,

the chief director, secretary general, and directors have been holding training classes for instructors for further extension into various local districts in Japan.

As a FD accuracy game is one of the FD games and does not require rapid or vigorous movement for the participants, the repeated attendance of this game might become a beneficial intervention to maintain PA in patients with LTOT. In order to introduce the game to LTOT patients, however, an objective evaluation of the intensity of activity during the FD game and the safety should be necessary.

In order to introduce the FD accuracy game to LTOT patients, we objectively evaluated the intensity of activity during the FD game, and also investigated the feasibility of playing the game and the desire of the patients to continue doing so.

MATERIALS AND METHODS

Subjects

Patients with LTOT who participated in the 2012 to 2014 annual meeting of the LTOT Patients Association in Wakayama Prefecture, Japan (held in June) were enrolled for the study. Exclusion criteria were as follows; [1] patients with percutaneous oxygen saturation by pulse oximetry (SpO₂) <90% during warming up or a trial throw with described amount of oxygen inhalation by medical attendant, [2] patients suffering from movement disturbance in their limbs.

Protocol

Study 1: Intensity of activity during the FD game: The participants wore triaxial accelerometers, Actimarkers (Panasonic; Osaka, Japan), on their waist during all events related to the FD game. The total measurement time of the FD game was defined as the total duration of warming up, trial throw, and competition of each participant. Furthermore, in order to evaluate the PA of daily living, the participants wore Actimarkers for 14 days from the next day after the competition. The total measurement time of PA of daily living was defined as the duration of the whole day except when bathing or sleeping. In order to compare between the duration of PA during FD game and that of daily living, the % duration of activity which was calculated as $100 \times (\text{duration of activity}) / (\text{total measurement time})$ was employed as an index of PA.

Study 2: Feasibility and desire to participate: The SpO₂, heart rate (HR) and modified Borg (mBorg) scale [12] were measured before and during the FD competition of 10 throws and were evaluated for the feasibility. The feasibility was evaluated by the following criteria: 1) SpO₂ is 90% or greater. If SpO₂ temporally dropped to less than 90%, it recovered to 90% or more in 20 seconds at rest; 2) HR is 140 /min or less; 3) mBorg scale is 7 or less; 4) no serious symptoms appear. When participants failed to meet these criteria, we forced them to stop playing the game. The impressions of the FD game were investigated with our originally created questionnaire performed after the game. The questions were: Do you agree with the contents of the text? Q1) "I enjoyed the FD game", Q2) "I'd like to participate in the FD game again in the future", Q3) "I think it is possible for LTOT patients to perform the FD game", Q4) "I did not feel fatigue", Q5) "I did not feel shortness of breath". Responses to questions were

chosen from among 1 to 5: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree.

Written informed consent was obtained from all participants, and the study was approved by the local ethics committee (Committee: IRB committee of Wakayama Medical University; authorization number: 968 and 1247) and registered with the University hospital Medical Information Network (UMIN000006293).

FD accuracy game

In the FD accuracy game, a FD is thrown toward a circular goal of 91.5 cm in diameter from 5m distance. The number of goals achieved in 10 attempts is tallied. The game was performed indoors. After warming up and being shown how to throw a FD by an instructor, participants practiced throwing to each other in pairs and made three trial throws at the goal. Then they each threw the FD 10 times in the competition. Participants sat on chairs and waited when not throwing.

Assessment of PA

The Actimarker is a small (74.5mm x 13.4mm x 34.0mm) and lightweight (36.0g) accelerometer that is worn only at the waist and can be continuously monitored for over one month. It collects the data of triaxial acceleration at 20Hz, and the standard deviation of the data for one minute is defined as the mean value of acceleration. The value of metabolic equivalents (METs) is calculated from the linear regression formula produced by the relationship between the mean value of acceleration and the METs measured using a respiratory gas metabolic system [13]. The Actimarker was already validated for evaluating the PA in COPD in terms of the intensities [14]. From among 2-week monitoring data, 3 non-rainy weekdays from the beginning, except the first and last days, were extracted and the mean values of the PA duration from the extracted 3 days were employed as representative values of the PA of daily living for individuals according to a previous investigation [14].

Statistical analysis

Statistical analysis was performed using GraphPad Prism 5 (GraphPad Software, San Diego, CA). Wilcoxon signed rank test was used for the comparison between the % duration of PA during the FD game and that of daily living, and also for the comparisons between the values of SpO₂, HR, and mBorg scale before and during the FD game. Significance was considered as a p-value of <0.05.

RESULTS

Total 17 patients participated in the 2012 to 2014 annual meeting of the LTOT Patients Association. Of 17 patients, 3 patients (2 with interstitial pneumonia, 1 with COPD) dropped SpO₂ to less than 90% during warming up or a trial throw even with described amount of oxygen inhalation and were excluded according to the exclusion criteria. Finally, cumulative total of 18 cases of 14 patients (9 patients with COPD, 4 patients with interstitial pneumonia and 1 patient with obesity hypoventilation syndrome) were included in the FD game. The value of forced expiratory volume in one second (FEV_{1.0}) was $1.16 \pm 0.48L$, FEV_{1.0} % predicted was $53.2 \pm 22.2\%$ and FEV_{1.0}/ forced vital capacity (FVC) was $70.3 \pm 25.3\%$ (Table 1).

During the FD game, the maximal intensity of PA was less than 3.5METs in 13 cases, less than 3.0METs in 8 cases, and less than 2.5METs in 1 case. In daily living, the maximal intensity of PA was less than 3.5METs in 4 cases. In the other cases it was 3.5METs or more. The % duration of activity during the FD game was significantly higher than that of daily living at an intensity ≥ 2.0 METs ($p=0.001$), ≥ 2.5 MET ($p=0.016$), but not at ≥ 3.0 METs ($p=0.055$) nor ≥ 3.5 MET ($p=0.670$) (Figure 1).

The values of SpO2 were significantly reduced, and the HR and mBorg scale values were significantly increased during the FD game compared to those before the game (SpO2: $p<0.0001$; HR: $p<0.0001$; mBorg scale: $p<0.0001$) (Figure 2). During the FD game, the lowest SpO2 among the participants was 88%, which recovered to more than 90% in a few seconds, the highest heart rate was 130 /min, the highest mBorg scale was 7 points, and no serious symptoms were observed, thereby meeting the feasibility criteria.

Although all participants felt slight fatigue and shortness of breath, they enjoyed, felt it possible to perform for LTOT patients, and desired to participate in the FD game again (Figure 3).

DISCUSSION

We demonstrated that the FD game was performed with mild intensity of activity compared to the physical activity of daily living, and was feasible for the LTOT patients and enjoyable to the extent that the patients desired to participate in the game again.

The % duration of PA during the FD game significantly increased at the intensity ≥ 2.0 METs and ≥ 2.5 METs compared to that of daily living. It has been expected that the intensity of FD accuracy game is not so high, but we could objectively confirm that the intensity of FD was relatively low for the first time. Not only high-intensity but also low-intensity exercise training

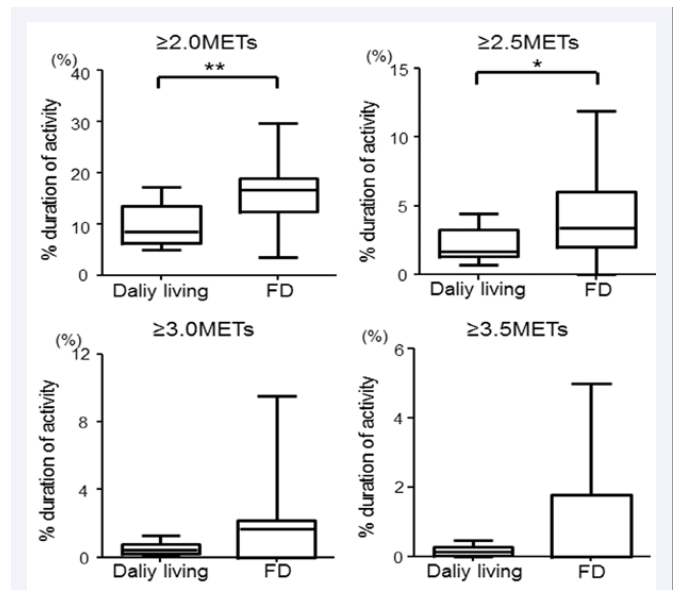


Figure 1 Comparison between the % duration of activity during FD game and that of daily living. Data are shown as box plots (each box represents the 25% percentile at the lower extreme of the box, the median at the central line of the box, and the 75% percentile at the upper extreme of the box). The minimum and maximum values are also depicted and correspond to the lines outside each box. Data were analysed with Wilcoxon signed rank test. FD: Flying Disc; METs: Metabolic Equivalents.

can improve dyspnea, functional performance, and health status in COPD [15], and low-intensity exercise training may be associated with better long-term adherence than higher intensity training [16]. Therefore, low-intensity exercise training is also recommended for patients with COPD [16]. The FD accuracy game, an activity with relatively low-intensity, could become an effective intervention to improve the PA of LTOT patients and also COPD patients.

During the FD game, the lowest value of SpO2 in most of the participants was more than 90%, with only two patients showing values of 88 and 89% that rapidly recovered to more than 90% in a few seconds. The highest values of HR and mBorg scale were 130 /min and 7, respectively. In the criteria for discontinuation of therapeutic exercise by Anderson, these are HR>140/min, 10 arrhythmia episodes/min, systolic blood pressure (BP) increases ≥ 40 mmHg or diastolic BP increases ≥ 20 mmHg, moderate dyspnea, and appearance of serious subjective symptoms (dizziness, nausea or chest pain) [17]. In the Japanese guidelines of pulmonary rehabilitation, the criteria are SpO2 <90, HR $\geq 85\%$ of age-specific maximum HR, mBorg scale <7-9, respiratory rate >30/min, large change of blood pressure, or appearance of serious subjective symptoms [18]. Based on these criteria, in the current study, we set the feasibility criteria of the game as follows. 1) SpO2 is 90% or more; if SpO2 temporally drops to less than 90%, at rest it recovers to 90% or more within 20 seconds. 2) HR is 140 /min or less. 3) mBorg scale is 7 or less. 4) No serious symptoms appear. According to our criteria, the FD accuracy game was feasible for all patients with LTOT who did not show hypoxemia (SpO2 $\leq 90\%$) during a trial throw with oxygen inhalation.

Table 1: Characteristics of patients.

COPD/IP/OHS	9/4/1
Gender (M/F)	10/4
Age	75.6±6.0
BMI (kg/m ²)	23.5±4.1
Smoking (non/ex/curr)	4/10/0
MMRC (0/1/2/3/4)	0/2/5/3/4
Pulmonary function tests	
FVC (L)	1.82±0.88
FEV1.0 (L)	1.16±0.48
FEV1.0% (%)	70.3±25.3
FEV1.0 % predicted (%)	53.2±22.2
IC (L)	1.31±0.59
Oxygen supply	
at rest (L)	0/-1.0/-2.0/-3.0
ambulatory (L)	-1.0/-2.0/-3.0/-5.0

Abbreviations: COPD: Chronic Obstructive Pulmonary Disease; IP: Interstitial Pneumonia; OHS: Obesity Hypoventilation Syndrome; BMI: Body Mass Index; MMRC: Modified Medical Research Council Dyspnea Scale; FVC: Force Vital Capacity; FEV1.0: Forced Expiratory Volume In 1 Second; IC: Inspiratory Capacity

Although pulmonary rehabilitation is beneficial for patients with chronic lung diseases, long-term maintenance of its effect is difficult after completion. Most of the effects of short-term pulmonary rehabilitation programs persisted for less than 24 months after starting the program [19-21]. A long-term (18-month) exercise program results in greater improvements in physical function in patients with COPD, when compared with a short-term (3-month) exercise program [22]. A weekly 12-month telephone-based maintenance program after pulmonary rehabilitation can maintain better exercise tolerance and overall health status, but even these effects disappeared after 24 months [21]. Interventions for the maintenance of PA in patients with chronic lung diseases are needed.

From the results of our questionnaire, the percent of patients with score 4 (agree) or 5 (strongly agree) in Q1 (enjoyed), Q2 (participate again), and Q3 (possible for LTOL) were 100%, and those with score 1 (strongly disagree) or 2 (disagree) in Q4 (without fatigue) and Q5 (without shortness of breath) were less than 50%. Although the participants felt slight fatigue and dyspnea, they enjoyed, felt it was not beyond the ability of LTOT patients, and desired to participate in the FD game again, which implied that the participants were motivated to play again, and the FD game could be an effective intervention for the maintenance of PA in patients with LTOT. The combination of pulmonary rehabilitation and FD game might be better for the PA in LTOT patients.

Furthermore, Japan Flyingdisc Federation for the Disabled has its branch in all prefectures and has been working for the spread and instruction of the FD game. The participation qualification of a FD game will be extended to the person with disorders of internal organ including pulmonary dysfunction by the National Sports Festival for People with Disabilities of 2016 in Japan. The FD game for disabled person is becoming popular and the environment for playing has been regulated in Japan. These circumstances suggest that the FD game might more easily become a beneficial intervention than the others to improve PA in patients with LTOT.

Clinically relevant anxiety or depression together with decreased levels of exercise tolerance, ADL and QOL are found in patients with COPD or interstitial pneumonia [23-28]. As exercise training reduces depression in COPD patients [23, 29,

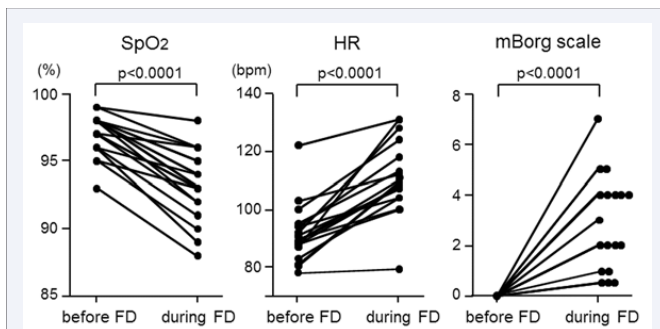


Figure 2 Changes of SpO₂, HR, and mBorg scale during FD game. Data were analysed with Wilcoxon signed rank test. SpO₂: Percutaneous Oxygen Saturation by Pulse Oximetry; HR: Heart Rate; MBorg Scale: Modified Borg Scale; FD: Flying Disc.

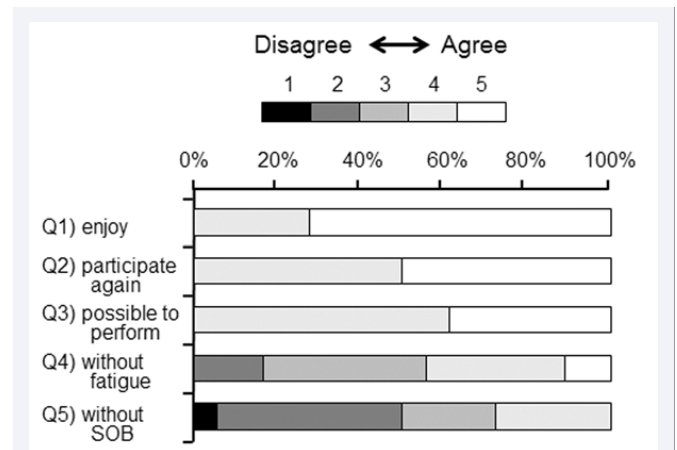


Figure 3 Impressions of the FD game. The questions were: Do you agree with the contents of the text? Q1) "I enjoyed the FD game", Q2) "I'd like to participate in the FD game again in the future", Q3) "I think it is possible for LTOT patients to perform the FD game", Q4) "I did not feel fatigue", Q5) "I did not feel shortness of breath". Responses to questions were chosen among 1 to 5; 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. SOB: shortness of breath.

30), the FD game might be also beneficial for the mental health status of such patients. As COPD patients with LTOT have lower ADL and fewer opportunities to go outside than those without LTOT [1, 2], repeated participation in FD game could increase the amount of time spent outside and increase patients' goal-directed behavior in desiring to obtain better game scores, facilitating the maintenance of PA. Although it was only observational findings with small number of patients, in 4 patients who participated in the FD game for 2 years, the mean value of the % durations of PA in daily living did not decreased but rather increased in one year at the intensity ≥ 2.0 METs (from 7.41% to 8.63%) and ≥ 2.5 METs (from 1.74% to 2.24%).

There are several limitations that need to be addressed. First, the number of participants was small. Small number of cases might not give us enough information on the true feasibility of the FD in LTOT. However, among total 18 cases with SpO₂ $\geq 90\%$ during warming up or a trial throw and without movement disturbance in their limbs, FD seemed to be feasible in patients with LTOT. Larger numbers of participants will need to be studied. Second, though the desire to participate in the game was evaluated with a questionnaire, this study was not a longitudinal but rather a cross-sectional study. The continuity should be evaluated, namely the effects of repeated participation with games held at regular intervals. Third, we did not evaluate the effect of FD game on the physical activity in daily living. The effect of the repeated participation of the game on physical activity in daily living should be evaluated in future study. Fourth, although patients whose SpO₂ was less than 90% with the trial throw were excluded, more appropriate criteria for participation in the game should be determined. Fifth, we did not monitor electrocardiograms during the FD game, though rhythm irregularities of the pulse by palpation just after the competition were not observed in any participant. The evaluation of electrocardiograms during the game should be considered in a future study.

CONCLUSION

The FD game was performed with mild intensity of activity compared to the activity of daily living, but caused no discomfort in those who met the provisional entry criteria. As the game was feasible and the patients were motivated to participate again, repeated participation in FD games might become a candidate of effective intervention to maintain or improve the PA of LTOT patients.

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