Validity of the Low-Impact Dance for exercise-based cardiac rehabilitation program

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ABSTRACT. Purpose: The aim of this study was to evaluate the oxygen uptake in patients with cardiovascular disease during the low-impact dance program and to compare the findings with the values at peak oxygen uptake (VO₂) and aerobic threshold (AT). Methods: The study included 19 patients with cardiovascular disease [age, 68.3±8.7 years; left-ventricular ejection fraction, 60.3%±8.7%; peak VO₂, 6.6±1.1 metabolic equivalents (METs)] who were receiving optimal medical treatment. Their heart rate and VO₂ were monitored during cardiopulmonary exercise testing (CPET) and during the low impact dance. The dance involved low-impact dynamic sequences. The patients completed two patterns of low-impact dance, and metabolic gas exchange measurements were obtained using a portable ergospirometry carried in a backpack during the dance sessions. Results: The mean values of VO₂ (4.0±0.2 METs and 3.9±0.3 METs) and those of heart rate (105.2±2.9 bpm and 96.8±2.6 bpm) during the dance program were not significantly different from the AT value (4.5±0.2 METs) obtained in CPET. The median (and interquartile range) RPE reported after the dance exercise trials was 11 (9-13). No signs of overexertion were observed in any of the patients during either dance exercise trial. Conclusions: The results suggest that it is reasonable to consider the low-impact dance program as an aerobic exercise program in cardiac rehabilitation. Our findings have important implications for exercise training programs in the cardiac rehabilitation setting and for future studies.

Key words: elderly patients, aerobic exercise, cardiopulmonary exercise testing, cardiac rehabilitation, heart rate

Exercise-based Cardiac rehabilitation (CR) has been reported to be associated with a 25% reduction in the overall mortality rate from cardiovascular causes after 3 years in patients with myocardial infarction1,2). Moderate and vigorous exercise is now prescribed not only as a preventive strategy for ischemic heart disease3), but also as a major component of treatment after myocardial infarction4), angioplasty, coronary bypass surgery, and heart transplantation5), as well as treatment for congenital heart disease6) and stable congestive heart failure7,8).

Aerobic exercise training in CR is usually performed using a cycle ergometer and treadmill. Furthermore, it is known that daily activity is important in rehabilitation, and daily walking at home is often recommended to patients in a CR setting. There is evidence that moderate-intensity aerobic exercise improves functional capacity and quality of life (QOL) in healthy elderly individuals and cardiac patients with normal or decreased cardiovascular function9,10).

Despite the evidence on the benefits of exercise training in patients with cardiovascular disease and the importance that is attributed to cardiac rehabilitation programs in all major evidence-based guidelines, non-pharmacological treatment stays largely underutilized11) and implementation in clinical practice is still very poor12). Some patients would prefer activities that are useful, such as gardening, or that incorporate a social element, such as bowling and dancing, rather than a pure exercise regimen13). In a previous study, submaximal exercise capacity after exercise over a period
of 12 months was higher in patients who were allowed to choose their own exercise activities following a period of supervised exercise training than in those involved in continuously supervised exercise or usual care16.

To increase patient interest in different kinds of exercises and to keep patients engaged for secondary prevention, alternative forms of exercise should be identified. One alternative exercise routine is aerobic dance program16. Dancing is a multidimensional physical activity and is also an excellent approach to improve physical fitness and develop social skills, thereby improving mental health17. In addition, dancing can be taken up early in life, and it can still provide entertainment well after retirement18.

Belardinelli et al.19 examined whether dance as exercise training improves functional capacity and QOL in patients with congestive heart failure, and reported that waltz dancing is safe and improves functional capacity and endothelial dysfunction. However, there are very few reports on dance exercise intensity in the elderly Japanese population. The purpose of this study was to investigate cardiovascular response to the low-impact dance program and to ensure the appropriateness and safety for the elderly with stable cardiovascular disease.

Methods

Subjects

All subjects who completed supervised cardiac rehabilitation program between October, 2014 and September, 2016 were recruited for the study. Eligible patients were those aged ≥60 years without cerebrovascular disease or any other non-cardiac conditions that could limit physical activities and without sufficient cardiac capacity for the exercise test (symptomatic at rest notwithstanding optimized oral therapy).

In addition, only patients who were community residents, functionally independent, hand ambulatory without the use of assistive devices were considered for inclusion. Patients were assessed when they were clinically stable with optimal treatment that included beta-blockers and angiotensin-converting enzyme inhibitors, and without any change in medication during the previous 3 months. Patients with comorbidities such as osteoarthritis, diabetes mellitus, hypertension, and dyslipidemia were included in this study.

A total of 125 patients 65 or more years of age met the criteria for the study. Among them 64 were excluded because the patient or the physician decided not to participate, or for logistic or discretionary reasons. An additional 32 patients were excluded because they went back to see their family doctors after completion of cardiac rehabilitation program or lived outside the catchment area (28), or because they had dementia, mild cognitive impairment or psychiatric illness (4). After verbal explanation and reading of a patient information sheet, written informed consent was obtained. The study was approved by the Ethics Committee of the Iwatsuki Minami Hospital (27), and all parts of the study were conducted according to the guidelines of the Declaration of Helsinki20.

In all of the evaluations, the subjects were conducted a general and specific evaluation consisting of the following: 6MWT and CPET for assessment of the aerobic capacity and endurance; the hand grip strength test for evaluating the muscle strength of the extremities; and Timed Up and Go test for assessing functional mobility.

6 Minute Walking Test (6MWT)

The 6MWT is a sub-maximal exercise test to assess aerobic capacity and endurance. The distance walked over a time of 6 minutes was used as the outcome by which to compare changes in performance capacity. This test was performed in a flat corridor, 30 meters in length, according to the standardized method of the American Thoracic Society (ATS)21.

Cardiopulmonary Exercise Testing

Provided clinical stability was fulfilled, a functional capacity evaluation was performed. Each patient underwent a symptom-limited CPET performed on a cycle ergometer (Strength Ergo 8, Fukuda Denshi Co. Ltd., Tokyo, Japan), using a 10 W/min continuous ramp protocol. The initial workload was 20W for 4 minutes and increased by 10W every minutes until maximal exertion was reached. The workload was computer controlled for electronically braked bicycle ergometers.

The breath-by-breath gas analyzer used in this study was the CPEX-1 System (Inter-Reha Co. Ltd., Tokyo, Japan). Expired gases were continuously collected throughout exercise and were analyzed for ventilation and for O2 and CO2 content, using dedicated analyzers.

The following variables were calculated: peak oxygen uptake (peak VO2, mL/kg/min); AT, defined as the point at which CO2 production increased disproportionately in relation to O2 uptake, which was determined from a graph of O2 uptake against CO2 production. Energy expenditure in this study was calculated in metabolic equivalents (METs). One MET is equal to 3.5 mL O2 per kg body weight per minute. Throughout the CPET, 12-lead electrocardiography (ML-5000, Fukuda Densi Co., Tokyo, Japan) was performed to continuously monitor the heart rate (HR), the detection of arrhythmia and ST segment changes. Patients were not asked to discontinue beta-blockers before the test. The test was terminated when the patient reached volitional exhaustion (peak VO2:) or earlier if another termination criterion was fulfilled20.

Handgrip strength

Hand grip strength were measured using a standard
movements for the following 5 parts of the song: intro, verse, bridge, chorus, and ending. After practicing these movements few times, the movements were integrated into the entire song in the latter half of the main dance phase.

Patients were required to carry a portable respirometer (AT-1100; Anima Co. Ltd., Tokyo, Japan) in a backpack to measure oxygen uptake and HR during the warm-up phase and main dance phase (Fig. 1), but not during the cool-down phase. The participants were asked to rest quietly until the parameter readings and HR stabilized. The rate of perceived exertion (RPE) was also determined using the Borg scale following the termination of measurements with the expired gas analyzer.

Data Analysis

Statistical analyses were performed using JUMP version 11.2 (SAS Institute Inc., Cary, NC, USA) for Windows. Data are presented as mean and standard deviation [mean±standard deviation (SD)] unless stated otherwise. Categorical variables are expressed as number (n) and percentage (%). A significance level of 0.05 was used. All dependent variables (BMI, AT, peak VO2, 6MWT, TUG, and hand grip strength) were found to be normally distributed by the Shapiro-Wilk test (p<0.05). A significance level of 0.05 was used. One-way analysis of variance (ANOVA) was performed to determine if significant differences existed in oxygen uptake and HR among the values of AT determined by CPET, which were the mean values during DE1 and DE2.

Results

During the data collection period, a total of 19 patients (8 men; age, 68.3±8.7 years; BMI, 23.4±3.1; left-ventricular ejection fraction, 60.3±8.7) with cardiovascular disease were recruited. The patient demographics are summarized in Table 1.

Oxygen uptake, HR and RPE

The mean oxygen uptake values at AT and peak VO2 determined in CPET were 4.5±0.2 METs (68.2% peak VO2) and 6.6±1.1 METs (Table 2), respectively. The maximum HR (HRmax) was 156±18.3 bpm, and HR at AT was 102.4±11.8 bpm (75% HRmax). The association between the intensity of the dance exercise and performance in CPET was moderate to moderately high for all participants, supporting the convergent validity of the test.

The 10-s average oxygen uptake in METs and HR during the dance exercise protocols are shown in Figure 2. The HR and VO2 increases and decreases in a directly proportional fashion during the dance exercise protocols and short rest periods were obtained in the dance exercise session. During dance program, the mean values of VO2 were 4.0±0.2 METs (61% peak VO2) for DE1 and 3.9±0.3 METs during the cool-down phase.
Table 1. Clinical Characteristics of Study Population

| Parameters                        | Values                        |
|----------------------------------|-------------------------------|
| N (M/F)                          | 19 (8/11)                     |
| Age (y)                          | 68.3±8.7                      |
| BMI (m/kg²)                      | 23.4±3.1                      |
| % of Body Fat (M/F)              | 26.3±7.1/31.2±8.1             |
| LVEF (%)                         | 60.3±8.7                      |
| HFrEF                            | 1 (5.3%)                      |
| HFpEF                            | 2 (10.5%)                     |
| IHD                              | 13 (68.4%)                    |
| VHD                              | 4 (21.0%)                     |
| CKD *eGFR<60ml/min/1.73m²        | 10 (52.6%)                    |
| HT                               | 19 (100%)                     |
| DL                               | 13 (68.4%)                    |
| DM                               | 7 (36.8%)                     |
| Smoking                          | 3 (15.8%)                     |
| Family history of CVD            | 4 (21.1%)                     |
| Obese (BMI>25)                   | 5 (26.3%)                     |
| β-blocker                        | 8 (42.1%)                     |
| Diuretics                        | 3 (15.8%)                     |
| ACEI                             | 13 (68.4%)                    |
| Statins                          | 14 (73.7%)                    |
| CCB                              | 8 (42.1%)                     |
| Antiarrhythmics                  | 4 (21.1%)                     |
| Hypoglycemic agent               | 7 (36.8%)                     |
| Anti-platelet agent              | 14 (73.7%)                    |
| Anticoagulant                    | 5 (23.3%)                     |

BMI, body mass index; LVEF, left ventricular ejection fraction; IHD, ischemic heart disease; VHD, valvular heart disease; CKD, chronic kidney disease; HT, hyper tension; DL, dyslipidemia; DM, diabetes mellitus; CVD, cerebrovascular disease; ACEI, Angiotensin-converting enzyme inhibitor; CCB, calcium channel blockers

Table 2. Physical performance

| Parameters          | Values            |
|---------------------|-------------------|
| Grip force (kgf)    | 27.4±6.9          |
| TUG (sec)           | 5.9±0.9           |
| 6MWT (m)            | 553.4±67.7        |
| CPET                |                   |
| Peak VO₂ (MET's)    | 6.6±1.1           |
| Resting HR (bpm)    | 75.3±9.4          |
| Peak HR (bpm)       | 136.5±18.3        |
| HRR (bpm)           | 61.3±13.5         |
| VE/VO₂ slope        | 26.3±6.2          |

Data are listed as mean±SD. VO₂: oxygen consumption
TUG: Timed up and go test, 6MWT: 6 minutes walk test, HR: heart rate, HRR: heart rate reserve (Peak HR-Resting HR)

Figure 1. Subjects are required to participate in the dance exercise lessons along with expired gas analyzer in a back pack. Permission to use this image was obtained from subjects.

(57.6% peak VO₂) for DE2, and the peak oxygen uptake during dance program were 5.6±1.3 METs (85% peak VO₂) for DE1 and 5.4±1.2 METs (81.8% peak VO₂) for DE2, respectively. There were significant differences in between the values of the peak VO₂ during dance programs and the peak VO₂ determined in CPET (p<0.05).

The mean HR values during DE1 and DE2 were 105.2±2.9 bpm and 96.8±2.6 bpm, respectively. Furthermore, the exercise intensity of the low impact dance have the percent of heart rate reserve (%HRR) of 50.2±26.4% for DE1 and 44.2±38.6% for DE2. Table 3 shows the mean values of oxygen uptake in METs, HR monitored during the session (DE1 and DE2), and the mean AT values identified in CPET. ANOVA revealed no significant differences in exercise intensities among them. The median RPE (and interquartile range) reported after the dance exercise trials was 11 (9-13). No signs of overexertion were observed in any of the patients during either dance exercise trial.

Discussion

Overall, the results provide some support for the view that the low-impact dance is a useful exercise as secondary prevention program for the patients with cardiovascular disease.

From the results of the present investigation, two factors appear to play an important role in the interpretation of the exercise intensity of the low impact dance. One is the “threshold-based” aerobic exercise intensity in METs and the other is the “range-based” intensity, which, when combined with through clinical evaluation and exercise-related risk assessment, could be easily monitored using a HR monitor and help maximize the benefits obtained with the
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Table 3. Results of ANOVA

|       | AT         | DE1        | DE2         | P-value |
|-------|------------|------------|-------------|---------|
| HR (95%CI) | 102.4±11.8 | 105.2±8.9  | 96.8±6.6    | 0.0978  |
| METs (95%CI) | 4.5±0.2    | 4.0±0.2    | 3.9±0.3     | 0.0561  |

Figure 2. Typical VO₂ and Heart Rate profile during Dance Exercise protocol. Ten-second averages VO₂ in METs and HR during dance exercise protocol. ① warm up phase, ② practice dance choreograph, ③ 1st Dance Trial ④ 2nd Dance Trial. For details, see text. CPET DATA of this subject; AT: 5.6 METs. Aerobic exercise range: 40-85% heart rate reserve.

use of aerobic exercise training in CR.

The mean VO₂ in METs during dance in our study based on 19 carefully executed tests were 4.0 METs (95% CI, 3.5 to 4.4 METs) for DE1 and 3.9 METs (95% CI, 3.5 to 4.3 METs) for DE2 (Table 3). With regard to exercise, Tai Chi and the Japanese radio exercise were reported to require energy expenditure of 4 METs. With respect to physical training, activities demanding 1-4 METs are generally considered to be of low intensity. Bouchard et al. reported that the exercise intensity of low-impact aerobic dancing is 3.9 METs; therefore, the low-impact dance can be considered as a low-intensity exercise.

The mean and maximum values of VO₂ during dance program in the current study were 61% and 85.1% of the peak VO₂, respectively, and these values are in accordance with the prescribed exercise intensity in CR patients. Figure 2 presents examples of VO₂ and HR during the dance exercise with the approximate aerobic training range indicated; the AT level was determined in the CPET, and 40%-85% HR reserve (HRR) was considered. Aerobic exercise training at 40%-85% of the maximum VO₂ (VO₂max) or 55%-90% of the maximum HR is typically prescribed for cardiorespiratory fitness.

It is suggested that sedentary older adults can enhance aerobic capacity by exercising at intensities as low as 40% of the VO₂max, and some health benefits are realized even if the effort intensity is insufficient to augment aerobic power, along with a Borg scale score of 12-14. Thus, in terms of the range based exercise intensity, it is reasonable to use this dance program as an aerobic exercise program in CR.

Our results on the HR response during dance program were in substantial agreement with the results of a previous review report on exercise prescription for heart failure, which describes planning for training sessions and the determination of the correct exercise training intensity level or domain. In the clinical setting, an important concept when using HR for exercise prescription is HRR, which is defined as the difference between HR at rest and at peak exercise.

Exercise training sessions for cardiac patients are generally proposed in the range of 40%-85% HRR. Our results reveal that both the %HRR of DE1 (50.2%HRR) and DE2 (44.2%HRR) are within the recommended range. Lower-intensity exercises are most applicable to patients who are
deconditioned. Some sedentary individual have shown an improvement in functional capacity with exercise intensities as low as 30% of the HRR.33

Perceived exertion should also be taken into account for estimating the exercise intensity. The most commonly used scale to show subjective indicators of the relative intensity of effort is the RPE scale.34 Although subjective, the RPE scale does have advantages, especially for patients using medications that affect HR. Often patients with cardiovascular disease have blunted chronotropic responsiveness to exercise or are taking medications that relieve stress on the heart. The RPE scale is also an important means of prescribing exercise to people, when no equipment is available for physiological assessment. A study by Zeni et al.35 overly applied the idea that production mode RPE could be used as an independent intensity regulator.

Both of the dance programs were of light-to-moderate intensity, and were rated between 9 and 13 on the Borg scale. An RPE range of 12-16 is recommended for the development of both health-based and rehabilitative cardiorespiratory fitness.36 Consistent with this recommendation, at an RPE value of 13, all our participants in the dance exercise sessions achieved the required exercise intensity range (50%-80% peak \( \dot{V}O_2 \)) for developing cardiorespiratory fitness.

Several limitations of the present study should be noted. Dance may not be suitable for all individuals. In the present study, patients who were willing to participate in a dance program were recruited and assessed. Although patients with many comorbidities were recruited, very sick patients might not be able to participate in this program.

Future studies should focus on examining the benefits of this dance program over other exercise programs, such as brisk walking or riding stationary cycle, with regard to health outcomes, including falls, incident fatal and non-fatal coronary heart disease, all-cause of mortality, and dementia.

Conclusion

The intensity of the low-impact dance program is reasonable and we can introduce the low-impact dance program to selected patients as an aerobic exercise in CR. We believe that this report will stimulate the appropriate use of dance exercise programs for the patients with cardiovascular disease when indicated and encourage further studies in areas that lack data. Our findings may have important implications for the dance exercise program in CR, especially in the maintenance phase.

Conflict of Interest: The authors declare that there is no conflict of interest. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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