A comparison of physiological responses and rating of perceived exertion in two modes of aerobic exercise in men and women over 50 years of age

S Grant, K Corbett, K Todd, C Davies, T Aitchison, N Mutrie, J Byrne, E Henderson, H J Dargie

The proportion of older adults in the population continues to grow, there is a great need to establish ways of delaying or preventing morbidity in later life and maintaining quality of life. Exercise has been shown to have a favourable effect on a variety of variables in older adults. Thus, older adults have been targeted as a sector of the population in need of specific encouragement to undertake physical activity.

It is acknowledged that low physical activity and fitness levels are associated with ill health. Although there is evidence that exercise can be of benefit to health, it must be regular if these benefits are to be attained or maintained. Thus, it is important that regular physical activity is encouraged and that appropriate exercise sessions are promoted. However, the mode of exercise must be acceptable to the target population—that is, the participants must find the activity enjoyable and be able to participate regularly—and it may be necessary to show that the exercise prescription is effective in improving fitness levels. The American College of Sports Medicine (ACSM) emphasises that endurance training in the elderly has the potential to improve peak oxygen uptake (VO₂) and submaximal performance. The concept of "a little exercise is better than nothing" has been promoted.

A variety of exercise possibilities exists for the ageing population. Indoor group exercise sessions are sociable but normally necessitate travel. Walking is easily accessible but may prove to be unpopular at certain times of the year. The cold of winter may be a deterrent in some locations and high summer temperatures may limit participation in other areas.

A previous study showed that there was no significant difference in adherence levels for aerobic dance sessions compared with walking sessions over a six month period. In this study a comparison was made of exercise heart rates with a small subsample of the aerobic dance and walking groups. The results based on exercise heart rates suggested that participants of both modes of exercise were exercising at an appropriate intensity (according to ACSM\(^{10}\)) to promote/maintain aerobic fitness. However, it is not clear if the exercise heart rates in this population are a true reflection of the metabolic cost of the exercise, eliciting unrepresentatively high heart rates for any given %peak VO₂. Although the intensity of aerobic dance and walking sessions has been assessed in young and middle aged subjects,\(^{14}^{15}\) we know of no study that has compared the physiological responses to aerobic dance and walking sessions at self selected intensities in a population over 50 years of age.

It is often not possible to provide participants in exercise sessions with heart rate recorders. Participants are normally asked to monitor heart rate by palpation of the radial or...
carotid artery. However, this technique is often subject to considerable error and may result in subjects exercising at an inappropriate intensity. The substitution of heart rate monitoring with a rating of perceived exertion (RPE) 15 point scale (the Borg 6–20 scale) could have advantages if it could be shown that the RPE scores were closely related to oxygen uptake. A good relation between RPE and oxygen uptake may allow intensity to be monitored using RPE. Thus, it is important to determine the relative intensities of these aerobic dance and walking sessions and to assess the appropriateness of available methods to monitor intensity, namely, heart rate and RPE. The aim of this study was to compare the physiological responses (as determined by oxygen consumption, heart rate) and RPE to aerobic dance and walking sessions completed at a self selected pace.

METHODS

Twelve subjects (6 women), with a sample mean (SD) age of 68 (7) years, volunteered for the study. They were recruited from the 55+ exercise classes run by the Sport and Recreation Service of the University of Glasgow. All volunteers were regular exercisers—that is, they regularly carried out at least two aerobic bouts of exercise a week. The study was approved by the local ethics committee before the start, and all subjects completed a consent form and underwent medical screening before testing. Potential subjects taking drugs that could have influenced the haemodynamic responses to exercise were excluded from the study.

The following three tests were performed by each subject: a class based aerobic session (18 minutes); a self paced walk on an indoor track (18 minutes); a treadmill (peak Vo2) test.

The aerobic dance and walking tests were carried out in random order to balance out any bias or familiarisation effect. Details of the three tests are given below.

Test 1: aerobic dance session
This session was conducted in a sports hall and organised by Sport and Recreation Service of the University of Glasgow. An instructor led the exercise session using a microphone. There were about 40 participants in the class. Subjects performed rhythmic continuous movements in time with the music. They were encouraged to regulate intensity by adjusting the

Table 2 Summary of repeated measures analyses of variance

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variable</th>
<th>V̇O₂</th>
<th>RPE</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>0.17</td>
<td>0.56</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Sex × mode</td>
<td>&lt;0.05</td>
<td>&lt;0.001</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Time × mode</td>
<td>0.11</td>
<td>0.61</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Time × sex</td>
<td>0.81</td>
<td>0.90</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Time × sex × mode</td>
<td>0.81</td>
<td>0.99</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

V̇O₂, Oxygen uptake; RPE, rating of perceived exertion; HR, heart rate.

Table 3 Comparison of sample means for % peak V̇O₂, % heart rate maximum, and ratings of perceived exertion for aerobic dance and walking sessions

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>%peak V̇O₂</th>
<th>%HRmax</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AD</td>
<td>Walk</td>
<td>AD</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>47</td>
<td>65</td>
</tr>
<tr>
<td>6</td>
<td>72</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>9</td>
<td>71</td>
<td>52</td>
<td>74</td>
</tr>
<tr>
<td>12</td>
<td>70</td>
<td>53</td>
<td>76</td>
</tr>
<tr>
<td>15</td>
<td>64</td>
<td>52</td>
<td>76</td>
</tr>
<tr>
<td>18</td>
<td>71</td>
<td>55</td>
<td>78</td>
</tr>
<tr>
<td>Overall mean (SD)</td>
<td>67 (17)</td>
<td>52 (10)</td>
<td>74 (12)</td>
</tr>
</tbody>
</table>

V̇O₂, Oxygen uptake; HRmax, maximum heart rate; RPE, rating of perceived exertion; AD, aerobic dance.

Figure 1 Plots illustrating the significant interaction of sex and mode of exercise for (A) %peak V̇O₂, and (B) rating of perceived exertion. The plots are of the sample means (across all six times), with vertical lines indicating one standard error of each sample mean.
magnitude of movement to enable them to exercise comfortably and “at their own pace”. In addition, they were shown how to carry out movements keeping one foot on the floor at all times. Previous research has shown that relative intensity can be reduced by adapting movements.15

Before each test the subject’s body mass was measured. Heart rate was recorded using a PE3000 sports tester, and expired air collected by a Douglas Bag connected by a Hans Rudolph valve and Velconia tubing to a mouthpiece. An experimenter supported the Douglas bag, stopcock, and some of the Velconia tubing so that the subjects had unrestricted movement. Previous studies have used the same method of gas collection and shown that it does not restrict movement.13

A nose clip was attached to the subject’s nose. The duration of gas collection was 18 minutes as this coincided with the aerobic component of the exercise session. Gas samples were of three minutes duration, and heart rate was recorded throughout, an average being collected for each three minute period. During the second minute of each three minute period, subjects were shown the Borg scale (category scale 6–20) and asked to point to the number on the scale that best described their perceived effort at that moment. Before the session began, subjects were given practice with the oxygen uptake apparatus and asked to exercise as they normally would without the apparatus.

Test 2: self paced walk
This test was conducted on an indoor track. The protocol and equipment were the same as test 1 except that the subjects were asked to walk at a “brisk but comfortable” pace for an 18 minute period. The subjects completed the self paced walk with only one experimenter who carried the Douglas bag. The variables measured were the same as for the aerobic dance session—that is, heart rate, \( V_0 \), and RPE. In both test 1 and test 2, guidance on the use of the RPE scale was given before the tests.

Test 3: treadmill (peak \( V_0 \)) test
This test was carried out so that the relative intensity of the two exercise modes could be evaluated and HRmax established. Tests were conducted in the exercise testing laboratory of the Western Infirmary, Glasgow. In accordance with safety criteria, a cardiologist was present at all times. Before each test, the subject’s mass was measured, and a 12 lead electrocardiograph attached to allow examination of resting and exercise electrocardiograms.

Subjects were given a familiarisation period of walking on the treadmill (Marquette) before the test started. The STEEP and exercise electrocardiograms.

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the sessions. All 12 subjects had higher %peak VO2 and % HRmax at all time points in the aerobic dance session compared with the walking session. For RPE values, one subject rated the walking session harder than the aerobic dance session.

Sample (within subject) correlations were evaluated between RPE and %HR max and then between RPE and %peak VO2 for each of the 12 subjects separately. Table 4 gives summaries for each set of sample correlations across the 12 subjects. It is clear that, in general, there is an extremely poor, if non-existent, correlation between RPE and either %HRmax or %peak VO2, as the median (across all 12 subjects) correlations are almost all zero. The only minor exception is a possible positive but moderate correlation between RPE and %HRmax where the sample median correlation reaches 0.23. Some of the within subject correlations were zero, as these subjects recorded exactly the same RPE values at all time points on that session.

**DISCUSSION**

We believe that these data are representative of actual participation in these types of sessions—that is, the aerobic dance data were collected during an exercise class in a gymnasium while the walking session data were gathered on an indoor track, which was therefore not influenced by environmental factors. The ACSM guidelines indicate that intensity should be 50–85% of peak VO2 and 65–90% of HRmax to improve aerobic fitness. However, the guidelines cite several studies that show that people with low fitness levels can achieve a significant training effect with %peak VO2 below 50%. Several studies have shown that elderly subjects can improve aerobic power by exercising at a range of intensities. Badenhop et al found that subjects with a sample mean age of 68 years who trained at 57–70% peak VO2 increased peak VO2 by 14% over nine week programme. Gossard et al showed that middle aged men improved their aerobic power while they trained at around or under 45% of peak VO2. Thus, it seems that the sample means of 67% and 52% of peak VO2 for the aerobic dance and walking sessions respectively in this study could result in the maintenance or promotion of aerobic fitness in most subjects if achieved on a regular basis. A possible criticism of these sessions is the short duration time of 18 minutes. However, previous studies in a predominantly middle aged group showed an improvement in aerobic fitness with group aerobic sessions of 20 minutes two to three times a week. In addition, several researchers advocate that intermittent exercise bouts of fairly short duration have the potential to improve aerobic fitness and promote health benefit. Several studies have shown improvements in peak VO2 with short, intermittent bouts of exercise.

Data from previous aerobic dance research have shown that younger subjects exercised at a similar %peak VO2 to the subjects in this study—that is, 67% of peak VO2 for the present study compared with 69% of peak VO2 in the study by Grant et al of female university students. Spelman et al reported that their 35 year old subjects walked, on average, at 52% of peak VO2 (exactly the same as this study) at their self selected pace during a walking session. It is important to emphasise that the subjects in our study were regular exercisers and had relatively high peak VO2 levels for their age.

The use of %HRmax to monitor intensity is more “user friendly” than %peak VO2. There is no consensus in the literature as to what a given %HRmax is equivalent to in %peak VO2. Swain et al have questioned the equivalent values given by the ACSM for %HRmax and %peak VO2. However, the relation between %HRmax and %peak VO2 in this study is fairly close to that given by the ACSM 1993 guidelines as well as by M Caru
dale et al. The sample means in this study of 74% of HRmax at 67% of peak VO2 for the aerobic dance session and 60% of HRmax at 52% of peak VO2 for the walking session show greater agreement—that is, the difference between the %HRmax and %peak VO2 is much less—than the data from the RPE study which reported a mean of 80% of HRmax at 67% of peak VO2. It is unclear why there is a closer margin between these two variables in this older population compared with the Swain study. These data suggest that, for this subject group, the monitoring of %HRmax is probably fairly reflective of the relative intensity as measured by VO2. However, a further study is needed to compare the hear rate/VO2 relation in this population using a variety of modes of exercise.

Relative intensities are clearly influenced by the maximum values attained in the peak VO2 test. A HRmax of 210 beats/min for one of the subjects in this study prompted the question of the validity of this value. A cardiologist who examined the 12 lead electrocardiograph print out confirmed that the heart rate was in sinus rhythm and therefore the HRmax was indeed genuine.

The finding that a higher metabolic cost results in an increased RPE confirms previous research. However, these results are for an elderly population and show that, in a comparison of self paced exercise, the metabolic cost and RPEs are higher for aerobic dance than walking. It may be that participation in a group setting in the aerobic dance sessions resulted in some degree of peer pressure, which resulted in higher intensity for the group session. It is to be expected that the use of music would lower RPE. As music is integral to an aerobic dance session, it is not possible to evaluate this hypothesis in a study of this kind.

The sample mean RPE values of 11 (2) for the aerobic dance sessions and 10 (2) for the walking sessions of this study are slightly lower than would be expected for relative intensities of 67% and 52% of peak VO2, as reported when compared with the guidelines of Birk and Birk. Birk and Birk indicate that RPE values of 12–15 correspond in general to 58–89% of peak VO2 respectively. Low RPE values for an aerobic dance could be attributed to the subjects dissociating from perceptions of effort because of background music and the fact that they had to concentrate on the movements in the class. However, the same is not true of the walking sessions. RPE guidelines from other sources do not concur exactly with the Birk and Birk relations. For example, the recommendations of Pollock and Wilmore are also cited in the ACSM 1993 guidelines, suggest that an RPE of 12–13 corresponds to 50–74% of %peak VO2, whereas Esten and Williams state that RPEs of 12–13 are equivalent to a %peak VO2 range of 60–80%. They report a lower %peak VO2 range for cycling at RPEs of 12–13, which indicates that mode can influence RPE. From a comparison of different modes of exercise cited in the literature, Esten and Williams concluded that the mode using smaller muscle groups is associated with a higher RPE. The above guidelines emphasise that it is not possible to be definitive about the RPE/%peak VO2 relation.

Studies using young and middle aged subjects have shown that RPE underestimates intensity in walking sessions and aerobic dance. The subjects in the study of Spelman et al produced a mean RPE of 10.9 during a walk at 52% of peak VO2 which is slightly higher than the 10 in this study with exactly the same %peak VO2. This finding prompted Spelman et al to conclude that their subjects had underestimated the exercise intensity. Conversely, Zeni et al reported that RPE levels of 13–15 resulted in %peak VO2 values within the recommended intensity range for several modes of exercise. Comparison with the relations outlined above indicates that RPE may be marginally lower in this study than expected. It is conceded that the differences are fairly small but may have some significance given that the Borg scale is 6–20. It is acknowledged that the sample size in this study is small and that it may be inappropriate to draw this inference. Further consideration should be given to the consequences of an unrepresentatively low RPE. The fact that the subjects perceived the exercise sessions to be not particularly stressful...
Aerobic dance and walking sessions can result in the maintenance or promotion of aerobic fitness in most elderly subjects if achieved on a regular basis. Further investigation into the relation between RPE and %peak VO₂ over representative exercise time periods would be useful.

could result in good adherence. On the other hand, if subjects rate RPE at 12 while they exercise at 70% of peak VO₂, they may exercise at very high intensities while the RPE is “low”, possibly triggering cardiac complications associated with very high intensity exercise.

The extent to which RPE can be substituted for %HRmax and/or %peak VO₂ is limited. The fact that some of the individual subject sample correlations were zero was due to some of the subjects having exactly the same RPE values at all time points during that session. It may be unrealistic to expect a good relation between RPE and the selected physiological variables in this study, as scrutiny of the %peak VO₂ values shows that the subjects exercised at fairly constant intensity throughout both sessions. However, it should be noted that a median correlation of 0.89 between %peak VO₂ and RPE was found in an aerobic dance session of female students who had fairly stable physiological variables.15

Although these results show that %peak VO₂, %HRmax, and RPE are higher in the aerobic dance than in the walking sessions, it should be noted that some subjects had considerably higher VO₂ and heart rate differences between modes than others. These differences are not associated with absolute values.

In this comparison of self selected exercise intensity of aerobic dance and walking, %peak VO₂, %HRmax, and RPE were significantly higher for aerobic dance than for walking. However, both the aerobic dance and walking sessions were of adequate intensity to improve aerobic fitness in most subjects. Further investigation into the relation between RPE and %peak VO₂ in a field setting over representative exercise time periods is deemed appropriate.

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REFERENCES

This study measured the self selected exercise intensity adopted by older adults (aged 54–78 years) performing two modes of exercise (aerobic dance and walking). Aerobic dance elicited a higher intensity (67% of peak $V_{\text{O}_2}$, 74% of maximum heart rate) than walking (52% of peak $V_{\text{O}_2}$, 60% of maximum heart rate). The authors concluded that both forms of exercise were of sufficient intensity to improve aerobic fitness based on the fact that the American College of Sports Medicine recommends a minimum intensity of 50% of peak $V_{\text{O}_2}$. The study findings are relatively novel because there are few data on the physiological responses to self selected exercise in older people. Identifying acceptable and effective forms of exercise for such people is important not only from the point of view of reducing disease risk but also because such exercise will help them to maintain their functional capacity and thus their ability for independent living. Ultimately the result is a better quality of life for those who remain active into old age.

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REFERENCES
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