Physiological and psychological responses to a university fitness session

S. Grant MSc, G. Armstrong BSc, R. Sutherland BSc, J. Wilson*, T. Aitchison† BSc, E. Paul† BSc and S. Henderson MSc

Department of Physical Education and Sports Science, *Institute of Physiology, University of Glasgow,
†Department of Statistics, Glasgow, UK

The purpose of this study was to examine the physiological and psychological responses to a university fitness session entitled 'popmobility'. A popmobility session consists of 20 min of aerobic activities, 5 min of local muscular endurance exercises and 5 min of flexibility exercises. Ten regular participants of these sessions, women of mean(s.d.) age 21.2(1.5) years, took part in the study. A maximal oxygen uptake (VO₂max) treadmill test was performed by each subject to obtain VO₂max and maximum heart rate values. In a laboratory, heart rate and VO₂ were measured throughout a popmobility session for each subject. Rate of perceived exertion (RPE) was measured every 5 min throughout the session. The mean intensity of the aerobic part of the session ranged from 67.7–82.6% of the subject's VO₂max (mean of 76.4% VO₂max). The mean heart rate reserve for the aerobic section was 75.6%. While the relative oxygen consumption remained fairly static during the aerobic section, the RPE score rose. The mean(s.d.) total energy expenditure was 236.6(28.4) kcal (range 203–288). The popmobility session is of adequate intensity to improve the aerobic fitness of its participants. Heart rate, as used as a measure of intensity during a popmobility session, would appear to be a fairly accurate indicator of intensity. However, the use of RPE for exercise prescription in popmobility sessions is inappropriate. Popmobility could also be useful in a weight-reduction programme.

Keywords: Aerobic training, indoor fitness sessions, energy expenditure

The general population is being encouraged to exercise regularly to improve/maintain various components of health related fitness. Each week over 1000 people take part in the University of Glasgow fitness session entitled popmobility. In a popmobility session exercises are carried out in rhythm with music. A popmobility session consists of 20 min of aerobic activities, 5 min of local muscular endurance exercises and 5 min of flexibility exercises. Aerobic dance sessions are similar to popmobility sessions. Previous studies have shown that aerobic dance sessions can stress the cardiorespiratory system sufficiently to produce training effects. These effects have been reflected in alterations in maximal oxygen uptake (VO₂max), ranging from nonsignificant increases to highly significant increases of 23%.

According to the American College of Sports Medicine (ACSM), aerobic fitness can be improved by exercising large muscle groups continuously for 20–60 min duration, at an intensity of 50–85% of maximum heart rate reserve (% HRR) or 50–85% VO₂max with a frequency of 3–5 days week⁻¹. However, there is no specific mention of aerobic dance/indoor fitness sessions in the ACSM guidelines. The intensity of effort of the participants in the popmobility sessions has been monitored using a Sport Tester PE3000 heart rate monitor (Polar Electro, Kempele, Finland). However, a recent aerobic dance study conducted by Parker et al. found that the equivalent exercise oxygen consumption to that during aerobic dance while running on a treadmill resulted in a 10% higher heart rate in the aerobic dance session. Therefore, Parker et al. found that the heart rate response during an aerobic dance session overestimated the exercise intensity.

It is not possible to provide the large number of participants in the popmobility sessions with PE3000 heart rate recorders. Participants are 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 rate of perceived exertion (RPE) 15-point scale could have advantages if it could be shown that RPE scores were closely related to oxygen uptake. Birk and Birk have previously claimed that the Borg ratings of perceived exertion chart scores of 12–15 exhibit strong correlations with 58–89% VO₂max. If a similar relationship held true for RPE scales and oxygen consumption during a popmobility class, the use of RPE scales in the exercise prescription could be of value.

Many of the participants in popmobility sessions wish to maintain their current body weight or decrease their body weight. The ACSM have also suggested that a weight-loss programme should provide a negative energy balance not greater than 500–1000 kcal day⁻¹ lower than recommended (and
not less than 1200 kcal day\(^{-1}\) for adults). A combination of reduced energy intake and increased energy expenditure is suggested for optimal results. According to ACSM energy expenditure should be 300–500 kcal per exercise session. Thus an investigation of the energy cost of the popmobility sessions would provide information on the potential for fat loss if subjects participated in these sessions regularly.

The aims of this study were to measure: the intensity of a popmobility session as determined by oxygen consumption and heart rate; RPE during a popmobility session and compare the RPE with oxygen consumption; the energy cost of a popmobility session.

Methods

Ten women students of mean(s.d.) age 21.2(1.5) years, volunteered for the study. All subjects had attended popmobility sessions three to five times per week for at least 5 months before the study. Regular exercisers were chosen because they would be familiar with the popmobility movements. The study was approved by the local Ethical Committee before commencing and all subjects completed a consent form and a medical activity history questionnaire before their first test.

Four tests were performed by each subject. A maximum oxygen uptake (\(\dot{V}O_2\text{max}\)) test followed by a popmobility session in a laboratory and a popmobility session in the gymnasium were carried out on separate days.

Test 1 – maximal oxygen uptake test

Maximal oxygen uptake was measured by a continuous treadmill test. An example of a maximum protocol is given in Table 1.

Over the first 5 min the treadmill speed was increased. Thereafter, the speed was held constant and a 2% increase in gradient took place every minute. This procedure was adopted so that the subjects were exhausted around of 10±2 min\(^{-1}\). The subject wore a noseclip and mouthpiece which was attached to a Hans Rudolph 2600 valve (Cranlea, Birmingham, UK) which was connected to the Douglas Bag (Cranlea, Birmingham, UK) by a length of tubing. Expired air was analysed immediately after each test using a Taylor Servomex 570A oxygen analyser (Servomex, Crowborough, UK) and a P.K. Morgan 801A carbon dioxide analyser (Morgan, Rainham, UK). Both analysers were calibrated before every test. A Harvard volume meter (Cranlea, Birmingham, UK) was used to measure volume.

Test 2 – popmobility session in the laboratory

A popmobility session was conducted in a laboratory. Subjects performed this test individually. Heart rate was recorded every 15 s throughout the 30-min session using the memory mode of a PE3000 Sport Tester (Polar Electric, Kempele, Finland). Expired gas was collected continuously in Douglas Bags (100–2001 size) which were held by an experimenter in front of the subject. The Douglas Bags were connected to the subject by a 1.5-m length of flexible tubing attached to the mouthpiece which was connected to a Hans Rudolph 2600 valve. Subjects wore a noseclip. The session was performed to a self-instruction tape which gave exercise commands in time to the music (without visual aid). All subjects had previously practised the session at least twice in a group session to ensure movement terminology would be understood. The 30-min session and corresponding gas collection times were as follows:

Part 1: Aerobic section
6 bags for 3 min, 3, 3, 4, 4, 3 – total 20 min.

Part 2: Local muscular endurance section
2 bags for 2.3 min – total 5 min.

Part 3: Flexibility section
1 bag for 5 min – total 30 min.

During bag changeovers the tubing was open to the atmosphere for no more than 2 s per changeover resulting in a negligible loss of gas (less than 1% of the total time). Subjects gave a rating on the 15-point Borg RPE scale\(^{7}\) every 5 min. Gas analysis was conducted as for test 1. Energy expenditure was calculated using the Weir formula\(^{7}\).

Test 3 – popmobility session in the gymnasium

A popmobility session was performed in a gymnasium within a normal group popmobility session. The subjects performed the same movements to the same music as test 2 while wearing a PE3000 Sport Tester.

During tests 2 and 3, subjects were instructed to work at their normal pace.

Test 4 – percentage fat, body mass and height

Percentage body fat was estimated using the skinfold method outlined by Durnin and Womersley\(^{11}\). Subjects were weighed, and skinfold was measurement carried out and height taken before the \(\dot{V}O_2\text{max}\) test.

---

Table 1. Example of maximum treadmill protocol

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Grade (%)(^a)</th>
<th>Speed (m.p.h.)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>1–2</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>2–3</td>
<td>0</td>
<td>4.5</td>
</tr>
<tr>
<td>3–4</td>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>4–5</td>
<td>0</td>
<td>5.5</td>
</tr>
<tr>
<td>5–6†</td>
<td>2</td>
<td>5.5</td>
</tr>
<tr>
<td>6–7§</td>
<td>4</td>
<td>5.5</td>
</tr>
<tr>
<td>7–8</td>
<td>6</td>
<td>5.5</td>
</tr>
<tr>
<td>8–9</td>
<td>8</td>
<td>5.5</td>
</tr>
<tr>
<td>9–10</td>
<td>10</td>
<td>5.5</td>
</tr>
<tr>
<td>10–11</td>
<td>12</td>
<td>5.5</td>
</tr>
<tr>
<td>11–12</td>
<td>14</td>
<td>5.5</td>
</tr>
</tbody>
</table>

\(^{a}\)Increments in gradient always as shown; \(^{b}\)Variable speed depending on subjects heart rate response during warm-up run; 
\(^{†}\)Noseclips and mouthpiece on at 5.30; 
\(^{§}\)Gas samples taken every minute until the end of the test

Responses to a university fitness session: S. Grant et al.
Responses to a university fitness session: S. Grant et al.

Training zones (50–85%) for each subject were determined for \( \dot{V}O_2 \) max and % HRR. Resting heart rates were recorded by subjects in bed before rising to enable % HRR to be calculated.

Results

The physical characteristics of the subjects are given in Table 2.

The maximum values for the maximum uptake test are given in Table 3. A comparison of mean heart rate between laboratory and gymnasium heart rates is shown in Figure 1. An analysis of variance with repeated measures showed that there were no differences in the first 20 min of the sessions. During the last 10 min there was a non-systematic difference in heart rate between the laboratory and gymnasium sessions.

The mean percentage \( \dot{V}O_2 \) max and standard deviations for the 30-min session (subdivided into bag collection times) are given in Figure 2. Only one subject was below 50% \( \dot{V}O_2 \) max at any time during the aerobic section (48% in the first bag). All but one subject (at bag 7) showed a decreased intensity to below 50% \( \dot{V}O_2 \) in the last 10 min of the session. The mean for the aerobic section was 76.4% \( \dot{V}O_2 \) max.

The mean percentage heart rate reserve and standard deviations for the 30-min session (subdivided into bag collection times) are given in Figure 3. All subjects were above 50% of maximum heart rate reserve during the aerobic section and the first 2 min of the muscle conditioning. The mean for the aerobic section was 75.6% HRR.

Rate of perceived exertion scores are shown in Figure 4 with the mean percentage \( \dot{V}O_2 \) max at the time locations.
Responses to a university fitness session: S. Grant et al.

heart rate reserve (HRR) to improve aerobic fitness. The mean % VO$_{2\text{max}}$ of 76.4% and mean HRR of 75.6% for the aerobic section clearly show that the intensity as determined by oxygen consumption and heart rate is high enough to elicit a training effect. Aerobic dance studies have shown VO$_{2\text{max}}$ intensities of 80.3%$^{12}$, 78.14%$^{13}$ and 70%$^{14}$ Thus it seems that the mean value of 76.4% from this study compares favourably with similar studies. Indeed, similar improvements in VO$_{2\text{max}}$ to aerobic training studies could be expected if popmobility sessions were performed three to five times per week. Davis and Convertino$^{15}$ indicated that the heart rate reserve and VO$_{2\text{max}}$ are interchangeable. This study shows that monitoring of heart rate would seem to be an appropriate indicator of intensity in a popmobility session when % HRR is compared with % VO$_{2\text{max}}$.

While the mean % VO$_{2\text{max}}$ and mean % HRR in this study are fairly closely matched, these findings contrast markedly with Parker et al.$^6$ who found a large difference between the % VO$_{2\text{max}}$ and the % HRR. Parker et al.$^6$ observed that the 86.8% HRR was much higher than the ‘oxygen intensity’ of 62.3%. The heart rates were compared to the heart rate response during treadmill jogging at the same VO$_2$ as the dance session. The heart rate proved to be significantly lower at the same VO$_2$ as the dance session. The authors postulate that the elevation in heart rate during aerobic dance is due to a greater amount of arm movement (especially at or above shoulder height) which, according to Astrand et al.$^{16}$, causes an increase in sympathetic tone which would increase heart rate. The findings of Williford et al.$^{13}$ are more in line with the popmobility results. Williford et al.$^{13}$ found heart rate responses of 83.6% HRR max and VO$_2$ values of 78.1% VO$_{2\text{max}}$ for a high impact routine.

When heart rates are used to estimate percentage VO$_{2\text{max}}$, this method presupposes that there is a linear relationship between heart rate and oxygen consumption. An added complication is the time effect on the heart rate/VO$_2$ relationship. In the period from 3 to 9 min the difference of % VO$_2$ and % HRR was significantly different from zero. However, at most the magnitude of difference was 7% which is equivalent to around nine beats min$^{-1}$. Thus, heart rate monitoring in a popmobility session is a fairly accurate indication of intensity.

A further study is needed to compare the heart rate/VO$_2$ relationship between a popmobility session and treadmill running. Furthermore, the maximum heart rate may be lower in a popmobility session.

The similar exercise heart rates in the gymnasium and laboratory during the first 20 min suggest that the gas collection equipment did not inhibit participation in the laboratory. Thus, it is believed that the laboratory session was representative of the activity carried out in the gymnasium. The reason for the significant difference in heart rates in the last 10 min between the gymnasium and laboratory sessions is unknown.

RPE values were not found to be accurate indicators of the measured aerobic intensity according to Birk and Birk$^8$ guidelines. While the relative

---

Table 4. Individual, mean energy expenditure and standard deviation for all ten subjects for the laboratory popmobility session

<table>
<thead>
<tr>
<th>Subject number</th>
<th>Energy expenditure (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>287.7</td>
</tr>
<tr>
<td>2</td>
<td>263.2</td>
</tr>
<tr>
<td>3</td>
<td>219.0</td>
</tr>
<tr>
<td>4</td>
<td>216.1</td>
</tr>
<tr>
<td>5</td>
<td>235.1</td>
</tr>
<tr>
<td>6</td>
<td>212.1</td>
</tr>
<tr>
<td>7</td>
<td>261.8</td>
</tr>
<tr>
<td>8</td>
<td>202.7</td>
</tr>
<tr>
<td>9</td>
<td>254.1</td>
</tr>
<tr>
<td>10</td>
<td>213.8</td>
</tr>
</tbody>
</table>

Mean(s.d.) = 236.6(28.4) kcal
Responses to a university fitness session: S. Grant et al.

Oxygen consumption remained fairly static for the aerobic section, the RPE score rose. The RPE values were low compared to the scores which Birk and Birk suggest for the relative intensity of 75% VO2 max. Possible explanations of this could be that the participants may not have realized how hard they were working because they were engrossed in the session and concentration on the movements along with loud pop music may have distracted the participants sufficiently that they were unaware of the true intensity. Fatigue factors could be implicated in the progressive increase in RPE throughout the aerobic session despite a relatively stable VO2. Therefore RPE as a measure of intensity would appear to be unsuitable for exercise prescription for popmobility sessions.

The mean energy expenditure of 237 kcal per session does not trigger the minimum energy expenditure of 300 kcal per session recommended by ACSM. However, the ACSM guidelines acknowledge the suggestion of Haskell and Haskell et al. that energy expenditure calculations should consider the subject’s body weight. Haskell suggests an energy expenditure of 4 kcal kg⁻¹ of body weight per person. Thus, the mean body weight of 58 kg in this study would result in a minimum energy expenditure threshold of 232 kcal per session. Regular participation in popmobility sessions could result in a decrease in body fat.

The Glasgow University popmobility session is of adequate intensity to improve aerobic fitness of its participants. Heart rate used as a measure of intensity during a popmobility session would appear to be a fairly accurate indicator of intensity. However, the use of RPE for exercise prescription in popmobility sessions is inappropriate. Popmobility could also be useful in a weight-reduction programme.

References

Physiological and psychological responses to a university fitness session.

S Grant, G Armstrong, R Sutherland, J Wilson, T Aitchison, E Paul and S Henderson

doi: 10.1136/bjsm.27.3.162

Updated information and services can be found at:
http://bjsm.bmj.com/content/27/3/162

These include:

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/