Physiological and psychological responses to a university fitness session

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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 ($\dot{V}O_{2\max}$) treadmill test was performed by each subject to obtain $\dot{V}O_{2\max}$ and maximum heart rate values. In a laboratory, heart rate and $\dot{V}O_2$ 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 $\dot{V}O_{2\max}$ (mean of 76.4% $\dot{V}O_{2\max}$). 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. Poptobility 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^{1–3}. These effects have been reflected in alterations in maximal oxygen uptake ($\dot{V}O_{2\max}$), ranging from nonsignificant increases⁴ to highly significant increases of 23%³.

According to the American College of Sports Medicine (ACSM)⁵, 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% $\dot{V}O_{2\max}$ 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.*⁶ 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.*⁶ 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 scale⁷ could have advantages if it could be shown that RPE scores were closely related to oxygen uptake. Birk and Birk⁸ have previously claimed that the Borg ratings of perceived exertion chart scores of 12–15 exhibit strong correlations with 58–89% $\dot{V}O_{2\max}$. 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 ACSM⁵ 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

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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 ($\dot{V}O_{2\max}$) 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 mins⁹. The subject wore a noseclip and mouthpiece which was attached to a Hans Rudolph 2600 valve (Cranlea,

Table 1. Example of maximum treadmill protocol

Time (min)	Grade (%) [*]	Speed (m.p.h.) [†]
0–1	0	3.0
1–2	0	4.2
2–3	0	4.5
3–4	0	5.0
4–5	0	5.5
5–6‡	2	5.5
6–7§	4	5.5
7–8	6	5.5
8–9	8	5.5
9–10	10	5.5
10–11	12	5.5
11–12	14	5.5

^{*}Increments in gradient always as shown; [†]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

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 each 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 (100–200 l 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 scale⁷ every 5 min. Gas analysis was conducted as for test 1. Energy expenditure was calculated using the Weir formula¹⁰.

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 Womersley¹¹. Subjects were weighed, and skinfold was measurement carried out and height taken before the $\dot{V}O_{2\max}$ test.

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 calculated¹².

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

Figure 2. Mean % $\dot{V}O_{2\max}$ versus time. The time relates to the collection time for each gas sample

Figure 3. Mean(s.d.) % HRR versus time. The time relates to the collection time for each gas sample

Table 2. Physical characteristics of subjects

Characteristics	Mean(s.d.)	Range
Height (m)	1.657(0.04)	1.575–1.695
Weight (kg)	58.6(4.3)	50.8–64.6
Fat (%)	23.6(3.8)	16.8–29.1

Table 3. Maximum values attained in treadmill test

Parameters tested	Mean(s.d.)
$\dot{V}O_2$ (l min ⁻¹)	2.67(0.228)
$\dot{V}O_2$ (ml kg ⁻¹ min ⁻¹)	45.67(4.16)
Heart rate max (beats min ⁻¹)	203.7(0.05)
Respiratory exchange ratio	1.17(0.05)
Treadmill time	10 min 30 s(53 s)

Figure 1. A comparison of mean heart rates between laboratory and gymnasium popmobility sessions. ○, gymnasium session; ●, laboratory session

Figure 4. The rate of perceived exertion taken at the end of each 5-min period and the mean(s.d.) % $\dot{V}O_{2\max}$ at that time

Figure 5. The difference of % $\dot{V}O_2$ and % HRR. *95% confidence intervals show that there are significant differences between % $\dot{V}O_2$ and % heart rate at these times (i.e. P values < 0.05)

of the assessment of the RPE scores. RPE scores ranged from six (the lowest on the chart) during the muscle conditioning and flexibility sections to 15 during the aerobic section. RPE scores increased despite a very similar $\dot{V}O_2$ throughout the aerobic session.

An analysis of variance with repeated measures was used to investigate the differences in % $\dot{V}O_{2\max}$ and % HRR. Figure 5 demonstrates that the difference of % $\dot{V}O_{2\max}$ and % HRR is significantly different from zero between 3 and 9 min.

Table 4 gives the individual and mean energy expenditure of the 10 subjects for the laboratory popmobility session.

The mean(s.d.) total energy expenditure was 236.6(28.4) kcal (range 203–288).

Discussion

The ACSM (1990) guidelines indicated that intensity should be between 50–85% $\dot{V}O_{2\max}$ and maximum

heart rate reserve (HRR) to improve aerobic fitness. The mean % $\dot{V}O_{2\max}$ 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 $\dot{V}O_{2\max}$ 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 $\dot{V}O_{2\max}$ to aerobic training studies could be expected if popmobility sessions were performed three to five times per week.

Davis and Convertino¹⁵ indicated that the heart rate reserve and $\dot{V}O_{2\max}$ 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 % $\dot{V}O_{2\max}$.

While the mean % $\dot{V}O_{2\max}$ 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 % $\dot{V}O_{2\max}$ 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 $\dot{V}O_2$ as the dance session. The heart rate proved to be significantly lower at the same $\dot{V}O_2$ 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 $\dot{V}O_2$ values of 78.1% $\dot{V}O_{2\max}$ for a high impact routine.

When heart rates are used to estimate percentage $\dot{V}O_{2\max}$, 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/ $\dot{V}O_2$ relationship. In the period from 3 to 9 min the difference of % $\dot{V}O_2$ 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/ $\dot{V}O_2$ 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 Birk⁸ guidelines. While the relative

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

Subject number	Energy expenditure (kcal)
1	287.7
2	263.2
3	219.0
4	216.1
5	235.1
6	212.1
7	261.8
8	202.7
9	254.1
10	213.8

Mean(s.d.) = 236.6(28.4) kcal

oxygen consumption remained fairly static for the aerobic session, the RPE score rose. The RPE values were low compared to the scores which Birk and Birk⁸ suggest for the relative intensity of 75% $\dot{V}O_{2\max}$. 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 $\dot{V}O_2$. Therefore RPE as a measure of intensity would appear to be unsuitable for exercise prescription for popmobility sessions.

The mean energy expenditure of 237kcal per session does not trigger the minimum energy expenditure of 300kcal per session recommended by ACSM⁵. However, the ACSM⁵ guidelines acknowledge the suggestion of Haskell¹⁷ and Haskell *et al.*¹⁸, that energy expenditure calculations should consider the subject's body weight. Haskell suggests an energy expenditure of 4kcal kg⁻¹ of body weight per person. Thus, the mean body weight of 58kg in this study would result in a minimum energy expenditure threshold of 232kcal 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.

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