Circulatory response to single circuit weight and walking training sessions of similar energy cost in middle-aged overweight females

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Summary

The aim of this study was to compare circulatory responses to circuit weight (CWT) and aerobic walking training sessions of similar energy cost in middle-aged overweight females. Thirty-three middle-aged pre-menopausal females participated in the experiment. They were divided into overweight (n = 18, 36.2 ± 6.3 years, 166.3 ± 8.0 cm, 83.5 ± 9.7 kg, BMI 30.2 ± 3.1 kg m⁻²) and non-overweight control (n = 15, 34.1 ± 6.3 years, 165.0 ± 5.6 cm, 61.6 ± 5.0 kg, BMI 22.7 ± 1.5 kg m⁻²) groups. Individual physical working capacity (PWC) was measured using the cycle ergometer test (calculated at the level of predicted HRmax (205 – ½ age). A CWT session consisted of leg extension, bench press, sit-ups and leg press exercises. The subjects performed four circuits at the maximal possible speed, using a work-to-rest ratio of 60 s. Blood pressure (BP) was measured during every rest period between the exercises, and the heart rate (HR) was recorded continuously during the whole CWT programme. During the walking training session, the subjects walked as fast as possible on the indoor track. The total energy cost of the walking training session was the same as during the CWT session, approximately 270 kcal, and was controlled by a CALTRAC accelerometer. HR and BP were measured every 5 min during the walking training session. The PWC index was significantly (P<0.05) higher in the overweight group in comparison with the control females (215.4 ± 76.1 and 187.9 ± 42.4 W, respectively). The resting BP was normal in both groups (<140/90 mmHg). HR was between 120 and 140 beats min⁻¹ during CWT and walking sessions. There were no differences in BP during both training sessions in overweight and control subjects. It was concluded that both CWT and walking training sessions were acceptable forms of physical activity to increase cardiovascular fitness in middle-aged overweight and normal body weight females.

Keywords: blood pressure, endurance exercise, heart rate, overweight, strength exercise.

Introduction

Recommendations for safe modes and risks of exercise depend on the type of exercise and physical condition of the participants (American College of Sports Medicine, 1991). Estimation of the cardiovascular load is based on the heart rate (HR) and blood pressure (BP). Several studies have demonstrated that systolic blood pressure (SBP) in dynamic exercise rises in proportion to the intensity of exercise while diastolic blood pressure (DBP) shows little or no change (American College of Sports Medicine, 1991). Wescott & Howes (1983) indicated that the acute BP response to iso-inertial resistance exercise may be more similar to that observed in aerobic activities.
(i.e. it increases linearly in SBP with no or a slight decrease in DBP).

An excessive increase in BP during exercise may be a sign of future sustained hypertension and an increased risk of cardiovascular mortality (Wilson & Meyer, 1981; Davidoff et al., 1982). Little is known about whether the changes in BP that occur during laboratory tests are similar to changes in the BP level that occur during exercise sessions (Palatini, 1994, 1998; Kjeldsen, 1999). Pedersen & Nielsen (1984) and Nazar et al. (1997) have related the BP responses to absolute workloads during exercise. Hyper-responders to the exercise stress are subjects with SBP exceeding 240 mmHg (Palatini et al., 1987) or 210 mmHg in males and 190 mmHg in females (Manolio et al., 1994).

Overweight has been described from the cardiovascular aspect as a condition of volume expansion, exemplified by an increased stroke volume, cardiac output and intra-vascular volume (Frolich et al., 1983). Hypertension and overweight are closely associated conditions. For example, epidemiological studies have suggested that overweight contributes to hypertension, while clinical studies have demonstrated that weight loss reduces the resting BP (Chiang et al., 1969).

Different exercise sessions have been recommended for the prevention of overweight. Therefore, both aerobic and weight exercises have been used in body weight control programmes. Usually, there is a linear increase in the SBP with increasing levels of dynamic exercise, approximating 8–12 mmHg per Metabolic equivalent (MET) (Franklin et al., 1989). There are fewer data about the reactions of BP to weight exercises. Some studies have indicated that BP could be extremely high during intensive weight exercise sessions (MacDougall et al., 1985), while other studies have demonstrated a direct relationship between the muscle mass involved in dynamic weight exercises and the response of BP (Lewis et al., 1985; MacDougall et al., 1985). Maximal SBP values may vary considerably, depending on age, weight, medications, fitness and gender. For example, young adult females may show maximal SBP values of 160 mmHg or less, while DBP usually falls slightly or remains unchanged during weight exercises (Franklin et al., 1991).

Aerobic exercises have mostly been recommended for the control of body weight. At present, walking seems to be the most popular exercise recommended for obese people (DiPietro, 1995). However, there are a lot of data indicating that weight exercises are also very useful in the control of body weight, especially when using lighter loads (40–60% of one repetition maximum [1RM]) (Gettman & Pollock, 1981). Circuit weight training (CWT) programmes have also been recommended (Gettman et al., 1978, 1982). Gettman et al. (1978) have defined CWT as the performance of several repetitions using a moderate amount of weight in a continuous fashion, moving from one station to another with minimum rest between the stations. CWT is also recommended to increase aerobic capacity (Gettman et al., 1982). It was hypothesized that, in comparison with a walking training session, the CWT session increases SBP more because of short stops of breathing during some weight exercises. The aim of this study was to compare circulatory responses to CWT and aerobic walking training sessions of the similar energy cost in middle-aged overweight females.

Methods

Thirty-three middle-aged pre-menopausal females were studied. All subjects were normotensive (resting BP<140/90 mmHg). Five readings were taken at 1 min intervals and the last three readings were averaged. The subjects were taking no medication (i.e. oral contraceptives), were free from cardiovascular, musculoskeletal or other diseases based on medical history, and were non-smokers. They had not participated in any regular exercise programme for at least 1 year prior to the start of the study (exercising less than once per week). The subjects were divided into overweight (n = 18) and non-overweight controls (n = 15) groups. The body mass index (BMI, kg m⁻²) of the overweight females was >27. The investigation was approved by the Ethical Committee of the University of Tartu and each volunteer gave her written consent after a full explanation of the procedures and risks. Subjects were familiarized with all the testing procedures one week before participation.

The height (Martin metal anthropometer) and body weight (medical balance scale) were measured and BMI calculated. In addition, waist and hip circumferences were measured to calculate the
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waist-to-hip circumference ratio (WHR). The percentage of body fat was obtained by using the bioelectrical impedance analysis method (Bodystat-500, Bodystat Ltd, Isle of Man, UK).

Individual physical working capacity (PWC) was measured using the cycle ergometer test. Three progressive workloads at intensities of 50, 100 and 150 W each for a period of 4 min were used. HR was measured at the end of each workload using Sporttester Polar Vantage NV (Kempele, Finland). Individual PWC was calculated at the level of predicted HRmax (205 – ½ age) by extrapolation (Eurofit for Adults, 1995).

The CWT session was performed 2–3 days after the PWC measurements in a specially equipped gym. The programme of the CWT session consisted of four exercises to increase cardiovascular fitness after a short (about 10 min), warm-up using leg extension, bench press, sit-ups, and leg press exercises (1RM leg extension, bench press and leg press exercises had been measured 2–3 days before). The subjects performed four circuits at a maximal possible speed, using a work-to-rest ratio of 60 s. The 75% of 1RM load and 8–12 repetitions per set were used. The duration of the whole programme was 32 min. The training session was held in the afternoon between 3 and 6 p.m. HR was registered continuously during the whole programme every 5 s using the Sporttester Polar Vantage NV. BP was measured immediately before the programme and during each rest period (60 s) after the exercise indirectly by a sphygmomanometer. BP was measured on the extended and relaxed left arm in the sitting position. The first Korotkoff sound (phase 1) was recorded as the SBP while the disappearance of sound (phase 5) was recorded as the DBP. BP was recorded to the nearest 2 mmHg. All readings were taken by the same researcher using the same measurement equipment. The total energy cost of the CWT session for each subject was calculated according to the energy expenditure table for different sports activities by McArdle et al. (1991).

The walking training session on the indoor track (150 m) was organized after 2–3 days of rest. The subjects walked as fast as possible during the walking training session. The distance was calculated to produce the same individual energy cost as during CWT (approximately 270 kcal). The energy cost during walking was controlled by a CALTRAC accelerometer (Hemokinetics Inc, Madison, Wisconsin, USA). HR was registered continuously using the Sporttester Polar Vantage NV. BP was measured in the sitting position after every 5 min, for which subjects stopped for as short a time as possible (about 15–20 s).

Descriptive statistics (means ± standard deviation) for each of the dependent variables were determined. The differences were estimated with Wilcoxon’s signed rank test with an error of estimate set at 0.05. The Kendall rank correlation coefficient was used to determine the relationships between dependent variables. Again an alpha level of 0.05 was used.

Results

Anthropometric and PWC parameters are presented in Table 1. The indices of body weight, BMI, WHR, body fat percentage and lean body mass (LBM) were significantly (P<0.01–0.001) higher in the overweight group. PWC was also higher in overweight subjects (P<0.05). The relative PWC (per kg body weight) was higher (P<0.001) in the control group.

Figure 1 presents the mean SBP and DBP after different weight exercises. The differences in the values of SBP and DBP after different weight exercises were not significant (P>0.05) in comparison with the pre-exercise levels. The highest BP was 175/75 mmHg in one overweight female during CWT. DBP did not change significantly in the overweight group, even decreasing (by 5–7 mmHg) (P>0.05)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overweight women (n = 18)</th>
<th>Control women (n = 15)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>36.2 ± 6.3</td>
<td>34.1 ± 6.3</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.3 ± 8.0</td>
<td>165.0 ± 5.6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>83.5 ± 9.7</td>
<td>61.6 ± 5.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>30.2 ± 3.1</td>
<td>22.7 ± 1.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>0.81 ± 0.05</td>
<td>0.73 ± 0.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fat percentage</td>
<td>34.0 ± 4.5</td>
<td>21.4 ± 4.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LBM (kg)</td>
<td>54.0 ± 6.5</td>
<td>48.3 ± 4.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PWC (W)</td>
<td>215.4 ± 76.1</td>
<td>187.9 ± 42.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>PWC/kg (W kg⁻¹)</td>
<td>2.54 ± 0.61</td>
<td>3.02 ± 0.40</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

BMI, body mass index; LBM, lean body mass; PWC, physical working capacity.
during the CWT session. SBP and DBP remained unchanged during the walking session (Fig. 2). The resting BP was normal in both subject groups before the CWT and walking exercise sessions (≤140/90 mmHg).

The mean HR during the CWT and walking training sessions was between 120 and 140 beats min⁻¹ (Fig. 3). There were no statistically significant \((P>0.05)\) differences in the HR values between the overweight and control groups during the CWT.
session. However, HR was significantly \((P < 0.05 - 0.001)\) higher in the overweight group in comparison with the control group during the walking exercise.

**Discussion**

The results of this study demonstrate that middle-aged females show a moderate post-exercise circulatory response to CWT and walking training sessions of similar energy cost. No high BP reactions were measured during the CWT session. BP did not increase significantly even after a very short stop for breath during sit-up weight exercises as had been hypothesized. The HR was relatively low in both exercise training sessions, corresponding to the lowest acceptable levels in accordance with the recommendations of the American College of Sports Medicine (1991). Thus, both types of exercise training sessions impose a sufficient stimulus to elicit improvements in cardiorespiratory endurance in sedentary middle-aged overweight and non-overweight women.

Walking is a popular form of exercise of moderate intensity, which has been reported to improve health-related physical fitness in sedentary women (Duncan et al., 1991; Hardman et al., 1992; Murphy & Hardman, 1998). Our results indicated that the HR response of our subjects in overweight and control groups to the aerobic walking exercise session was in accordance with the recommendations of the American College of Sports Medicine (1991) for recreational purposes. The mean HR was between 126.7 ± 11.2 and 138.2 ± 9.7 and 119.8 ± 14.1-132.3 ± 10.5 beats min\(^{-1}\) in the overweight and control groups, respectively (Fig. 3). This is about 65–70% of the estimated maximal HR. Our subjects were probably psychologically not ready for more intensive exercise. Surprisingly, the SBP and DBP did not change significantly during the walking session.

The weight training programme has been criticized for the lack of observed cardiovascular benefits (Nagle & Irwin, 1960). However, many investigations have confirmed that weight training might promote improvements in cardiovascular endurance (Gettman et al., 1978, 1982; Anton-Kuchly et al., 1984; Pollock & Evans, 1999). In the present study, the intensity of 75% of 1RM was used in the weight training session. This has been reported to be the most appropriate initial intensity for the development of strength endurance (Harris & Holly, 1987). In contrast, Gettman et al. (1978) suggested that the intensities >50% of 1RM could not be tolerated by subjects attempting to complete a 22–30 min CWT programme. In our study, in most cases, the HR during different weight exercises was about 120–130 beats min\(^{-1}\) in the overweight and control groups (Fig. 3). This is about 60–65% of the estimated maximal HR (205 – ½ age).

Our study did not reveal any statistically significant differences in circulatory responses (HR, BP) to different CWT exercises. However, Tipton (1984) suggested that the magnitude of muscle mass undergoing contraction might be the primary factor determining the haemodynamic response. Our study revealed only small differences \((P > 0.05)\) between arm (bench press) and leg (leg extension or leg press) exercises in both groups (Figs 1 and 3). BP was not significantly related to percentage body fat, lean body mass, BMI and WHR indices before or during both exercise sessions in overweight and non-overweight women. By contrast, a previous study by Krotkiewski et al. (1983) indicated that middle-aged females showed a close relationship between the resting BP and the amount of body fat. The reason for this difference could be explained by the fact that none of our females had a high resting BP. Furthermore, changes in BP were moderate during exercise training sessions in our subjects. The overweight subjects performed the relatively heavy walking training session reasonably well. Nobody found walking painful or very tiring. The overweight women walked more slowly during the walking training session in comparison with the control subjects. The overweight subjects have a lower mechanical efficiency than subjects with a normal body weight (Frey scuss & Melcher, 1978). In accordance with the study by Mattson et al. (1997), it was speculated that the overweight women in our study were able to tolerate the necessary intensity and duration of walking to achieve beneficial effects.

In summary, there were no differences between middle-aged overweight and normal body weight females in the adaptation of the walking training session. The results did not support the hypothesis that some weight exercises, especially exercises that are connected with the stopping of breath (e.g. sit-
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ups), increased BP too high. It was concluded that both CWT and walking training sessions are acceptable forms of physical activity to increase cardiovascular fitness in middle-aged overweight and normal body weight females.

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References


