Worksite intervention effects on physical health: a randomized controlled trial

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SUMMARY
Overweight and physical inactivity are risk factors for increased disease burden and health care expenditure. Well-designed studies are still needed to determine the treatment efficacy of worksite interventions targeting such risk factors. This randomized controlled trial was conducted at one of Australia’s casinos in 2002–2003, to investigate the effects of a comprehensive exercise and lifestyle intervention on physical fitness. Only 6.4% of the workforce expressed interest in being study participants. Seventy-three employees (aged 32 ± 8 years, 51% overweight/obese, 73% shift workers and 52% women) were recruited and randomized to treatment or wait-list control groups for 24 weeks, 44 of whom completed the intervention. Components of the intervention include supervised moderate-to-high intensity exercise including combined aerobic (at least 20 min duration 3 days/week) and weight-training (for an estimated 30 min completed 2–3 days/week), and dietary/health education (delivered via group seminars, one-on-one counselling and literature through the provision of a worksite manual). ANCOVA, by intention-to-treat and of study completers, found significant between-group differences in the mean waist circumference and predicted maximal oxygen uptake (VO₂max), favouring the intervention, but effects were concentrated in one subject. For study completers, between-group differences in the mean waist circumference (82.3 ± 9.2 versus 90.5 ± 17.8 cm, p = 0.01) and predicted VO₂max (47 versus 41 ml/kg/min, p < 0.001) remained significant without the outlier, favouring the intervention. Higher intervention compliance predicted greater improvements in physical fitness. No significant effects on body mass or body mass index were found. This worksite intervention significantly improved waist circumference and aerobic fitness in healthy but sedentary employees, most of whom were shift workers. Worksite interventions have the potential to counter the increasing burden of overweight and obesity, particularly visceral adiposity, as well as physical inactivity; however, substantial barriers to adoption/adherence need to be overcome for greater feasibility and impact on employee physical health.

Key words: exercise; health promotion; waist circumference; aerobic fitness

INTRODUCTION
Obesity and physical inactivity are leading risk factors for morbidity and mortality, according to the World Health Organization and Harvard School of Public Health’s Global Burden of Disease Study (Murray and Lopez, 1997), and the Australian Burden of Disease Study (Mathers et al., 2001). Overweight and obesity prevalence in Australian men and women has increased over the past decade, despite a small decrease in ‘sedentarism’ (Australian Bureau of Statistics, 2002). In addition to this public health concern, there is an extensive and consistent growing
body of evidence to show that obesity and physical inactivity are also risk factors for increased health care expenditure and absenteeism among employees (Bertera, 1991; Goetzel et al., 1998; Anderson et al., 2000; Pronk et al., 2004).

Exercise is postulated to play an important role in the treatment and prevention of obesity. For weight loss treatment, the American College of Sports Medicine has recommended that overweight and obese individuals engage in aerobic exercise of at least 150 min/week, and that this should be increased to 200–300 min/week (Jakicic et al., 2001). This large dose of exercise is recommended for the general population, and is unlikely to be adopted by policy-makers and practitioners targeting overweight and obesity in the workforce because of inherent time constraints in worksite settings.

The worksite presents extensive opportunities to reach large numbers of people for health promotion and disease prevention, given that most of the adult population is employed. We reviewed 10 randomized controlled trials (RCTs) of worksite physical activity interventions and found substantial heterogeneity between studies for effects on overweight outcomes (Harma et al., 1988; King et al., 1989; Oden et al., 1989; Gemson and Sloan, 1995; Grandjean et al., 1996; Lee and White, 1997; Pritchard et al., 1997; Fukahori et al., 1999; Proper et al., 2003; Elliot et al., 2004). A quality check of these studies revealed that such inconsistencies are likely owing to methodological shortcomings (most studies prescribed unspecified doses of unsupervised exercise) and/or inadequate weight loss programme design (most studies did not prescribe a dietary intervention), or participant characteristics affecting exercise adoption as well as treatment response (clinical heterogeneity). Therefore, well-designed RCTs are still needed to establish the efficacy of moderate exercise when accompanied with dietary intervention for improving overweight outcomes in worksite cohorts.

In this study, we hypothesized that combined aerobic and weight-training exercise (≈150 min/week) plus dietary/health education counselling would improve waist circumference, body mass, body mass index and predicted maximal oxygen uptake (predicted VO$_{2\text{max}}$) measures over 24 weeks. The data presented here were collected in the context of a worksite wellness programme with broad goals of improving psychological and physical health.

**METHODS**

**Subjects and study design**

Details of subject recruitment have been previously reported (Atlantis et al., 2004). Briefly, 73 (women = 37, men = 36) healthy but sedentary subjects were recruited from a single worksite (Australian casino with ≈3800 employees). Written informed consent and a doctor’s clearance to commence an exercise programme were obtained from each subject before study entry. The Human Ethics Committee approved this study at the University of Sydney on 8 March 2002.

Subjects were stratified before randomization into either treatment (24 weeks) or wait-list control (24 weeks control, then 24 weeks treatment) groups after baseline assessment, by gender, and by normal or greater than normal scores for any one of three psychological constructs using the Depression, Anxiety and Stress Scales (DASS) (Lovibond and Lovibond, 1995) via computer-generated permuted blocks, as this study was initially conceived and designed to investigate effects on psychological outcomes (Atlantis et al., 2004).

**Intervention**

**Supervised exercise prescription**

Subjects were prescribed 20 min of moderate-to-high intensity aerobic exercise at least 3 days/week. Each subject was prescribed an exercise intensity corresponding to 50–60% of his/her age-predicted (220 – age) maximal heart rate (HR$_{\text{max}}$) for week 1, 60–70% HR$_{\text{max}}$ for week 2 and ≥75% HR$_{\text{max}}$ for each week thereafter.

Subjects were also prescribed moderate-to-high intensity whole body weight-training exercise, for an estimated 30 min to complete, for those training 3 days/week (most subjects), whereas a split routine (upper versus lower body) was prescribed for those attending ≥4 days/week. Weight-training was initially performed with machine weights (weeks 1–8), whereas free weights were progressively used throughout the remainder of the study (weeks 8–24). All subjects were prescribed an intensity range of 15 repetitions maximum (RM) to 3 RM across multiple sets (2–10), with a training volume (sets multiplied by repetitions) range of 28–40 and a recovery between sets range of 30–120 s. Each subject commenced using light loads (15 RM), which were progressively
increased weekly. Timing of exercise sessions were not standardized owing to the varied work schedules and subjects were free to choose when to exercise between any of the available time periods (between 7 a.m. and 11 a.m., 1 p.m. and 3 p.m., or 5 p.m. and 7 p.m.).

Although the minimum exercise prescription was ~150 min/week, at moderate-to-high intensity, daily sessions may have ranged between 20–120 min/day, dependent on (i) whether aerobic exercise was completed alone or in combination with weight-training; and/or (ii) the type of weight-training programme (i.e. whole-body or split routine); or (iii) whether more than the minimum aerobic exercise prescribed (20 min/day) was completed to achieve weight loss. The supervisor to subject ratio was 1:1 during the introduction of each new exercise programme (at baseline, and every 4 weeks over 24 weeks), whereas this ratio ranged from 1:1 up to 1:9 for all other training periods.

**Behaviour modification strategies**

The behavioural programme, conducted at the worksite, aimed to provide general health education, and was delivered via group seminars, one-on-one counselling and through the provision of a worksite manual created for this project. There were five health education seminars, which were designed to educate and alter employees’ perceptions on the costs and benefits of exercise, good nutrition and ergonomics. Each subject received a manual containing all the lecture material presented at these seminars, as well as crossword puzzles which were created based on the health education literature, to reinforce the acquisition of this knowledge. One-on-one health counselling sessions were made available to each subject (60 min/month per subject) mostly for dietary assessments, but goal setting and removing barriers to exercise were also discussed. Subjects were encouraged to reduce the number of servings consumed per day of energy dense food items, such as ‘fast foods’ and ‘sweets’. Rewards were given for compliance milestones in the form of ‘Bonus Activity Points’, which were tallied at the end of each month and redeemed for prizes by the top 4 or 5 compliant subjects (points were awarded for attending seminars and exercise sessions, completing crossword puzzles, participating in health counselling and for completing surveys). Prizes offered (monthly) as incentives included one full body massage gift voucher, one polo-top and two bottles of wine, with a total value of $140 AUD.

**Wait-list controls**

The wait-list control group neither received the intervention described above nor were they given any verbal nutritional/health education or exercise advice throughout this study, or discouragement from increasing current physical activity levels.

**Health risk appraisal**

Each subject received a written health risk appraisal report subsequent to each physical assessment, and dietary profile data collection, which included asterisks symbols used to mark values that indicated an increased risk of disease.

**Outcomes**

Outcomes were non-blindly assessed. Each subject was instructed to avoid consuming anything other than water 3 h prior to assessments, and to empty his/her bladder before stature and body mass were measured. The mean of three waist circumference measures were obtained to the nearest 0.1 cm, midway between the iliac crest and the lowest margin of the last costal rib. To minimize measurement error, the same researcher (E.A.) obtained this outcome measure on each occasion, with a coefficient of variation (CV) of 0.6 ± 0.5%. A single stage treadmill protocol was used to predict relative VO$_{2\text{max}}$ values (ml/kg/min) (Ebbeling *et al*., 1991).

**Dietary profile**

The numbers of servings consumed per day from all major food groups were obtained from a 7-day dietary recall questionnaire created for this study.

**Statistical analysis**

A sample size requirement of 50 was estimated to detect an effect size of –0.8, powered at 80% and alpha of 5%, based on published mental health literature with depression symptom outcomes (DiLorenzo *et al*., 1999). The target sample size was inflated to 70, to allow for 40% attrition based on previous exercise-based interventions on depression (Klein, 1985; Doyne *et al*., 1987). Our target sample of 70 would have provided
sufficient statistical power to detect a significant effect on body mass, based on a previous 24-week study of combined exercise and diet (Kraemer et al., 1999).

This study was a pre- and post-design with one between subjects factor. Analysis was by intention-to-treat (data were carried forward from the last time point) reflecting the ‘policy’ effects of the intervention, and of study completers reflecting the ‘actual’ effects of the intervention. Baseline characteristics were compared using a two-sample t-test or a Chi-square test. Shapiro–Wilk tests were used for tests of normality. Analysis of covariance (ANCOVA) was used to compare means between groups at 24 weeks, adjusted for baseline values. Age, gender and shift category at baseline were also entered as potential covariates. Mann–Whitney U-tests were used for non-normally distributed data. Linear regressions (stepwise, forward) were used to obtain regression coefficients and 95% confidence intervals (CIs) to determine the strength of association between effects on outcomes and intervention compliance. Logistic regressions were used to determine the predictive strength of baseline variables for non-compliance (dropping out) over 24 weeks, including odds ratios (ORs) and 95% CIs. A p-value of <0.05 was considered indicative of statistical significance. All data were analysed using the Statistical Package for Social Sciences (SPSS for Windows, version 11.5 SPSS, Inc., USA).

**RESULTS**

A summary of subject flow and retention is presented in Figure 1. There were no significant differences in baseline characteristics between groups (treatment versus controls) for study completers (Table 1) or for the whole cohort (data not presented) or for study completers versus dropouts (data not presented) (Table 1).

**Compliance**

**Completers versus non-completers**

Out of the 73 subjects recruited, 42% dropped out of the study, and were not requested to return for follow-up testing, and while 44 subjects completed the 24-week intervention only 42 subjects attended the 24-week follow-up session for testing. No baseline characteristics significantly predicted increased dropouts, and the reason most commonly cited for dropping out of the treatment group was ‘lack of time’. The mean (± SD) level of compliance for study completers over the 24-week study period was 1998 ± 1214 min of aerobic exercise (83 ± 51 min/week), 8031 ± 1883 weight-training repetitions (335 ± 78 repetitions/week), 324 ± 151 min of counseling, 2 ± 2 crossword puzzles (32% completed none) and 3 ± 2 seminars (95% attended 3 of 5 seminars).

**Men versus women**

Women accrued more aerobic exercise minutes than men (1723 ± 1521 versus 948 ± 708 min), whereas a similar number of weight-training repetitions was accrued by both women and men (5800 ± 3638 versus 4878 ± 3470) over 24 weeks.

**Adverse events**

There were no exercise-related adverse events observed or reported in the treatment group throughout the 24-week intervention. Adverse events or health status changes that occurred outside the intervention or assessment sessions were not recorded in either group.

**Outcomes**

**Analysis of study completers**

Outcomes for study completers are presented in Table 2. At 24 weeks, significant between-group differences, after adjusting for baseline values, were found in the mean waist circumference.
and predicted VO$_{2\text{max}}$, favouring the intervention. Both gender ($p < 0.001$) and age ($p = 0.01$) were related to predicted VO$_{2\text{max}}$ at 24 weeks. There were also no significant betweengroup differences in changes in the median body mass or body mass index.

**Intention-to-treat analysis**

At 24 weeks, there were significant between-group differences found in the mean waist circumference ($83.7 \pm 9.8$ versus $87.8 \pm 16.0$ cm, $p = 0.01$) after adjusting for baseline values, and predicted VO$_{2\text{max}}$ ($43.4 \pm 10.1$ versus $40.9 \pm 10.2$ ml/kg/min, $p = 0.02$) after adjusting for baseline values, age and gender, favouring the intervention. There were no significant between-group differences in changes (post–pre) in the median body mass or body mass index.

**Effect of intervention compliance on treatment response**

Treatment effects on waist circumference and predicted VO$_{2\text{max}}$ were compared with level of intervention compliance over 24 weeks, to
explore potential mechanisms explaining any heterogeneity in treatment response between subjects. The following variables were included in linear regression models: (i) aerobic exercise minutes; (ii) weight-training repetitions; (iii) counselling minutes accrued; and (iv) change in snack foods, spreads, fats and oils, and sugar servings consumed/day; visits to fast foods outlets (past week) and alcohol servings (past week), over 24 weeks.

### Analysis of study completers

#### Waist circumference
Univariate analysis revealed that an additional 1000 min of aerobic exercise predicted a reduction in the mean waist circumference of 3 cm (95% CI 2–4 cm, $r^2 = 39\%, p < 0.001$). The multivariate model showed that an additional 1000 min of aerobic exercise predicted a reduction in the mean waist circumference of 5 cm (95% CI 3–7 cm), and conversely, an additional 1000 weight-training repetitions predicted an increase in the mean waist circumference of 1 cm (95% CI 0–1 cm), which explained 49% ($p = 0.008$) of the variation in changes in waist circumference values.

#### Predicted VO$_{2\max}$
An additional 1000 weight-training repetitions predicted an increase in the mean predicted VO$_{2\max}$ measure of 1 ml/kg/min (95% CI 0–1 ml/kg/min, $r^2 = 20\%, p = 0.003$).

### Intention-to-treat analysis

Similar results were seen for predictors of treatment response following intention-to-treat analyses (data not presented).

### Influence of outliers

All analyses were repeated without data from one severely obese female subject (40.7 kg/m$^2$) who was highly motivated and exhibited very large treatment effects that may have driven the statistically significant observations. She had a change in body mass of –33.7 kg, body mass index of –12.6 kg/m$^2$ and waist circumference of –30.9 cm.

### Analysis of study completers

#### Waist circumference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment ($n = 19$)</th>
<th>Control ($n = 23$)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference (cm)$^b$</td>
<td>Pre 86.3 (13.2) 91.5 (19.3) 0.1$^b$</td>
<td>Post 82.1 (9.0) 90.5 (17.8) 0.008$^c$</td>
<td></td>
</tr>
<tr>
<td>Body mass (kg)$^d$</td>
<td>Pre 78.2 (31.0) 76.6 (29.8)</td>
<td>Post 75.1 (21.5) 77.9 (36.7)</td>
<td></td>
</tr>
<tr>
<td>Body mass index (kg/m$^2$)$^d$</td>
<td>Pre 25.3 (6.0) 25.0 (9.6)</td>
<td>Post 25.4 (4.9) 24.7 (7.8)</td>
<td></td>
</tr>
<tr>
<td>Predicted VO$_{2\max}$ (ml/kg/min)$^a$</td>
<td>Pre 35.8 (9.8) 36.8 (12.1) 0.4$^b$</td>
<td>Post 46.7 (7.9) 40.9 (9.4) $&lt;0.001^f$</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Mean (SD), $^b$p-Value using $t$-test, $^c$p-Value using analysis of covariance, adjusted for baseline value, $^d$Median (interquartile range), $^e$p-Value using Mann–Whitney U-test, $^f$p-Value using analysis of covariance, adjusted for baseline value, age and gender.
serving consumed/day over 24 weeks predicted greater increases in predicted VO$_{2\text{max}}$ ($r^2 = 57\%$, $p = 0.009$).

**DISCUSSION**

This intervention significantly improved waist circumference and aerobic fitness in healthy but sedentary employees from a single worksite, most of whom were shift workers. Much of the observed effects were explained by the volume of aerobic and weight-training exercise completed over 24 weeks, while smaller proportions of these effects were caused by changes attributable to some of the behavioural components of the intervention. Combined aerobic and weight-training exercise has been shown to be superior to either aerobic or weight-training exercise alone for decreasing body fat, particularly during dietary restriction (Kraemer et al., 1999), and our findings suggest that worksite interventions which include combined exercise plus dietary education for dietary restriction can improve waist circumference, an important marker of visceral adiposity.

Despite a large proportion of the effect on waist circumference being due to changes in one subject, these findings are also important because only three other worksite RCTs of exercise have reported effects on central obesity outcomes (Lee and White, 1997; Pritchard et al., 1997; Fukahori et al., 1999), and only one other RCT of exercise effects on central obesity has been conducted in shift workers (Harma et al., 1988); a particularly unique subset of employees associated with a higher incidence of ischemic/coronary heart disease (Knutsson et al., 1986; Kawachi et al., 1995; Tenkanen et al., 1997), first episode myocardial infarction (Knutsson et al., 1999), and of colorectal cancer (Schernhammer et al., 2003) compared with non-shift workers. The lack of studies reporting effects of exercise and dietary intervention on overweight outcomes, particularly central obesity, in both shift workers and non-shift workers highlights extensive opportunities for future research.

Compared to general population studies, our effects on waist circumference are comparable to those reported in two of the largest RCTs that used similar interventions to ours (Tuomilehto et al., 2001; The Diabetes Prevention Program

**Fig. 2:** Relationship between changes in waist circumference and the total amount of aerobic exercise completed over 24 weeks, $r^2 = 0.21$, $p = 0.006$ (without outlier, $n = 35$).
The Diabetes Prevention Program Research Group study randomized 3234 non-diabetic overweight and obese persons to lifestyle-modification, metformin or placebo controls for 4 years (The Diabetes Prevention Program Research Group, 2002). In the Finnish Diabetes Prevention Study (Tuomilehto et al., 2001), the improvements in waist circumference were sustained long-term (mean follow-up of 3.2 years), and there was an associated reduction in the incidence of diabetes Type 2 after 4 years (58% less than controls). Thus, exercise plus dietary interventions have the potential to decrease the risk of disease associated with excess visceral adiposity in both worksite as well as general population cohorts. Furthermore, we prescribed approximately 150 min/week of combined exercise, which is lower than the dose currently recommended to the general population for weight loss treatment (Jakicic et al., 2001). Thus, the most effective and feasible option available for targeting overweight and obesity in the time-constrained worksite setting may be a moderate dose of combined exercise plus dietary intervention.

A large ES (0.7) and per cent change was seen in the mean predicted VO$_{2\text{max}}$ favouring the intervention (30 versus 11%), and the improvement was mostly driven by changes in men despite women completing almost twice the volume of aerobic exercise than men. Men may have exercised at higher intensities than women, which would explain some of the greater improvements seen in men (Kemi et al., 2005), and/or men may be more physiologically responsive to exercise, as shown in another 6-month worksite study which reported that VO$_{2\text{max}}$ increased by 13.5% in men versus 9.3% in women, despite a greater exercise compliance (proportion of time spent at prescribed intensity) found in women than men (King et al., 1989). Interestingly, there was a dose–response relationship between weight-training repetitions accrued and improved predicted VO$_{2\text{max}}$. Significant effects on aerobic fitness following weight-training are usually seen in elderly cohorts (Vincent et al., 2002; Haykowsky et al., 2005), and our findings suggest that weight-training may be beneficial for aerobic fitness in young to middle-aged, previously sedentary, cohorts as well.

Limitations of this study include (i) large attrition; (ii) non-concealed randomization; (iii) lack of placebo or attention control treatment for the wait-list controls; (iv) non-blinded assessments; (v) non-precise measures of visceral adiposity.

Fig. 3: Relationship between changes in predicted VO$_{2\text{max}}$ and the total amount of weight-training repetitions completed over 24 weeks, $r^2 = 0.47, p < 0.001$ (without outlier, $n = 35$).
and aerobic fitness; (vi) limited generalizations due to our unique cohort (i.e. casino employees most of whom were shift workers); and (vii) changes in muscle mass were not measured (which might have explained some of the effects on waist circumference and lack of effects on weight-related outcomes). Casino shift workers may be a difficult-to-treat population given that only 6.4% of the whole worksite cohort expressed interest in participating, and only 44 of 73 subjects who entered the study completed the 24-week intervention. In addition, we did not collect sufficient data to calculate changes in dietary expenditure from our prescribed exercise or from changes in physical-activity patterns outside our study, or to calculate changes in dietary intake from our dietary intervention. As a result, we cannot determine the relative contribution of these individual components to the energy deficit (expressed as KJ or kcal/day) achieved in our cohort, nor to their relationship with changes in waist circumference. Further studies of moderate exercise plus diet are needed in regards to this matter.

In summary, we found that a prescribed dose of ~150 min/week of supervised moderate-to-high-intensity aerobic and weight-training exercise, and dietary/health behavioural counselling significantly improved waist circumference and aerobic fitness in a healthy but sedentary employee cohort, but a substantial proportion of these effects were concentrated in one subject. Our treatment effect on waist circumference is comparable with those reported in other worksite physical-activity interventions as well as exercise and dietary weight-loss interventions in clinical or community-dwelling cohorts. These findings emphasize the vast opportunities available to health care specialists and employers who aim to counter the increasing burden of overweight and obesity, particularly visceral adiposity, as well as physical inactivity. However, substantial barriers to adoption and adherence of exercise in the worksite need to be overcome for greater effectiveness and impact on employee physical health, which could be the focus of future research.

ACKNOWLEDGEMENTS

We are grateful to management and staff of the participating casino for supporting this trial. We thank the numerous undergraduate students from the School of Exercise & Sport Science at the University of Sydney who assisted in data collection. Finally, we thank the management of UTS union gym for allowing us free access to their facilities and the staff for their patience and support throughout this trial.

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