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An effective exercise-based intervention for improving mental health and quality of life measures: a randomized controlled trial

Evan Atlantis, B.Sc.,[a,*] Chin-Moi Chow, M.Sc., Ph.D.,[a]
Adrienne Kirby, M.Sc.,[b] and Maria Fiatarone Singh, M.D., F.R.A.C.P.[a]

[a] School of Exercise and Sport Science, Faculty of Health Sciences, University of Sydney, Cumberland Campus, Sydney, NSW 1825, Australia
[b] NHMRC Clinical Trials Centre, Camperdown NSW 1450, Australia

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Abstract

Objectives. This study investigates the effectiveness of 24-week aerobic and weight-training exercise plus behavior modification for mental health and quality of life (QOL) outcomes.

Methods. Mental health and QOL data was collected using the Depression Anxiety and Stress Scales and SF-36 Health Status Survey, respectively. Employees from a single work-site were randomized into either treatment or wait-list control groups.

Results: Mental Health ($P = 0.005$), Vitality ($P < 0.001$), General Health ($P = 0.009$), Bodily Pain ($P = 0.005$), Physical Functioning ($P = 0.004$), Depression ($P = 0.048$), and Stress ($P = 0.036$) scales significantly improved for the treatment group compared to wait-list controls after 24 weeks.

Conclusions. Multimodal exercise is as effective as other single-modality exercise treatments for depressive symptoms and, in contrast to other studies, does improve stress symptoms and QOL outcomes.

Keywords: Mental health; Depression; Anxiety; Stress; Aerobic exercise; SF-36; Quality-of-Life; Weight-training; Work-site

Introduction

In Australia in 1996, mental disorders accounted for nearly 30% of all nonfatal disease burden among which depression (8%) was the leading cause, in both men and women [1]. Prevalence estimates for mental disorders were obtained from self-administered questionnaires (surveys). General population mental health screening instruments have been demonstrated to be valid tools that can identify associated negative outcomes. For example, the StayWell HealthPath® health-risk appraisal contains 78 questions including two on stress and one on depression, has demonstrated predictive validity for higher health care expenditure [2,3], absenteeism [4], and cardiovascular-disease-related mortality [5] in high-risk employees vs. low-risk employees according to stress and depression scores. Interventions that reduce self-reported psychological distress have the potential to increase employee productivity in the workplace. The Australian National Health Survey used the self-administered SF-36 Health Status Survey to measure and develop normative quality of life (QOL) values for the Australian population using over 17,000 observations [6]. Those with self-reported serious physical and medical conditions including cancer, heart disease, stroke, hypertension, and diabetes had lower Mental Health scores by approximately 7 points compared to those without these conditions [6]. Improving mental health scores (SF-36) may have clinically meaningful implications in terms of reducing the communities' health care burden as reported by Ware [7].

Therapeutic options available to health care specialists in the mental health domain include antidepressant medication, psychotherapy, or combination therapy (antidepressant medication and psychotherapy, i.e., ‘‘standard care’’) [8]. Mental disorders often coexist with each other (e.g., depression and anxiety) and with physical conditions and disabilities (e.g., depression and obesity). These comorbid conditions may contribute to or result from mental disorders [8], which may

* Corresponding author. School of Exercise and Sport Science, Faculty of Health Sciences, University of Sydney, Cumberland Campus, PO Box 170, Lidcombe, Sydney, NSW 1825, Australia.

E-mail addresses: E.Atlantis@fhs.usyd.edu.au (E. Atlantis), Chin-Moi.Chow@fhs.usyd.edu.au (C.-M. Chow), adrienne@ctc.usyd.edu.au (A. Kirby), m.singh@fhs.usyd.edu.au (M. Fiatarone Singh).

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translate into poorer physical health, and QOL. Therefore, additional *interventions* beyond "standard care" are needed, which specifically address depressive symptoms and generally has no efficacy in improving additional variables that may act as causal or complicating factors. Exercise is one such *intervention*, as it has been shown to address both psychological and physiological factors associated with reduced QOL as well as many risk factors for loss of healthy life years [i.e., disability-adjusted life years (DALYs)] [1,9]. Some evidence suggests exercise interventions may have a preventive as well as therapeutic role for mental health disorders; however, optimal dose in terms of frequency, duration, and intensity needed for treatment and prevention efficacy is not fully defined.

The work-site offers extensive opportunities for testing the effectiveness of interventions to improve mental health and QOL in large populations. Features that enhance feasibility include a cohesive cohort with similar characteristics, geographical localization, access to facilities, potential for social and behavioral reinforcement, and benefits to both the employee and employer. Previous work-site interventions have not reported significant improvements in the mental health domain [10,11]. This may have been due to methodological shortcomings. Well-designed randomized controlled trials are still needed to establish the efficacy of exercise-based interventions for the treatment of self-reported psychological distress in the workplace.

This study investigates the effectiveness of a 24-week combined aerobic and weight-training exercise plus behavior modification intervention for improving mental health and QOL outcomes. We hypothesized that this multimodal intervention would improve QOL, depressive, anxiety, and stress symptoms relative to wait-list controls over a 24-week period.

Method

Participants and study design

Star City casino employees (approximately 3,800) were invited to participate. The recruitment process consisted of orientation seminars, posters, and a research team member (EA) setting up a stall in the lunchroom to promote the project. The orientation seminar involved a detailed description of the project including subject requirements, timetable, costs, location of testing and training facilities, and to answer any questions regarding the project mentioned herein. The promotional material explicitly requested employees who were not currently participating in aerobic or weight-training exercise for 20-min duration more than 2 days/week, or in the 3-month period preceding. Further eligibility criteria included the following: (1) willing to obtain fasted blood analyses of lipid and glucose levels; (2) able to produce a doctors clearance to commence an exercise regime; (3) able to attend the fitness center for a duration of 60 min, minimum of 3 days/week and for each physiological data collection on three occasions over the 24-week study; and (4) willingness to be randomized to either treatment or wait-list control groups. Employees were not permitted to enter the study if they met the following exclusionary criteria: (1) presence of clinically diagnosed medical (e.g., HIV) or psychiatric condition (e.g., depression) to preclude those receiving treatment; or (2) currently classified as a workers compensation case. Employees were not informed of the main research hypothesis (exercise efficacy on mental health); rather, an overall change in health was explained as the main outcome to be investigated. Informed consent and a doctor's clearance to commence an exercise program were obtained. The Human Ethics Committee approved this study at the University of Sydney on March 8, 2002.

Participants were stratified before randomization into either treatment (24 weeks) or wait-list control (control 24 weeks, then treatment 24 weeks) groups, by gender, and normal or >normal scores for any one of three psychological constructs using the Depression, Anxiety, and Stress Scales (DASS) [12]. Randomization lists produced the following four permuted blocks: (1) females normal, (2) females > normal, (3) males normal, and (4) males > normal scores. Participants' names were allocated to each treatment group sequentially from the top of each appropriate stratum list, by EA. Although there was no concealment, at this early stage of the study participants were not known to the research team and could not be identified by name. Ten more participants entered the study in July 2002. Following stratification, the remaining number per stratum did not permit computer-generated randomization lists to be created; therefore, these 10 participants had their names drawn "out of a hat" for group allocation.

Intervention

Supervised exercise prescription

Participants were prescribed a regime of moderate- to high-intensity aerobic exercise for minimum 20-min duration, 3 days/week on treadmill, bicycle, stepper, or concept II rowing ergometer machines. Each participant was prescribed their age-predicted (220 − age) maximal heart rate (HRmax) range according to the following protocol: week 1, 50–60%; week 2, 60–70%; and ≥75% each week thereafter. The weight-training protocol was carried out using machine weights initially (weeks 1–8), and then free weights were progressively introduced for the remainder of the study period (weeks 8–24). All major muscle groups were targeted with an intensity range of 15 repetitions maximum (RM) to 3 RM, multiple sets (3–10) and a training volume (sets multiplied by repetitions) range of 30–45. Each participant commenced on light loads (15 RM), which were progressively increased weekly according to the following protocol: week 1, 15 RM; week 2, 12 RM; week 3, 10 RM; week 4, 8 RM; and remained less than 8 RM each week thereafter. While a minimum weight-training frequency of 2 days/week of whole-body exercises was prescribed for most participants, a split routine (upper vs. lower body) was prescribed for those attending ≥4 days/week. After the first program (4 weeks), for the training stimulus to remain optimal, these training variables continued to be progressively changed each week. For example, we used the following protocol for weeks 5, 6, 7, and 8: loads lifted were adjusted to achieve 8, 6, 5, and 4 RM, respectively; number of sets were 5, 6, 7, and 8, respectively, maintaining the training volume between 32 and 40; and recovery between sets were 120, 90, 60, and 45 s, respectively. EA was present at the fitness center Monday to Friday during designated hours (7–11 am, 1–3 pm, and 5–7 pm) allocated to the research project for exercise supervision, which included motivational feedback and encouragement to maximize participation. All exercises took place at an independently owned fitness facility located approximately 5 km from the work site. Gym membership fees were waived for the program subjects by agreement with the facility management. The supervisor to participant ratio was 1:1 during the introduction of each new exercise program (at baseline, and every 4 weeks until the 24-week period) whereas this ratio ranged from 1:1 up to 1:9 for all other periods.

Behavior modification strategies

Five health education seminars were designed to educate and alter employees' perceptions on the costs and benefits of exercise, good nutrition, and ergonomics for the prevention of DALYs. Each participant received a manual containing all the seminar material. Additionally, crossword puzzles created on material covered at each seminar were included in the manual to reinforce this education. One-on-one health counseling sessions (60 min per month per participant) were allocated to each participant for nutritional and dietary analysis mainly. However, goal setting and removing barriers to exercise were topics also discussed. "Bonus Activity Points" were allocated to each level of participation, and tallied at the end of each month, which was redeemed for prizes for the top 4 or 5 participants. The following points were allocated for each level of participation: gym attendance 3, 4, and 5 days/week, 50, 100, and 200 points/week, respectively; seminar attendance, 500 points/month; completion of crossword puzzle, 500 points/month; 60-min counseling, 300 points/month; and completion of questionnaires, 400 points/month. Each participant received personalized email (one per week) providing compliance, weekly Bonus Activity Points tally, and performance feedback. Prizes offered (per month) as incentives include one full-body massage gift voucher, one polo-top, and two bottles of wine, with a total value of $140 Aus.

Wait-list controls

The wait-list control group did not receive the intervention mentioned above nor were they given any verbal nutritional or exercise advice throughout this study. Minimal contact (by phone or email) was made when mental health questionnaires were not collected on time, to ensure the data collection occurred concurrently between groups. They attended the fitness center for the physical assessments at baseline, weeks 12 and 24, and were instructed to continue life as normal and were allowed to engage in any physical activity of their choice. Wait-list controls were encouraged to comply with all instructions throughout the 24-week study, to ensure they would receive the treatment during the subsequent 24-week period, as agreed.

Health screening

Both groups received a health screening report after each physical assessment, blood analyses, and dietary profile data collection, including recommendations on any parameter/s categorized as risk factors that increase DALYs. This report, in table format, included rows containing physiological/anthropometrical outcomes such as body mass index, waist circumference, predicted cardiorespiratory fitness; biochemical outcomes, such as cholesterol, triglyceride, and glucose levels; and dietary profiles, such as numbers of serves consumed/day in fruits and vegetables, etc., and columns for each data collection period (e.g., week 0, 12, and 24). Each outcome measure that did not meet recommended Australian norms for good health received one asterisk, defined as "Requires attention for long-term health"; while parameters of high-risk categories such as obesity received two asterisks, defined as "Requires urgent attention for immediate and long-term health".

Data collection

Psychological and QOL data were collected at baseline and per 8 weeks, using the DASS and the SF-36 Health Status Survey [13], respectively. The self-administered DASS questionnaire contains depression and anxiety psychometric properties that correlate with the Beck Anxiety Inventory (r = 0.81) and Beck Depression Inventory (r = 0.74), respectively [14]. Depression, Anxiety, and Stress subtotal scores above 9, 7, and 14, respectively, are categorized as abnormal, with increasing scores indicating increasing severity ratings [12]. For a detailed interpretation of items in the self-administered SF-36 questionnaire, we recommend readers to see *SF-36 Health Survey, Manual, and Interpretation Guide* [13]. Briefly, there are four physical and four mental health components that quantify QOL measures in eight domains. Raw scale scores can be transformed into a 0–100 scale using the following formula: [(actual raw score − lowest possible raw score) / possible raw score range] 100 [13] (p.6:17), representing the percent of the total possible score (0 = worse, to 100 = best). The transformed scores allow contrasts to be made with national and international norms, and other published literature.

All questionnaires were made available for collection over a period of 1 week from the 24-h medical staff's health care unit at the Star City casino. Participants were instructed to collect a set of questionnaires, to fill these out at their convenience in a quiet location and then place them in a pad-locked communication box (created for the study) located at the work site. Participants were guaranteed no Star City casino staff member would have access to this information.

Statistical analysis

A sample size of 50 was calculated based on previous mental health literature with depression outcomes, powered at 80% and alpha of 5% to detect an effect size and treatment effect of −0.8 and approximately 30%, respectively [15]. The target sample size was inflated to 70, to allow for a 40% attrition rate based on previous exercise-based interventions on depression [16,17]. All data were analyzed using the Statistical Package for Social Sciences (SPSS for Windows, SPSS Inc., USA). This study was a pre- and post-design with one between-subjects factor (treatment vs. control). For continuous outcome measures, comparison of mean response between groups used analysis of variance and analysis of covariance. Baseline characteristics were compared using a two-sample t test with unequal variances for continuous variables, whereas Chi-square analysis was used for categorical data. Binary logistic regression analysis was used to identify if one or more baseline covariate/s would predict participant dropouts. Pearson's correlations were calculated to determine how treatment effects were related to baseline scores in variables of interest. P values have not been adjusted for multiple comparisons. Effect sizes (ES), commonly used to compare treatment efficacy between interventions, were determined using Cohen's method by dividing the treatment effect by its SD value, and reported as the treatment group ES minus the control group ES. Relative effects are expressed as the percentage change (%Δ) in treatment effects from baseline.

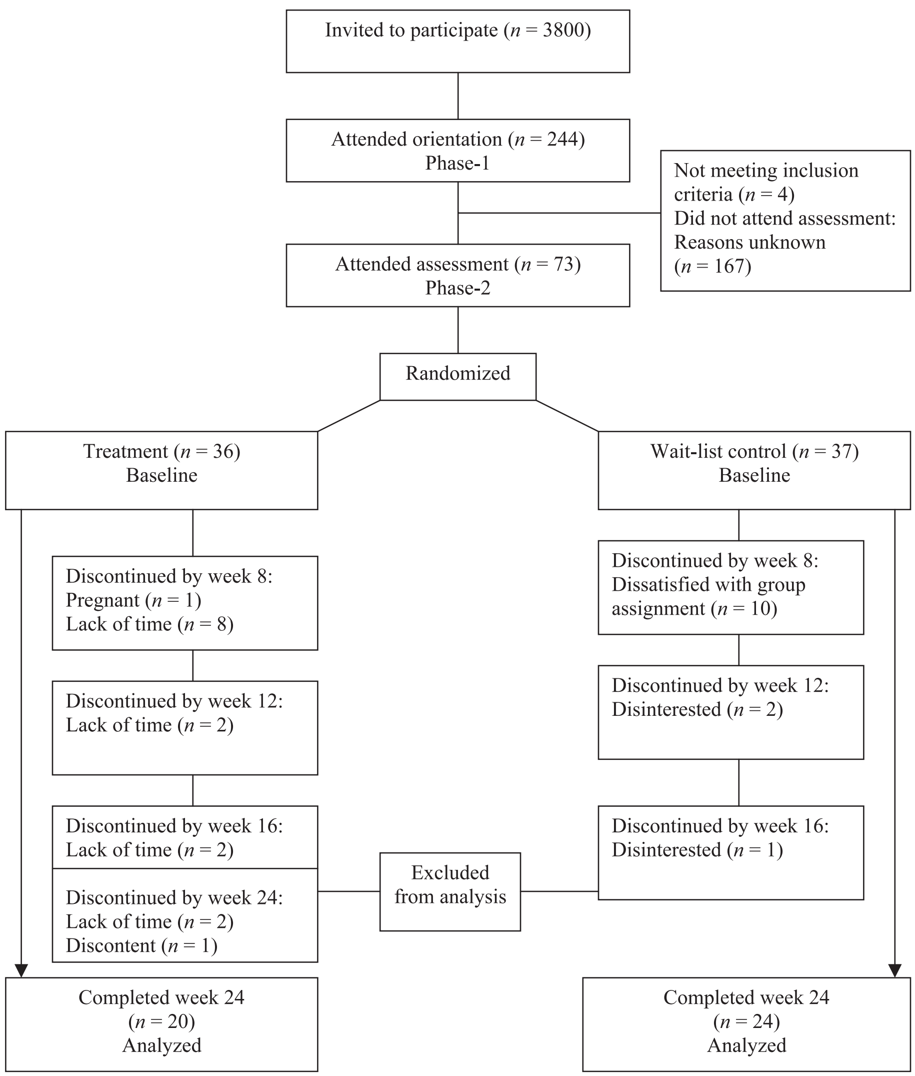

Fig. 1. Flow of participants throughout various periods (weeks) of the trial.

Results

A summary of participant flow and retention is presented in Fig. 1. Of the 3,800 employees invited to participate, 244 attended an orientation seminar where informed consent was obtained (Phase 1). These employees were instructed to obtain a doctor's clearance and then attend the local (to the work-site) designated fitness center for anthropometrical and physiological data collection, before random group assignment (Phase 2). Of the 244 employees that entered Phase 1, 167 did not attend the fitness center (reasons unknown), and 4 were screened out for the following reasons: 1 was HIV positive; 1 was clinically depressed on medication; and 2 were workers compensation cases. The remaining 73 were deemed eligible participants (female = 37, male = 36) who complied with all the instructions above (Phases 1 and 2), and entered the study as volunteers. Baseline characteristics of these volunteers are presented in Table 1. There were no significant differences between groups at baseline for any of the following characteristics: age, gender, shift category, or number of participants per category for waist circumference, Body Mass Index (BMI) and predicted aerobic fitness (VO_2max) based on age and gender-matched Australian norms [18].

Baseline values were *above normal* for Depression (>9), Anxiety (>7), and Stress (>14) *scales* compared to Australian norms in 16%, 18%, and 23% of the sample, respectively [12]. The following proportion (in parentheses) of our sample with baseline values for SF-36 scales that were 1 standard deviation below average Australian norms were observed for Physical Functioning (9%), Role-Physical (2.3%), Bodily Pain (21%), General Health (25%), Vitality (30%), Social Functioning (23%), Role-Emotional (27%), and Mental Health (16%).

Table 1
Descriptive statistics at baseline

	Treatment (n = 20)	Controls (n = 24)	P
Age (years)[a]	30 (6.8)	33 (8.3)	0.23
Range	21–52	20–54	
Gender			0.97
Female	11	13	
Male	9	11	
Shift			0.90
Day	6	6	
Night	4	6	
Varied (rotating days/nights)	10	12	
Job title			NA[b]
Dealer	7	7	
Dealer/higher duties	5	4	
Higher duties/pit manager	1	5	
Surveillance	2	0	
Cleaner	2	2	
Usher service/bar/waiter	3	2	
Chef	0	3	
Administration	0	1	
Waist circumference			0.82
<90 cm	11	14	
>90 cm	9	10	
Body mass Index (kg/m^2) classification[c]			0.74
Underweight (<18.5)	0	1	
Normal (18.5–24.9)	9	11	
Overweight (25–29.9)	8	6	
Obesity I (30–34.9)	1	3	
Obesity II (35–39.9)	0	1	
Obesity III (>40)	2	2	
Aerobic fitness[d]			0.94
Low	5	7	
Average	11	12	
High	4	5	

[a] Mean (± SD).
[b] Meaningful comparisons were not permitted due to low numbers for some categories.
[c] Comparisons were made between groups for numbers of subjects with BMIs of <25 and ≥25 kg/m^2.
[d] Low = 1 SD below mean; Average = mean; High = 1 SD above mean. Based on age- and gender-matched Australian aerobic fitness (VO_2max) norms.

Compliance

Out of the 73 participants recruited, almost 40% dropped out of the study, with 44 (treatment n = 20, wait-list control n = 24) remaining after the 24-week period. Two participants were removed from the treatment group (one female falling pregnant at week 3, and one male indicating discontent with the research team at week 19). Dissatisfaction with group assignment was the main reason for discontinuing for the wait-list control group, as there was no further compliance or contact received immediately after random group allocation for 10 of 13 dropouts. Although not quantified, the predominant reason verbally communicated to the research team for dropouts from the treatment group was "lack of time". The treatment group was frequently reminded via email and telephone messages of their obligation to comply with the minimum three exercise sessions per week. Compliance indices for all components (levels) of the intervention in the treatment group were calculated using the number of sessions attended divided by the number of sessions prescribed, expressed as percentages. The highest compliance was for exercise (80% ± 14), followed by health education seminars (60% ± 0.04), crossword puzzles (40% ± 37) and then health counseling sessions (21% ± 11).

Adverse events

There were no exercise-related physiological adverse events observed in the treatment group throughout the 24-week period of this study.

Primary outcomes

All outcome measures, reported as mean (± SD) unless otherwise specified, are presented in Table 2. There were no between-group differences observed at baseline for all primary outcome measures.

Table 2
Primary outcomes: SF-36 and DASS questionnaires

Outcome measure	Treatment		Controls		*t* test (week 0)	Adjusted baseline[a] (week 24)	Adjusted covariates[b] (week 24)	Effect size[d]
SF-36[c]	Mean	(SD)	Mean	(SD)	*P*	*P*	*P*	
Physical functioning								
Pre	85.5	(11.5)	82.5	(19.7)	0.53	0.001	0.004	0.93
Post	98.0	(3.4)	84.0	(20.2)				
%Δ	15		2					
Role-physical								
Pre	91.3	(14.7)	84.4	(27.4)	0.30	0.73	0.73	−0.04
Post	90.0	(24.9)	84.4	(27.4)				
%Δ	−1		0					
Bodily pain								
Pre	75.8	(19.6)	72.9	(19.8)	0.64	0.005	0.005	0.62
Post	87.1	(15.6)	71.0	(19.3)				
%Δ	15		−3					
General health								
Pre	62.5	(13.6)	63.5	(14.9)	0.81	0.04	0.009	0.44
Post	69.5	(8.6)	64.4	(11.9)				
%Δ	11		1					
Vitality								
Pre	50.3	(14.5)	54.4	(18.0)	0.42	<0.001	<0.001	1.54
Post	72.3	(13.5)	54.2	(17.2)				
%Δ	44		0					
Social functioning								
Pre	79.4	(29.3)	80.2	(18.0)	0.91	0.16	0.16	0.35
Post	89.4	(17.8)	82.3	(21.1)				
%Δ	13		3					
Role-emotional								
Pre	66.7	(30.6)	68.1	(37.4)	0.90	0.06	0.06	0.69
Post	93.3	(13.7)	80.6	(32.5)				
%Δ	40		18					
Mental health								
Pre	70.0	(19.3)	75.0	(12.2)	0.30	0.005	0.005	0.68
Post	82.7	(9.5)	76.7	(11.2)				
%Δ	18		2					
DASS[e]								
Depression								
Pre	7.4	(9.6)	6.0	(7.7)	0.58	0.085	0.048	−0.16
Post	3.0	(2.9)	4.1	(4.1)				
%Δ	−59		−31					
Anxiety								
Pre	3.6	(4.8)	5.3	(6.5)	0.35	0.23	0.23	0.05
Post	1.7	(1.8)	3.2	(4.4)				
%Δ	−53		−40					
Stress								
Pre	10.6	(8.8)	9.5	(8.0)	0.67	0.012	0.036	−0.56
Post	4.0	(3.4)	7.1	(7.5)				
%Δ	−62		−25					

%Δ = Percentage change relative to baseline.
[a] Adjusted for corresponding baseline value.
[b] Adjusted for corresponding and other baseline variables.
[c] Transformed raw scores: 0 = lowest (worse); 100 = highest (best) possible score.
[d] Difference in treatment group ES minus control group ES.
[e] Lower scores indicate less symptoms; increasing scores indicate increasing severity ratings.

SF 36 quality of life measures

Physical Functioning, Bodily Pain, General Health, Vitality, and Mental Health scores improved by 12.8% (P = 0.004), 17.7% (P = 0.005), 9.9% (P = 0.009), 44.5% (P < 0.001), and 15.9% (P = 0.005), respectively, for the treatment group compared to controls. Comparisons between groups for those within the lowest (0–68), middle (69–84), and highest (85–100) baseline Mental Health score subgroups revealed differences in treatment effects of 90.5%, 18.7%, and −3.4%, respectively, for the treatment group compared to controls. Greater improvements were observed for the lowest and middle tertiles compared to marginal negative effects for the highest Mental Health tertile. There were no significant treatment effects observed for Role-Physical, Social Functioning, and Role-Emotional scales.

DASS outcome measures

Subsequent to the intervention, the treatment group significantly improved for Depression (P = 0.048) and Stress (P = 0.036) scores by −26% and −37%, respectively, compared to controls. There were no significant treatment effects observed for the Anxiety scale.

Baseline characteristics among the treatment participants were analyzed with respect to their ability to predict both responsiveness to the intervention, as well as adherence to the program. Treatment effects observed in all but one (Vitality) of our primary outcome measures after the 24-week period significantly correlated with baseline scores in these domains such that those with the *worse* scores at baseline had the most robust response to the intervention. This was seen for Physical Functioning (r = −0.96, P < 0.001), Role-Physical (r = −0.66, P = 0.002), Bodily Pain (r = −0.80, P < 0.001), General Health (r = −0.80, P < 0.001), Social Functioning (r = −0.80, P < 0.001), Role-Emotional (r = −0.90, P < 0.001), Mental Health (r = −0.87, P < 0.001), Depression (r = −0.96, P < 0.001), Anxiety (r = −0.94, P < 0.001), and Stress (r = −0.94, P < 0.001) scales. No baseline characteristic/s significantly predicted subject dropouts.

Discussion

This 24-week exercise-based intervention significantly improved QOL, depression, and stress outcome measures within a heterogeneous employee population. Mental health constructs that improved included the Vitality and Mental Health (SF-36), Depression and Stress (DASS) scales. Similar trends were observed for both Role-Emotional and Social Functioning constructs, with Role-Emotional mean changes over the 24-week period almost reaching statistical significance (P = 0.06). Based on the ES of 0.35 for Social Functioning, a larger sample size would be required to detect a significant treatment effect in this outcome. This domain may be less sensitive to exercise treatment effects, considering the numerous factors that may interfere with social activities. Relative changes in all mental health outcomes, except for Vitality, significantly correlated with baseline scores, in that those with worse scores at baseline improved the most.

Quality of life—Mental Health

The absolute difference of 11 points observed in our treatment group in SF-36 derived Mental Health scores is of a magnitude reported to correlate with clinically meaningful improvements in mental health care utilization. Ware reported for every 20-point increase in the Mental Health inventory scale, there was a 10% decrease in average prevalence of patients with one or more chronic condition/s who reported depressive symptoms, clinical diagnosis of depression, and mental health care service utilization (outpatient, past 6 months; specialist current; inpatient past 12 months) [3] (p.9:13). The mental health inventory is a 38-item questionnaire that has been highly correlated with the SF-36 Mental Health scale (0.97) [13] (p:9.15). Employees and their families within the lowest tertile for Mental Health *inventory* scores (0–61) have previously been found to have total mental health care expenditure of 3.4 and 2.6 times greater than those within middle and highest tertiles, respectively [7]. We found those within the lowest tertile for Mental Health scores in our study (0–68) exhibited the most robust response (90.5%) compared to middle and highest tertile scores, a change of potentially major clinical importance, given the implications in mental health care utilization [7].

The improvement in Mental Health scores reported here is larger than those reported by others using single modality exercise interventions [19–21], one of which had no control group [19]. Singh's study showed a similar, but nonsignificant, treatment effect of 13% vs. 15.9% in our cohort for this outcome using weight-training in clinically depressed participants whose Mental Health baseline scores were 20 points below age-matched U.S. norms in a smaller sample size [20]. There were, however, large effects observed using other assessment tools in this domain, suggesting the possibility of a type II error. By contrast, a ceiling effect was the likely shortcoming in Lalonde's supervised aerobic exercise (group classes of 6–10) study, as baseline mental health scores (Mental Component Summary) were 2.2 points higher than U.S. norms [21].

In contrast to our findings, other studies in the literature have failed to improve the SF-36 Mental Health scale through multimodal exercise [22,23]. These two studies, however, had largely normal baseline mental health scores, and their exercise regimes were delivered through group classes, which inevitably increases the participant to supervisor ratio. Therefore, in addition to ceiling effects described above, failing to ensure exercise compliance, in terms of intensity, may further undermine the treatment efficacy of exercise interventions for mental health outcomes. This is supported by the finding in Singh's study that those who exercised at the highest relative intensity had the greatest reduction in depressive symptoms [20].

Mental Health—DASS

Improvements in the Mental Health scale were consistent with results using the DASS questionnaire for both Depression and Stress scales. The difference in relative effects found in this study for Depression (−26%) and Stress (−37%), are better than other nonclinical controlled trials that have used exercise regimes for treating depressive symptoms [24–26]. Compared to clinical controlled trials, our results are similar to other exercise-based interventions. Veale reduced clinical depression by 17–23% in runners compared to controls [27], while Singh reduced depression by 29% in their weight-training depressed group compared to attention controls [20]. Larger treatment effects are commonly found in uncontrolled studies in both clinical and nonclinical depressed populations [16,28,29]. In one such study, Doyne compared aerobic to weight-training exercise without an untreated control group and found both similar in efficacy for decreasing clinical depression (−58 and −68%, respectively), at 12 months follow-up [16]. Single modality, aerobic, or weight-training exercise regimes appear to be equally efficacious in treating depressive symptoms. In contrast to studies of exercise in depressed cohorts described above, other studies in the literature of work-site health promotion interventions for improving stress have not been uniformly successful [10,11]. One of these interventions was an observational retrospective study in a cohort receiving predominately health screening without any supervised exercise [10], while the other had a cohort informed of organizational restructuring and an intention to reduce the work force from 2,300 to 1,400 during the study period, a possible confounder [11]. We significantly improved subjective stress irrespective of any work-related causal factors, as these were not targeted or addressed in our intervention.

Thus, our results in mental health domains are comparable to most controlled trials studying clinical populations and better than other work-site health promotion programs. There are several characteristics of our study that may explain these results. Firstly, the quality of the exercise-based intervention was high, given that we supervised each exercise session to ensure high compliance for intensity, frequency, and duration, and utilized behavior modification strategies to maximize participation. Secondly, at baseline, we had sufficient numbers of mental health scores above normal in our cohort to show significant improvements—a fundamental difficulty faced in studies described above. The higher prevalence of depression (16%) and anxiety (18%) *symptomotology* in this cohort, compared to the general population (5.8 and 9.7%, respectively) [8], suggests that shift worker cohorts are good target groups for testing interventions for mental health outcomes. The range of treatment effects, as reported by controlled trials, suggests heterogeneity in responsiveness to exercise-based interventions from a variety of populations, similar to the variability in responsiveness to different antidepressant medication. As with antidepressant medication, some individuals may respond better to aerobic exercise while others may respond better to weight training. Multimodal exercise may therefore increase treatment efficacy in mental health constructs by increasing the proportion of responders.

Quality of life—Physical Health

In the SF-36 QOL measures, three of four physical component constructs improved including Physical Functioning, Bodily Pain, and General Health. A ceiling effect is the likely explanation for nonsignificant effects observed for Role-Physical, as baseline scores were 10 points and 5 points higher than average Australian norms for the treatment and wait-list controls, respectively. Our treatment effects in physical component domains were better than most studies in the literature of single or multimodal exercise regimes [20,22,23,30]. After the 24-week intervention, our Physical Functioning and Bodily Pain scores were 15 points and 10 points greater, respectively, while General Health scores became normalized (similar), compared to average Australian norms [6]. Such improvements, if sustained, would reflect a reduction in disability, more functional independence, and ability to participate in societal roles, and translate to a better overall QOL. As with Mental Health outcomes, relative changes in all SF-36 derived physical component outcomes significantly correlated with baseline scores, with those worse at baseline improving the most. This suggests that targeting those with poor mental and physical function may gain the most from interventions such as ours.

Finally, the large treatment effects observed in our study for both physical and mental-health-related QOL outcomes are better than or equal to those reported in a variety of controlled clinical trial populations with medical disease, mainly cardiovascular illness, that used single or multimodal exercise treatments [31–36]. This suggests multimodal exercise interventions such as ours can improve self-reported QOL in a variety of both clinical and nonclinical populations. Theoretically, combined exercise modalities should be able to better improve QOL measures compared to single modality exercise, because some individuals may experience limitations to perform physical, work, and social activities (items from the SF-36) due to lack of musculoskeletal fitness (strength), whereas others may experience these limitations due to low aerobic fitness. This notion is supported by Beniamini's study, which yielded further improvements in QOL outcomes in those prescribed high-intensity weight-training compared to flexibility exercise as adjunctive aerobic exercise treatment in cardiac rehabilitation outpatients [34].

Limitations

Limitations of this study include low recruitment numbers with large participant dropout rates, threatening external validity; nonconcealed randomization; lack of placebo or attention control treatment for the wait-list controls; and no follow-up beyond the 24-week intervention period. This cohort was predominately composed of shift workers (73%), with less opportunity to attend the fitness center compared to permanent day shift employees, which may have increased their propensity to discontinue. The high dropout rate was partly due to our rigid compliance requirement of three sessions per week, consequently participants may have felt pressured to dropout due to "lack of time". The feasibility of such an intervention making a health impact on the greater employee population would require identification of, and designing solutions for, the major barriers to exercise adoption and adherence. Providing on-site exercise and child minding facilities, health professionals trained in behavior modification and exercise prescription, and flexible work hours allowing time to exercise during each shift, for example, might address some barriers commonly experienced by employees. As we did not provide an intervention for the wait-list controls, other than receiving physical assessments and subsequent health screening reports, possibly some of the effects attributed to the exercise or behavioral components of our intervention were instead due to attention by the research staff, increased health care utilization outside of the study, or other confounding factors. However, these confounding factors are unlikely to produce the large treatment effects and ES observed in most of our primary outcomes. The treatment effects observed in our control group, as a result of the above intervention, are comparable with that reported in another study on depressed elderly, which used health education as a control intervention [20]. No experimental evidence has demonstrated health screening alone to produce any real effect on mental health outcomes. For example, Dunnagan found participants of a work-site health promotion intervention, predominately health screening with subsequent recommendations every 13–16 months plus periodic monitoring between screening, did not have improved workplace stress, anger, and depression scores compared to nonparticipants in a 2-year retrospective study [10].

We believe that the improvements in outcomes observed in our study are mainly attributable to the supervised exercise component of our multimodal intervention. This notion is supported largely by the high exercise compliance (80%) relative to the behavior modification components. Although behavior modification strategies alone are unlikely to produce any real mental health outcomes, they have been effective for improving dietary habits [37,38], and are believed to be essential to promote exercise adherence [39]; therefore, their inclusion in exercise-based interventions is recommended. Modifications to the behavioral program we utilized may be necessary to increase the initial proportion of the workforce attracted to the program (73 of 3,800), as well as to improve long-term adherence rates (60%). Strategies that could be tested include (1) targeting the approach to the current stage of behavioral change within the transtheoretical model (e.g., precontemplator vs. contemplator) [40]; and (2) offering concrete financial incentives from employers (e.g., days off, bonuses) for adherence and performance outcomes such as reducing BMI and smoking cessation.

Summary

In summary, this moderate- to high-intensity aerobic and weight-training exercise intervention along with behavior modification improved health-related quality of life measures, both physical and mental health components, and depression and stress symptoms in a heterogeneous sedentary employee population. These findings emphasize the vast opportunities available to health care specialists, both in primary care and the workplace, for targeting mental and physical health through exercise-based interventions. Multimodal exercise regimes, such as ours, may offer the best opportunity for simultaneously addressing multiple comorbidities of mental health, including low aerobic fitness, poor blood lipid profiles, arthritis, obesity and health-related QOL outcomes, most prevalent in the developed world. Such improvements are likely to translate into reductions in loss of healthy life years, and greater productivity in the workplace. Those with worse symptoms in these domains are likely to benefit most compared to those with less severe symptoms. Future research is required to contrast aerobic, weight-training, and combined exercise interventions in different populations, including clinically depressed individuals, with adequate follow-up (at least 12 months). Variables that predict participant dropout rates reported in exercise-based interventions such as ours (e.g., "lack of time"), need to be identified with a view to addressing these barriers with specific pragmatic and behavioral strategies. Finally, a framework for delivering, and monitoring the progress of, exercise as "first line" or as adjunctive treatment to "standard care" for mental health needs to be tested, since most health care practitioners treating mental health disorders are not yet sufficiently trained in the techniques of screening, prescribing, and monitoring exercise as a modality to improve mental health.

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