Exercise supervision is important for cardiometabolic health improvements: a 16-week randomized controlled trial

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ABSTRACT

Exercise supervision enhances health and fitness improvements in clinical populations compared to unsupervised or home-based exercise, but effects of supervision type are unknown in healthy employees. Eighty-five Australian university employees (62 female; mean ± *SD* 43.2 ± 9.8 years) were randomized to personal (1:1; SUP, $n = 28$), non-personal (typical gym-based; NPS, $n = 28$) supervision or unsupervised control (CON, $n = 29$) exercise groups. Subjects received a 16-week individually-tailored, moderate-to-high intensity aerobic and resistance exercise program completed at an onsite exercise facility (SUP and NPS) or without access to a specific exercise facility (CON). Repeated measures ANOVA analysed changes to cardiometabolic outcomes. Mean ± *SD* increases to $\dot{V}O_2$ peak were greater ($p < 0.01$) with SUP (+10.4 ± 11.1%) vs. CON (+3.8 ± 8.9%), but not different to NPS (+8.6 ± 8.2%). Compared to CON (+1.7 ± 7.7%), upper-body strength increases were greater with SUP (+12.8 ± 8.4%; $p<0.001$) and NPS (+8.4 ± 7.3%; $p < 0.05$). Lower-body strength increases were greater with SUP (+26.3 ± 12.7%) vs. NPS (+15.0 ± 14.6%; $p < 0.05$) and CON (+4.1 ± 12.4%; $p < 0.001$), and NPS vs. CON ($p < 0.01$). Body fat reductions were greater with SUP (-2.2 ± 2.2%) vs. NPS (-0.6 ± 1.9%; $p < 0.05$) and CON (-0.7 ± 1.9%; $p < 0.05$). Access to an onsite exercise facility with personal or non-personal exercise supervision was important for improving several cardiometabolic outcomes, with greater improvements to lower-body strength and body composition from personal 1:1 exercise supervision.

Key Words: aerobic training, resistance training, worksite intervention

INTRODUCTION

Compounding the high rates of global physical inactivity (48), the environment of many modern workplaces has led to widespread occupational sedentarism and reduced cardiovascular and musculoskeletal demand (35). Such a reduction in occupational physical demand can lead to diminished physical capacity and increase the prevalence of obesity due to energy imbalance (13, 14, 35). This is a significant problem that highlights the need to remain physically active, as low cardiorespiratory fitness (CRF), poor muscular strength and obesity are each independently associated with increased mortality risk (8, 18, 33, 34). Whether intended or not, many workplaces incidentally constrain physically active behavior and thus limit or reduce physical capacity. This potentially affects a significant proportion of the global population (35) given that two-thirds of people over 15 years of age are employed worldwide (47). However, with 3.6 billion people projected to be working by 2020 (47), workplaces simultaneously present a scalable opportunity to facilitate exercise engagement, improve cardiometabolic risk factors including CRF, muscular strength and body composition, and reduce overall chronic disease risk.

A key component to engaging people in regular exercise is overcoming barriers to participation, of which the most frequently reported in workplace and community settings is a perceived lack of time (10, 16, 25, 30). Along with reported inadequate access to exercise facilities, this perceived lack of time may be attenuated by residing or working nearby a fitness center (28). Workplace physical activity and health promotion programs have previously been investigated for their potential to reduce participation barriers and to facilitate improvements in employee health and fitness. However, several reviews of workplace physical activity interventions (15, 44, 46) and health-promotion programs (1) indicate limited effectiveness to influence employee health (46), fitness (15) and physical activity (1, 44) outcomes particularly in the long-term, citing inadequate program uptake and poor adherence as key underlying factors. Therefore, in addition to providing onsite exercise facilities to reduce participation barriers, other strategies to improve program adherence and subsequent health and fitness outcomes require investigation. While the reviewed workplace exercise studies have prescribed several modes, intensities and volumes or exercise over various periods of time, none have directly compared the effects of different types of exercise supervision on cardiometabolic health outcomes.

Supervising exercise is a strategy that may improve the impact of workplace exercise programs. Specifically, studies involving cancer (6, 11), intermittent claudication (20), chronic low back pain (24), knee osteoarthritis (7) and obese (36) patients have reported greater improvements to health, fitness and quality of life outcomes (aerobic capacity (20), fat mass (36), fatigue (6), low back and knee pain (7, 24)) for patients receiving supervised as opposed to unsupervised or home-based exercise over periods of 6 weeks to 12 months. These findings are potentially mediated through increased motivation (20) and program adherence (36). Results from research investigating the effects of exercise supervision in otherwise healthy populations are more ambiguous. For example, a 6-month diet and exercise non-randomized controlled trial involving inactive and overweight Bulgarian adults found similar improvements to fat mass, muscle mass and aerobic capacity for those receiving either direct supervision (instructor:subject ratio unknown) or no supervision compared to a non-exercise control group; although improvements to resting blood pressure, fasting insulin and high-sensitive C-reactive protein were only observed in the directly supervised exercise group who were significantly more adherent to the exercise intervention (42). A limitation of this study is that all subjects were provided with a tailored low-calorie diet at baseline, and therefore any exclusive effects that the exercise training may have had on metabolic health are unknown. In comparison, an

11-week resistance training study found greater upper and lower body strength improvements when subjects were supervised at an instructor:subject ratio of 1:5 compared to 1:25, despite similar overall exercise volume and training attendance between groups (21). Although improvements in muscular strength and aerobic fitness were reportedly similar when subjects were either directly (1:1 supervised) or indirectly (standard gym) supervised during an 8-week aerobic and resistance training program, however, the 8-week duration may not have been sufficient to investigate potential differences over time (26). Therefore, the effect of exercise supervision and the most appropriate instructor:subject ratio remains unclear.

Based on the current literature comparing exercise supervision in workplace, non-workplace and clinical settings, it is unclear whether exercise adherence and cardiometabolic health outcomes are improved to a greater extent with more personal exercise supervision and instruction, or whether effects of different levels of exercise supervision may change over time. However, findings from these studies suggests that exercise adherence and subsequent physiological adaptations is improved with lower instructor:subject ratios. This study investigated the effects of personal, non-personal and no-exercise supervision on changes to cardiometabolic risk factors in a workplace population after 8 and 16 weeks of exercise training. It was hypothesized that greater improvements to CRF, muscular strength and body composition would be observed in employees who received ongoing personal (1:1) exercise supervision and instruction compared to employees receiving non-personal or no supervision at both 8-week and 16-week time-points.

METHODS

Experimental Approach to the Problem

This parallel-group randomized controlled trial investigated the effects of different types of exercise supervision on CRF, muscular strength and body composition. Computer-generated concealed randomization was stratified by sex to allocate 85 Australian university employees to either personal (1:1; SUP, *n* = 28) supervision with onsite exercise facility access, non-personal (typical gym-based; NPS, *n* = 28) supervision with onsite exercise facility access or unsupervised control (CON; *n* = 29) following baseline testing (Table 1). Randomization was implemented using individual opaque envelopes by an independent researcher.

Subjects

The intervention took place from April to December 2015 and is reported in accordance with the CONSORT statement (41). Subjects were recruited using flyers and an advertisement on the university research webpage. Employees aged 18-70 years who were free from any condition for which exercise is contraindicated (3) were eligible for inclusion, and provided written informed consent prior to participation after receiving both a written and verbal explanation of the experimental protocol and its potential risks and benefits. Of the 85 Australian university employees enrolled, 78 completed the study (Figure 1). The study was approved by the university Human Research Ethics Committee and registered with the Australian New Zealand Clinical Trials Registry.

INSERT TABLE 1 HERE

Procedures

Data were collected immediately before, mid-way through (8 weeks) and following the 16-week intervention. All data were collected onsite at the university by an accredited exercise physiologist who was not blinded to group allocation due to limitations of funding and expertise. As part of the initial risk assessment, subjects fasted for 12 hours overnight prior to venous blood sample collection by a qualified and experienced phlebotomist for the measurement of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), blood glucose, and high-sensitive C-reactive protein (CRP), each of which were analyzed by a commercial pathology laboratory (Melbourne Pathology). In addition to providing information about the initial health status of subjects, hematological data were compared between groups for baseline comparisons. Height, body mass, resting blood pressure and body composition (Dual-energy X-ray Absorptiometry; DXA) were also assessed during this initial visit. Subjects returned to the laboratory a minimum 24 hours later for CRF assessment ($\dot{V}O_2$ peak), and again a minimum 72 hours later for muscular strength assessment (1RM bench and leg press exercises). All subjects were instructed to maintain their usual dietary intake and to avoid strenuous exercise for 48 hours prior to each testing session.

Cardiorespiratory fitness was assessed by an incremental cycle test using indirect calorimetry (TrueOne 2400, Parvo Medics, USA). Subjects cycled at 70-75 rpm while resistance was increased (15-20 and 20-25 watts per stage for females and males respectively) every 150 seconds until volitional exhaustion (23). Peak oxygen consumption ($\dot{V}O_2$ peak) was determined as the highest 30-second average oxygen consumption recorded. Concurrently, 12-lead electrocardiogram monitoring (Quinton Q-Stress, Cardiac Science, USA) was performed to screen for any abnormal cardiac responses that would indicate early test termination (3). The metabolic cart was calibrated with gases of known concentration (16% O_2 and 4% CO_2) and a 3-litre Hans Rudolph calibration syringe prior to each test. Muscular strength was assessed using one-repetition maximum (1RM) bench press (upper body) and 45° incline leg press (lower body) exercises. Three submaximal warm-up sets of 10, 5 and 3 repetitions were performed followed by single lifts interspersed by 2-3 minutes of passive rest until failure (5). The point of failure was defined by two consecutive unsuccessful attempts. The highest successful lift was recorded as the 1RM.

Subjects underwent a whole-body DXA scan (GE Lunar Prodigy Pro, GE Healthcare; software: Encore 2009, version 12.20.033) for the assessment of total fat and lean mass wearing a hospital gown and underwear while fasted. Subjects remained supine following the DXA scan for resting blood pressure assessment (Omron HEM-7200, Omron Healthcare, Kyoto, Japan); measured twice with ≥ 1 minute between measurements and the arm elevated on a pillow (38). The mean of two measurements were recorded unless a difference of ≥ 5 mmHg was measured for either systolic or diastolic pressure, in which case the median of three measurements was recorded.

All subjects were prescribed a 16-week individually-tailored moderate-to-high intensity aerobic and resistance exercise program based on ACSM guidelines (3). In addition to onsite exercise facility access in which to perform the exercise program, subjects in the SUP group received personal (1:1) supervision for each training session, and subjects in the standard care NPS group only received assistance from floor staff if requested or required as occurs in a typical gym environment. Both SUP and NPS groups trained at an onsite exercise facility at different times, with access to the facility equal between groups. Subjects allocated to the CON group performed their exercise program at a location they chose (e.g. at home or joined a public exercise facility as a member). An accredited exercise physiologist prescribed all exercise and directed each subject, including those allocated to CON, through their individual program at the beginning of the intervention and at the beginning of weeks five, nine and thirteen when new exercises targeting the same muscle groups were introduced. If CON subjects had any questions about their program the accredited exercise physiologist was available to be contacted as was the case for all study subjects. Trained undergraduate exercise science students assisted with the day-to-day delivery of the programs under the guidance of an accredited exercise physiologist (i.e. the students assisted with exercise supervision for the SUP and NPS groups). No dietary advice was provided to participants.

Each exercise session involved 20-30 minutes of aerobic exercise (stationary cycling, outdoor walking and jogging) and a combination of six multi- and single-joint resistance exercises (e.g. chest press, lateral pulldown, squats, lunges, calf raises, crunches) for the development of whole-body muscular strength. All programs were structured similarly with each session commencing with 10-15 minutes of aerobic exercise followed by 6 resistance exercises, concluding with 10-15 minutes of aerobic exercise. Exercise intensity and complexity was individually-tailored. Aerobic exercise intensity was progressed from 55-70% heart rate reserve during weeks 1-8 to 65-80% heart rate reserve during weeks 9-16. SUP and NPS subjects wore heart rate monitors (Polar RC3 GPS, Polar Electro Oy, Finland) to verify aerobic training intensity. Resistance exercises were performed as 3 sets of 8-12 repetitions with a between-set rest period of 30-120 seconds, at an intensity of 15-18 on the 6-20 Borg RPE scale (9) with RPE measured immediately after the third set of each exercise. Heart rate and RPE data were measured to provide real-time feedback to the participants to ensure they were complying with the prescribed intensity of exercise, not as a comparison measure between groups. Subjects in CON who were exercising from home were prescribed similar resistance exercises to SUP and NPS.

Onsite gymnasium opening times were 0730 to 0930, 1130 to 1400, and 1600 to 1830 Monday to Thursday, and 0730 to 0930, 1130 to 1400 on Friday each week. Both SUP and NPS groups were each allocated 7 separate training session times per week to choose from to ensure equal access over the intervention. All subjects (SUP, NPS, CON) were prescribed a minimum of 2 exercise sessions per week based on clinically meaningful increases to CRF observed in a previous workplace exercise intervention (26). Subjects could choose to complete up to 5 sessions per week (Monday to Friday) and were not restricted in their activities outside of the study. Along with session duration, the exercise mode, intensity and RPE were measured for aerobic exercises. Sets, repetitions, weight and RPE were measured for resistance exercises. Mechanical work was calculated using the equations:

Mechanical work (kgm) of cycling (22) = resistance (kg) × 6 (m) × 50 (rpm) × duration (min).

Mechanical work (kgm) of walking/jogging (39) = body mass (kg) × displacement (m).

Resistance training work (kg) was calculated using the equation (19):

Resistance training work = sets × reps × mass lifted (kg).

Statistical analyses

All data were analyzed using the Statistical Package for Social Sciences (SPSS for Windows, vers. 23.0, SPSS Inc., Chicago, IL, USA). Data are presented as mean ± *SD* unless otherwise specified. An alpha level of 0.05 was set as significant for all statistical testing. *A-priori* sample size calculation was based on the primary outcome CRF, predicted effect size = 0.4 (26), β = 0.05, α = 0.05, resulting in a required sample of 23 per group or a total of 69 subjects. One-way ANOVA compared baseline characteristics between groups. Repeated measures ANOVA investigated interaction (group × time), group and time effects on CRF, muscular strength, body composition and weekly session attendance using an intention-to-treat (ITT) analysis, whereby missing values were substituted with the last known observation. If the assumption of sphericity was breached, the Greenhouse-Geisser statistic was reported. Contrasts indicated where significant interactions occurred (e.g. baseline to mid-intervention), and one-way

ANOVA indicated which groups interacted (Tukey's HSD post-hoc). Only intention-to-treat analyses are reported as no differences in any outcomes were found for secondary per-protocol analyses that excluded the seven withdrawals and dropouts (NPS: *n* = 4; CON: *n* = 3; Figure 1).

One-way ANOVA compared total session attendance, mechanical work from aerobic exercise and resistance training work between groups. Effect sizes (ES) are reported as partial eta squared (.01 = small; .06 = moderate; .14 = large). Normality was checked visually and statistically using the Kolmogorov-Smirnov statistic prior to analysis. However, non-normal distributions were not transformed given the adequate sample size required for robustness (43). A sensitivity analysis was conducted on outliers (> 1.5 box-lengths from edge of box in boxplot) which changed statistical outcomes for mechanical work from aerobic exercise and resistance training work, therefore outliers (*n* = 9 data points) were removed for analyses involving these outcomes (43).

RESULTS

Subject recruitment and dropout is presented in Figure 1. From the initial 85 subjects recruited, 8% (NPS: *n* = 4; CON: *n* = 3) did not complete the study. Reasons for withdrawal or dropout are provided in Figure 1. One subject (CON) experienced a flare-up of a pre-existing injury and withdrew from the intervention; no other adverse events occurred. There were no between-group differences at baseline with regard to demographics or any other variable (Tables 1 and 2). The majority of subjects were female (73%), and employment type varied between academic (47%), professional (38%), technical (8%) and sessional academic (7%). Subjects were (mean ± *SD*): 43.2 ± 9.8 years old (age range: 26-67 years), had a BMI of 26.1 ± 3.6 kg/m^2 (overweight) and a fat mass of 39.8 ± 7.6% (females) and 26.0 ± 6.8% (males).

Cardiorespiratory fitness was generally low at baseline (3), with (mean ± *SD*) absolute and relative $\dot{V}O_2$ peak values of 1.9 ± 0.4 $L \cdot min^{-1}$ and 27.4 ± 5.4 $ml \cdot kg \cdot min^{-1}$ (females) and 3.0 ± 0.5 $L \cdot min^{-1}$ and 36.2 ± 7.1 $ml \cdot kg \cdot min^{-1}$ (males). Mean TC and LDL-C values were above normal ranges at baseline and not different between groups (Table 2) (3).

INSERT FIGURE 1 HERE

INSERT TABLE 2 HERE

Exercise capacity outcomes are shown in Table 3. Significant group × time interaction effects were observed for changes to $\dot{V}O_2$ peak, upper (1RM bench press) and lower (1RM leg press) body strength. Compared to the CON group, subjects in the SUP group achieved a significantly greater increase in both absolute (mean ± *SD* +9.1 ± 10.1% vs. +3.7 ± 7.9%; $p < 0.05$) and relative (mean ± *SD* +10.4 ± 11.1% vs +3.8 ± 8.9%; $p < 0.01$) $\dot{V}O_2$ peak over 16 weeks, but changes were not significantly greater than the NPS group. No differences in change to $\dot{V}O_2$ peak were found between the NPS and CON groups. Upper body strength increased significantly more in the SUP than the CON group after both 8 weeks (mean ± *SD* +9.6 ± 5.6% vs +0.6 ± 6.2%; $p < 0.001$) and 16 weeks (mean ± *SD* +12.8 ± 8.4% vs +1.7 ± 7.7%; $p < 0.001$) of the intervention. NPS resulted in significantly greater upper body strength gains than the CON group after both 8 weeks (mean ± *SD* +5.8 ± 6.2% vs +0.6 ± 6.2%; $p < 0.05$) and 16 weeks (mean ± *SD* +8.4 ± 7.3% vs +1.7 ± 7.7%; $p < 0.05$) of the intervention. Lower body strength increased significantly more in the SUP vs. NPS ($p < 0.05$) group, SUP vs. CON ($p < 0.001$) group, and NPS vs. CON ($p < 0.01$) group after both 8 weeks (mean ± *SD:* SUP = +17.1 ± 8.8%; NPS = +9.2 ± 10.6%; CON = +0.7 ± 9.1%) and 16 weeks (mean ± *SD:* SUP = +26.3 ± 12.7%; NPS = +15.0 ± 14.6%; CON = +4.1 ± 12.4%) of the intervention.

Changes to body composition are shown in Table 4. Significant group × time interaction effects were observed for changes to absolute and relative fat and lean mass. Significantly greater reductions to both absolute (mean ± *SD:* SUP = -1.8 ± 2.1 kg; NPS = -0.6 ± 1.8 kg; CON = -0.5 ± 2.0 kg) and relative (mean ± *SD*: SUP = -2.2 ± 2.2%; NPS = -0.6 ± 1.9%; CON = -0.7 ± 1.9%) fat mass for the SUP vs. CON ($p < 0.05$) group, and the SUP vs. NPS ($p < 0.05$) group after the 16-week intervention were found, with no between-group differences after 8 weeks. Lean mass increased significantly more in the SUP compared to NPS group (mean ± *SD*: +1.2 ± 1.2 kg vs -0.3 ± 1.3 kg; $p < 0.01$) after 16 weeks but not 8 weeks.

There were no significant interaction effects for exercise session attendance over the 16-weeks ($p = 0.18$), with mean attendance declining in all groups ($p < 0.001$). However, a significant group effect was observed ($p = 0.002$) with post-hoc analysis identifying the SUP group attended a mean (95% CI) of 0.53 (0.02 to 1.05) sessions per week more than the NPS group and 0.76 (0.25 to 1.27) sessions per week more than the CON group. No differences in mean weekly attendance were identified between NPS and CON groups (0.23 (-0.28 to 0.74)). Overall, the SUP group completed significantly more exercise sessions (mean ± *SD*: 30.2 ± 12.3) than the NPS (mean ± *SD*: 21.6 ± 11.6; $p < 0.05$) and CON (mean ± *SD*: 18.0 ± 14.4; $p < 0.01$) groups (Figure 2). Results showed that 21% ($n = 6$) in the SUP, 5% ($n = 1$) in the NPS and 4% ($n = 1$) in the CON group adhered to the minimum prescription of two exercise sessions per week across all 16 weeks.

INSERT FIGURE 2 HERE

Mechanical work form aerobic exercise (walking and cycling combined) over the intervention was greater for the SUP (mean ± *SD*: 3,592,436 ± 1,407,430 kgm) compared to the NPS (mean ± *SD*: 2,228,453 ± 1,562,243 kgm; $p < 0.01$) and CON (mean ± *SD*: 2,130,972 ± 1,890,400 kgm; $p < 0.01$) groups. Mechanical work from aerobic exercise for weeks 1 to 8 was 1,960,173 ± 712,743 kgm for SUP, 1,473,953 ± 850,055 kgm for NPS, and 1,349,972 ± 1,143,050 kgm for CON (significantly less than SUP, $p < 0.05$), and for weeks 9 to 16 was 1,632,263 ± 827,985 kgm for SUP, 754,500 ± 845,657 kgm for NPS (significantly less than SUP, $p < 0.05$), and 781,000 ± 896,537 kgm for CON (significantly less than SUP, $p < 0.05$). There were no significant differences in the mechanical work from aerobic exercise performed each session (mean ± *SD*) between SUP (120,705 ± 30,155 kgm), NPS (124,970 ± 61,208 kgm) and CON (97,986 ± 71,955 kgm) groups. Total resistance training work (mean ± *SD*) was greater for the SUP (77,490 ± 39,832 kg) compared to the CON (36,600 ± 38,008 kg; $p < 0.001$) group, but not different to the NPS (56,066 ± 33,443 kg) group. Total resistance training work for weeks 1 through 8 was 40,755 ± 20,604 kg for SUP, 33,452 ± 21,237 kg for NPS, and 22,127 ± 23,401 kg for CON (significantly less than SUP, $p < 0.05$), and for weeks 9 through 16 was 36,735 ± 22,018 kg for SUP, 22,614 ± 20,256 kg for NPS (significantly less than SUP, $p < 0.05$), and 14,473 ± 17,209 kg for CON (significantly less than SUP, $p < 0.05$). There were no significant differences in the resistance training work performed each session (mean ± *SD*) between SUP (2,492 ± 604 kg), NPS (2,538 ± 1,020 kg) and CON (1,867 ± 1,683 kg) groups.

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

DISCUSSION

Providing an individualized exercise program, access to an onsite exercise facility as well as personal (SUP; 1:1) exercise supervision achieved significantly greater increases to employee CRF compared to providing an individualized exercise program alone (unsupervised exercise, control; CON) over both 8 and 16 weeks, but not greater than the increases achieved with non-personal (typical gym-based; NPS) supervision. Compared to both the NPS and CON groups, the SUP group achieved a superior increase to lower body strength over both 8 and 16 weeks, and a greater reduction in fat mass over 16 weeks. The SUP group also achieved a greater increase in lean mass compared to the NPS group over 16 weeks, possibly due to the higher exercise session attendance and greater total mechanical work completed by the personally supervised subjects. These findings suggest that personal exercise supervision and instruction at the workplace can enhance CRF and strength improvements compared to unsupervised home-based exercise in as little as 8 weeks. However, the greater effects of personal exercise supervision on changes in body composition over and above non-personal supervision and no supervision may take a longer period of time to become apparent (e.g. 16 weeks).

Reductions to all-cause mortality risk in the order of 8% to 14% have been observed from 1 MET (3.5 $ml \cdot kg \cdot min^{-1}$) increases to peak CRF (17). The 22 subjects (SUP = 9; NPS = 8; CON = 5) who achieved this clinically meaningful CRF increase in the current study attended a mean ± *SD* 2.1 ± 0.7 exercise sessions per week between them, confirming the weekly attendance requirement identified in previous research (2) to stimulate significant aerobic capacity improvements in a workplace exercise program. Comparable increases to $\dot{V}O_2$ peak have been observed in a similar demographic of inactive UK university employees who were prescribed twice-weekly supervised aerobic onsite exercise training for 10 weeks (2). A meta-analysis found that peak CRF above 7.9 METS (27.7 $ml \cdot kg \cdot min^{-1}$) in middle-aged adults may significantly contribute to the prevention of all-cause mortality, cardiovascular and coronary heart disease, with greater risk reductions for higher (≥ 38.2 ml·kg·min^{-1}) CRF levels (27). The proportion of subjects with a peak CRF above 27.7 ml·kg·min^{-1} increased from 57% to 68% for the SUP group, 50% to 64% for the NPS group, and 62% to 64% for the CON group over the 16-week intervention. Furthermore, the proportion of subjects with a peak CRF ≥ 38.2 ml·kg·min^{-1} (27) increased from 14% to 29% for the SUP group, 11% to 21% for the NPS group, and 10% to 14% for the CON group. As well as achieving the greatest improvements to CRF and muscular strength, the SUP group had the highest mean $\dot{V}O_2$ peak levels (mean ± *SD* 34.2 ± 8.9 ml·kg·min^{-1}) after the 16-week intervention, and thus, a lower all-cause and cardiovascular risk (12).

Similar to the greater strength gains experienced by the SUP group, Gentil and Bottaro (21) detected larger strength improvements in untrained young men after 11 weeks of resistance training when the exercise supervision ratio was lower (1:5 vs. 1:25 supervisor:subject ratio). Session attendance and training volume were similar between groups in the Gentil and Bottaro (21) intervention and although evidence was not presented in their paper, the authors suggest that the differences in strength gains may be explained by intensity, i.e. a more frequent use of maximum repetitions by the more closely supervised group (21). In the present study however, the superior strength improvements for the SUP group are likely explained by the greater exercise session attendance and not differences in training intensity, given the similar resistance training work performed within each session across the groups. Furthermore, our data show that providing access to an onsite exercise facility with either personal or non-personal supervision confers greater strength improvements than unsupervised home-based exercise in as little as 8 weeks, with an even greater difference at 16 weeks. The importance of these muscular strength gains must not be understated, given that strength is a cardiovascular (4) and mortality (18, 34) risk factor independent of CRF level.

While there were no differences in the changes to body composition between groups after 8 weeks, the significantly greater increase in lean mass and reduction in fat mass for the SUP group compared to the NPS and CON groups after 16 weeks is crucial given the incidence of sarcopenia in an ageing population and the significant associations between sarcopenic obesity and chronic disease (45). Furthermore, CVD risk reduction is heightened when increases in CRF are combined with reductions in fat mass (29), and thus personal exercise supervision is likely to be a more effective chronic disease prevention strategy compared to non-personal or unsupervised exercise over a 16-week intervention in the workplace. The superior changes to body composition for the SUP group is likely a consequence of the greater exercise adherence by this group over the 16 weeks, particularly during the second half of the intervention. As this was a randomized study with no between-group differences in subject demographics or health and fitness levels at baseline, we don't expect individual demographic factors (e.g. age) of subjects to have influenced the results of this study. However, future research could investigate potential differences in adherence between participants with different identifying factors to guide the type of exercise supervision delivered for individual groups.

Personally supervised subjects adhered most closely to the prescription of a minimum two exercise sessions per week over the intervention, possibly facilitated by building positive rapport with their individual exercise instructors. It is also possible that the higher attendance of the SUP group increased their exercise self-efficacy (31). More frequent exercise participation has been shown to increase exercise self-efficacy which in turn facilitates ongoing participation, and may explain the higher exercise adherence of the personally supervised subjects over the intervention (37, 40). The higher attendance and aerobic exercise training work performed by the SUP group also likely explains the greater exercise-induced changes to body composition and fitness (32). Of interest for future research is whether the attendance and training work achieved by personally supervised subjects are maintained if personal supervision is gradually withdrawn to promote long-term independent exercise behavior. For example, personal exercise supervision could be transitioned over time to the lower-cost standard exercise supervision provided to the NPS subjects in the current study. This progression would be of financial interest from an employer's perspective. However, whether exercise behavior and the subsequent health and fitness benefits are maintained during such a transition remains to be investigated.

PRACTICAL APPLICATIONS

In a university workplace setting, access to an onsite exercise facility and personal (1:1) exercise supervision confers greater improvements to muscular strength and body composition than non-personal (typical gym) supervision or unsupervised exercise over 16 weeks. Furthermore, access to an onsite exercise facility with either personal or non-personal supervision is sufficient to increase CRF, with greater effects when an average of two sessions per week are achieved. An initial period of personal (1:1) exercise supervision should therefore be considered when aiming to improve cardiometabolic health and fitness.

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FIGURE LEGENDS

Figure 1. Subject recruitment and withdrawal through the 16-week university workplace exercise intervention in accordance with the CONSORT statement.

Figure 2. Workplace exercise session attendance for each type of supervision over the 16-week intervention. Significantly lower mean attendance across the three groups vs. week 1 indicated by *$p < 0.05$ or **$p < 0.01$. Significantly higher overall mean weekly attendance for SUP vs. both NPS ($p < 0.05$) and CON ($p < 0.05$) groups indicated by $^{\#}$.

Table 1. Physical characteristics of subjects.

	Exercise supervision group		
	SUP (*n* = 28)	**NPS (*n* = 28)**	**CON (*n* = 29)**
	Mean ± *SD*	**Mean ± *SD***	**Mean ± *SD***
Sex (male/female)	8 / 20	7 / 21	8 / 21
Age (years)	41.6 ± 9.5	46.1 ± 9.1	42.0 ± 10.5
Height (cm)	169.3 ± 7.6	167.8 ± 8.9	170.3 ± 9.2
BMI ($kg \cdot m^{-2}$)	25.2 ± 3.8	26.9 ± 3.1	26.2 ± 3.8

CON, unsupervised control group; NPS, non-personal supervision group; SUP, personal supervision group; *n* = number of subjects.

Table 2. Summary of baseline exercise capacity, body composition, blood pressure and blood haematology of subjects randomised into the 16-week workplace exercise study.

Outcomes	Exercise supervision group		
	SUP (*n* = 28) **Mean ± *SD***	**NPS (*n* = 28)** **Mean ± *SD***	**CON (*n* = 29)** **Mean ± *SD***
Exercise capacity			
$\dot{V}O_2$ peak, absolute ($L \cdot min^{-1}$)	2.2 ± 0.6	2.2 ± 0.6	2.3 ± 0.7
$\dot{V}O_2$ peak, relative to BM ($ml \cdot kg \cdot min^{-1}$)	31.0 ± 7.7	28.8 ± 6.3	29.6 ± 7.1
Power output at $\dot{V}O_2$ peak (W)	160 ± 43	160 ± 50	164 ± 49
1RM bench press (kg)	38.2 ± 15.7	40.3 ± 6.5	39.4 ± 17.1
1RM leg press (kg)	143.5 ± 44.6	150.7 ± 56.6	153.3 ± 55.6
Body composition and blood pressure			
Resting systolic BP (mmHg)	122 ± 12	120 ± 11	122 ± 14
Resting diastolic BP (mmHg)	72 ± 8	72 ± 7	72 ± 9
Body mass (kg)	72.3 ± 13.7	76.1 ± 12.5	75.9 ± 12.1
Fat mass (kg)	24.5 ± 10.5	27.8 ± 7.3	26.3 ± 9.6
Fat mass (%BM)	34.4 ± 10.5	38.0 ± 7.5	35.8 ± 10.4
Lean mass (kg)	45.2 ± 9.3	45.6 ± 9.8	46.9 ± 10.9
Blood haematology			
TC ($mmol \cdot L^{-1}$)	5.3 ± 1.0	5.3 ± 0.8	5.4 ± 1.1
HDL-C ($mmol \cdot L^{-1}$)	1.64 ± 0.51	1.50 ± 0.46	1.60 ± 0.46
LDL-C ($mmol \cdot L^{-1}$)	3.2 ± 0.9	3.3 ± 0.8	3.2 ± 1.1
LDL-C:HDL-C ratio	2.1 ± 0.8	2.5 ± 1.1	2.2 ± 1.1
TC:HDL-C ratio	3.4 ± 0.9	3.9 ± 1.4	3.6 ± 1.3
TG ($mmol \cdot L^{-1}$)	1.0 ± 0.3	1.1 ± 0.6	1.2 ± 0.5
Blood glucose ($mmol \cdot L^{-1}$)	5.0 ± 0.4	5.2 ± 0.8	5.2 ± 0.8
High-sensitive CRP ($mg \cdot L^{-1}$)	1.7 ± 1.6	1.7 ± 1.5	2.0 ± 1.9

1RM, 1-repetition maximum; BM, body mass; BP, blood pressure; CON, unsupervised control group; CRP, C-reactive protein; NPS, non-personal supervision group; SUP, personal supervision group; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides; W, watts. *n* = 28 for SUP group, except *n* = 27 for 1RM leg press; *n* = 28 for NPS group; *n* = 29 for CON group, except *n* = 27 for high-sensitive CRP, *n* = 28 for 1RM bench press. 1RM strength measured using bench press and leg press protocols. Body composition measured using dual-energy X-ray absorptiometry. $\dot{V}O_2$ peak measured as peak oxygen consumption during incremental cycle test. *p* values using one-way ANOVA. No significant differences were observed between groups at baseline for any variable ($p > 0.05$).

Table 3. Exercise capacity outcomes of apparently healthy university employees for each exercise supervision group prior to beginning the 16-week exercise intervention (baseline), at the intervention midpoint (mid), and at the conclusion of the intervention (post) using intention-to-treat data.

Outcome	Exercise supervision	Time point: Baseline (0-weeks) Mean ± *SD*	Time point: Mid (8-weeks) Mean ± *SD*	Time point: Post (16-weeks) Mean ± *SD*	Effects (group) *p*	Effects (time) *p*	Effects (time) ES (90% CI)	Effects (group x time interaction) *p*	Effects (group x time interaction) ES (90% CI)
V̇O2 peak, absolute ($L{\cdot}min^{-1}$)					0.96	**<0.001**	0.36 (0.22-0.47)	**0.02**	0.07 (0.00-0.16)
	SUP	2.2 ± 0.6	2.4 ± 0.6	2.4 ± 0.7$^{◊}$					
	NPS	2.2 ± 0.6	2.3 ± 0.6	2.4 ± 0.7					
	CON	2.3 ± 0.7	2.3 ± 0.7	2.3 ± 0.7					
V̇O2 peak, relative to BM ($ml{\cdot}kg{\cdot}min^{-1}$)					0.27	**<0.001**	0.35 (0.21-0.46)	**0.01**	0.09 (0.01-0.18)
	SUP	31.0 ± 7.7	33.5 ± 7.9*	34.2 ± 8.9$^{◊}$					
	NPS	28.8 ± 6.3	30.5 ± 6.4	31.2 ± 6.8					
	CON	29.6 ± 7.1	30.6 ± 6.5	30.6 ± 7.4					
1RM bench press (kg)					0.90	**<0.001**	0.44 (0.30-0.54)	**<0.001**	0.18 (0.06-0.28)
	SUP	38.2 ± 15.7	41.6 ± 16.7*	42.9 ± 17.9$^{◊}$					
	NPS	40.3 ± 16.5	42.4 ± 16.9^	43.4 ± 17.1†					
	CON	39.4 ± 17.1	39.8 ± 18.0	40.4 ± 18.9					

1RM leg press (kg)					0.84	**<0.001**	0.52 (0.39-0.60)	**<0.001**	0.29 (0.15-0.40)
	SUP	143.5 ± 44.6	166.3 ± 46.0$^{*\#}$	178.7 ± 48.4$^{\lozenge\ddagger}$					
	NPS	150.7 ± 56.6	164.3 ± 62.1^	171.6 ± 62.0†					
	CON	153.3 ± 55.6	151.1 ± 57.6	154.9 ± 56.4					

Δ, change; 1RM, one-repetition maximum; BM, body mass; CI, confidence intervals; CON, unsupervised exercise group; ES, effect size (partial eta squared); (ml·kg·min^{-1}), millilitres of oxygen consumed per kg body mass per minute; NPS, indirectly supervised exercise group; SUP, directly supervised exercise group; W, watts. 1RM strength measured using bench press and leg press protocols. $\dot{V}O_2$ peak measured as peak oxygen consumption during incremental cycle test. Analysis based on intention to treat; *n* = 28 for SUP, *n* = 28 for NPS, *n* = 29 for CON. *p* values using between-within analysis of variance, bold font indicates statistical significance. * indicates interaction between SUP and CON from baseline to mid-intervention; $^{\lozenge}$ indicates interaction between SUP and CON from baseline to post-intervention; ^ indicates interaction between NPS and CON baseline to mid-intervention; † indicates interaction between NPS and CON baseline to post-intervention; $^{\#}$ indicates interaction between SUP and NPS baseline to mid-intervention; ‡ indicates interaction between SUP and NPS baseline to post-intervention.

Table 4. Changes to body composition in apparently healthy university employees across exercise supervision groups from baseline (0 weeks) to mid- (8 weeks) to post- (16 weeks) workplace exercise intervention using intention-to-treat data.

		Time point			Effects (group)	Effects (time)		Effects (group x time interaction)	
Outcome	**Exercise supervision**	**Baseline (0-weeks) Mean ± *SD***	**Mid (8-weeks) Mean ± *SD***	**Post (16-weeks) Mean ± *SD***	***p***	***p***	**ES (90% CI)**	***p***	**ES (90% CI)**
Body composition									
Body mass (kg)					0.40	0.13	0.03 (0.00-0.10)	0.59	0.02 (0.00-0.07)
	SUP	72.3 ± 13.7	72.0 ± 13.6	71.5 ± 13.4					
	NPS	76.1 ± 12.5	76.0 ± 12.3	75.7 ± 12.2					
	CON	75.9 ± 12.1	75.9 ± 12.3	75.9 ± 12.1					
Fat mass (kg)					0.29	**<0.001**	0.16 (0.05-0.27)	**0.03**	0.07 (0.00-0.15)
	SUP	24.5 ± 10.5	23.5 ± 10.4	22.7 ± 10.1◊‡					
	NPS	27.8 ± 7.3	27.3 ± 7.5	27.2 ± 7.8					
	CON	26.3 ± 9.6	25.9 ± 9.5	25.8 ± 9.6					
Fat mass (%BM)					0.25	**<0.001**	0.21 (0.09-0.32)	**<0.01**	0.09 (0.01-0.18)
	SUP	34.4 ± 10.5	32.9 ± 10.5	32.2 ± 10.5◊‡					
	NPS	38.0 ± 7.5	37.3 ± 8.1	37.3 ± 8.1					
	CON	35.8 ± 10.5	35.2 ± 10.3	35.1 ± 10.6					
Lean mass (kg)					0.83	**<0.001**	0.15 (0.05-0.27)	**0.03**	0.07 (0.00-0.15)
	SUP	45.2 ± 9.3	46.2 ± 9.4	46.5 ± 9.5‡					
	NPS	45.6 ± 9.8	46.0 ± 10.1	45.7 ± 9.7					
	CON	46.9 ± 10.9	47.3 ± 10.9	47.5 ± 11.2					

p values using between-within analysis of variance, bold font indicates statistical significance. ◊ indicates interaction between SUP and CON from baseline to post-intervention; ‡ indicates interaction between SUP and NPS baseline to post-intervention. CI, confidence intervals; ES, effect size (partial eta squared); NPS, indirectly supervised exercise group; SUP, directly supervised exercise group. Body composition measured using dual-energy X-ray absorptiometry. Analysis based on intention to treat; *n* = 28 for SUP, *n* = 28 for NPS, *n* = 29 for CON.