A randomised controlled trial of the effectiveness of an exercise training program in patients recovering from severe acute respiratory syndrome

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The aim of this study was to evaluate the effectiveness of an exercise training program on cardiorespiratory and musculoskeletal performance and health-related quality of life of patients who were recovering from severe acute respiratory syndrome (SARS). A 6-week supervised exercise training program was carried out in the physiotherapy department of a university teaching hospital. One hundred and thirty-three patients referred from a SARS Review Clinic solely for physiotherapy were included. Cardiorespiratory fitness (6-minute walk test, Chester Step Test for predicting VO_{2max}), musculoskeletal performance (isometric deltoid and gluteal muscles strength, handgrip strength, 1-minute curl-up and push-up tests) and health-related quality of life (SF-36) were measured and evaluated. Patients were assigned randomly to either a control group (standardised educational session about exercise rehabilitation) or an exercise group. After 6 weeks, significantly greater improvement was shown in the exercise group in the 6-minute walk test (77.4 m vs 20.7 m, $p < 0.001$), VO_{2max} (3.6 ml/kg/min vs 1 ml/kg/min, $p = 0.04$), and musculoskeletal performance (handgrip strength, curl-up and push-up tests, $p < 0.05$). Effects on health-related quality of life were not statistically significant. It was concluded that the exercise training program was effective in improving both the cardiorespiratory and musculoskeletal fitness in patients recovering from SARS. However, health-related quality of life was not affected by physical training. **[Lau MC, Ng YF, Jones YM, Lee WC, Siu HK and Hui SC (2005): A randomised controlled trial of the effectiveness of an exercise training program in patients recovering from severe acute respiratory syndrome. *Australian Journal of Physiotherapy* 51: 213–219]**

Key words: Severe Acute Respiratory Syndrome, Rehabilitation, Exercise Training, Randomised Controlled Trials, Physiotherapy

Introduction

There was a major outbreak of severe acute respiratory syndrome (SARS) in Hong Kong in March 2003 (Lee et al 2003, Tsang et al 2003). The disease soon turned into a global outbreak, and by the end of the epidemic in June 2003, there were 1755 SARS cases in Hong Kong with a death toll of 299. Most of the patients presented with one or more respiratory symptoms, including cough, shortness of breath, and difficulty in breathing (Donnelly et al 2003). Chest radiographs revealed a significant degree of lung opacification which was characterised by multiple areas of consolidation unilaterally or bilaterally (Wong et al 2003).

Many SARS patients, following discharge from hospital after treatment of the acute illness, still experienced difficulties in coping with simple activities of daily living, such as walking, climbing stairs or simple housework. Many of them complained of palpitations, hand tremor and exertional dyspnoea. These complaints might be related to atelectasis, ongoing alveolitis, pulmonary fibrosis, varying degrees of muscle weakness, or deconditioning. As many of them received short bursts of high dose steroid to prevent immune-mediated lung injury during the acute illness, these complaints might be due to prolonged bed-rest, adverse drug effects and residual disease pathology (Decramer et al 1996, Lee et al 2003, Nakago et al 1999).

From our previous study, patients who had recovered from SARS showed a decrease in a 6-minute walk distance and below average performance in the curl-up and push-up tests. In addition, there was also a decrease in the physical domains of health-related quality of life as revealed in the medical outcomes study 36-item short-form health survey (SF-36) (Lau et al 2005).

A key component in the rehabilitation program to restore SARS patients' physical fitness and independence is exercise training. Physical fitness is defined as the ability to perform occupational, recreational and daily activities without undue fatigue (ACSM 1998). Cardiorespiratory fitness is related to the ability to perform large muscle, dynamic, moderate-to-high intensity exercise for prolonged periods. Performance of such exercise depends on the functional status of the respiratory, cardiovascular, and musculoskeletal systems. Muscular fitness has been used to describe the integrated status of muscular strength and muscular endurance (Graves et al 1998). It has also become increasingly important to review health-related quality of life as an outcome measure for health interventions and SF-36 has been extensively adopted to assess physical and psychological well-being (Schelling et al 2000).

The documented benefits of exercise training in patients with respiratory disease include increased exercise capacity (endurance) and functional status, decreased severity of dyspnoea, and improvement in health-related quality of life (Donner and Howard 1992). As SARS is a recently emerged disease, limited information is available about the rehabilitation of the survivors and their profile of return of
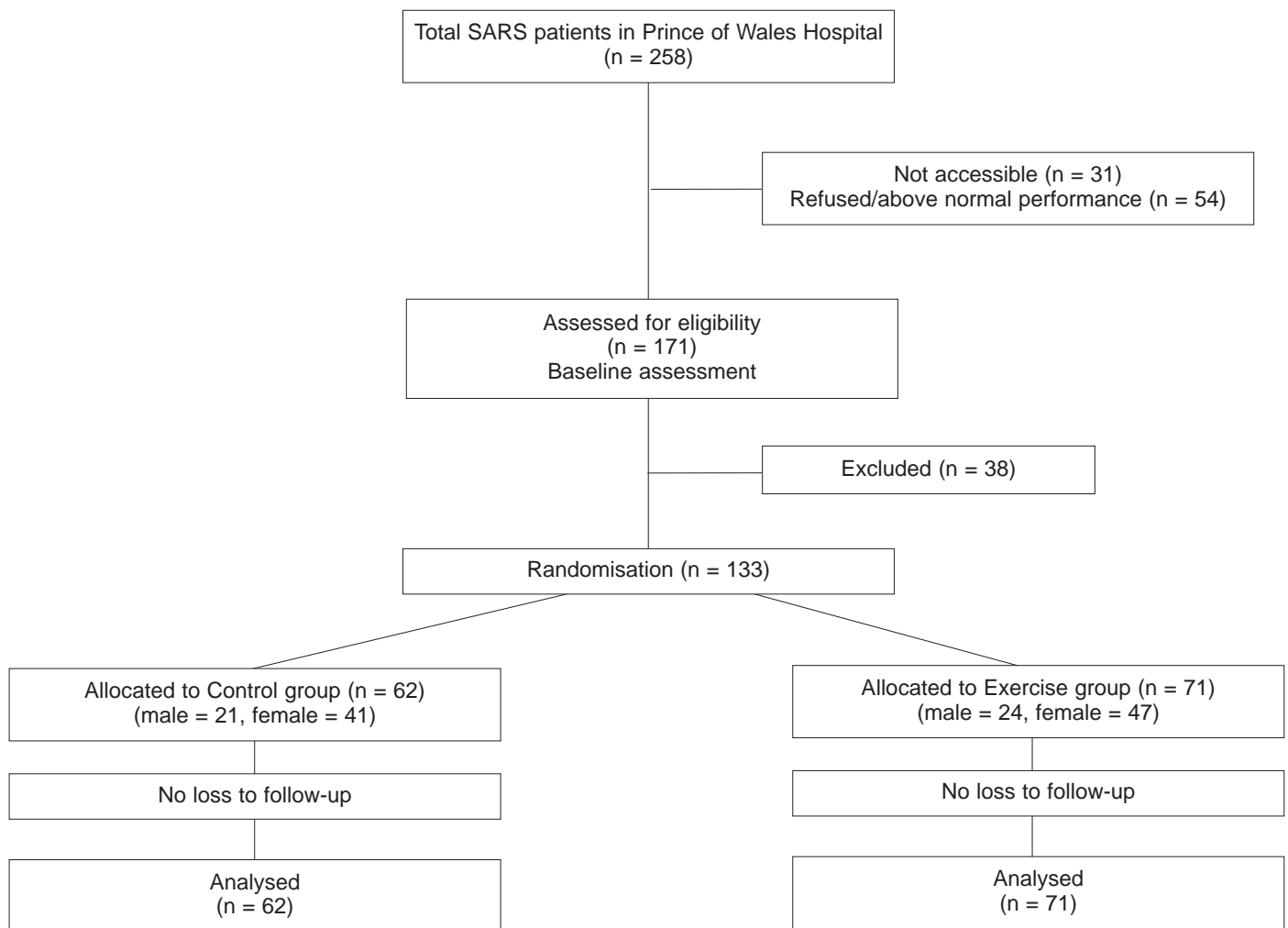
Figure 1. Flowchart showing study design and the number of subjects recruited throughout the study.

physical fitness and health-related quality of life. In 2003, most patients with SARS were given only general advice on medical and personal care upon discharge. Thus, the purpose of the study was to investigate into the effect of a 6-week physical rehabilitation program on the post-discharge SARS patients in improving their physical fitness (cardiorespiratory and musculoskeletal fitness) and health-related quality of life. On the basis of a power calculation, it has been estimated that 80 subjects were required to have an 80% statistical power and a 5% significance level of detecting a difference in 6-minute walk test distance of 60 metres (Berry et al 1999).

Method

All patients followed up at the SARS Review Clinic of the Prince of Wales Hospital, Hong Kong Special Administrative Region, between May and July 2003 who were referred solely for physiotherapy were invited to participate in the study. Patients who were haemodynamically unstable (fluctuating blood pressure and resting heart rate), poorly motivated, unco-operative, unable to communicate, with poor pre-SARS mobility, unstable medical conditions (e.g. known cardiopulmonary disorders) or musculoskeletal conditions which affect mobility (such as rheumatoid arthritis and avascular necrosis) were excluded from the study. In addition, subjects with above-normal performances compared to normative data in the 6-minute walk test and the Chester Step Test were also excluded after baseline assessment

(Coordinating Committee for Physiotherapy 2003, Sykes 1998).

Approval had been obtained from the Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Ethics Committee. The baseline measurements of cardiorespiratory and musculoskeletal fitness, and health-related quality of life were conducted at least 2 weeks after the patient had been discharged from the hospital (i.e. 5 weeks after disease onset). No sample size calculation was performed prior to the conduct of study as we aimed to recruit all SARS patients admitted in the Prince of Wales Hospital. However, the sample size of the current study was 133 and adequate to have statistical power and significance level of detecting changes in 6-minute walk test distance as suggested by Berry et al (1999). Of the 258 SARS patients, 31 (12.0%) were not accessible, and 54 (20.9%) either refused to participate or were found to have above-normal performances; 2 (0.8%) had died. Finally, 171 (66.3%) patients with subnormal performances with respect to the same age range of healthy subjects were recruited for baseline assessment (Lau et al 2005). With 38 patients unable to participate in the subsequent training sessions, 133 remained and were allocated randomly to the control or exercise group using computer-generated minimisation (Jensen 1991). Each patient's particulars were keyed in and the computer program automatically allocated the patient to the group that yielded the smallest imbalance in age, gender,

Table 1. Baseline characteristics of the patients (n = 133).

	Control (n = 62)	Exercise (n = 71)	*p* value
Age	38.3 ± 11.2	35.9 ± 9.3	0.18
Days of hospitalisation	22.1 ± 10.9	23.2 ± 11.3	0.57
Total dosage of prednisolone (mg)	435.3 ± 465.1	555.9 ± 428.0	0.12
Six-minute walk distance (m)	614.3 ± 95.1	590.7 ± 89.3	0.14
Predicted VO_{2max} (ml/kg/min)	37.8 ± 8.2	35.1 ± 5.5	0.05*
Anterior deltoid strength (total) (kgf)	20.4 ± 7.8	19.5 ± 8.8	0.53
Gluteus maximus strength (total) (kgf)	28.6 ± 13.2	26.2 ± 13.7	0.32
Handgrip strength (right) (kgf)	28.1 ± 11.2	27.6 ± 9.8	0.80
Handgrip strength (left) (kgf)	25.5 ± 10.0	25.7 ± 9.2	0.90
Curl-up (repetitions in one minute)	14.1 ± 11.1	13.4 ± 11.5	0.83
Push-up (maximum number of repetitions in one trial)	9.7 ± 7.4	9.5 ± 8.1	0.74
SF-36			
Physical functioning	71.1 ± 20.5	69.6 ± 19.7	0.67
Role physical	35.7 ± 38.3	26.8 ± 38.3	0.19
Role emotional	47.0 ± 41.4	42.3 ± 42.2	0.52
Bodily pain	69.4 ± 25.2	65.2 ± 23.9	0.33
Social functioning	61.1 ± 24.7	59.5 ± 24.7	0.71
General health	46.6 ± 21.5	51.6 ± 20.9	0.18
Mental health	64.0 ± 19.1	67.9 ± 18.1	0.23
Vitality	47.5 ± 17.6	51.2 ± 19.5	0.25
Return to work	43.9%	35.7%	0.29

Values are means ± standard deviations *Statistically significant at *p* < 0.05

and cardiorespiratory and musculoskeletal fitness. The allocation was concealed (that is, the person who recruited subjects and the potential subjects were unaware, at the time subjects agreed to enter the study, of which group they would subsequently be allocated to). Details of the study design and number of subjects recruited throughout the study are provided in Figure 1.

The control group received a standardised educational session from the physiotherapists. The session involved provision of advice about general exercise, and a video on exercise was shown to them. Subject compliance and problems related to the exercise were monitored and discussed through weekly phone contact by the physiotherapists. The exercise group underwent a 6-week supervised exercise training program in the physiotherapy department on top of the standardised treatment. The baseline physical profile and SF-36 were assessed. Follow-up assessment for both groups was conducted 6 weeks after the recruitment (i.e. at the end of training for the exercise group) by another independent assessor blinded to allocation.

Patients in the exercise group completed an intensive exercise program provided and monitored by the physiotherapists for 4–5 sessions a week (two sessions in the physiotherapy department) with 1–1.5 hours per session for 6 weeks. They were instructed to continue training on other days of the week to ensure that they had adequate training effects. For cardiorespiratory training, subjects were asked to perform 30–45 minutes of aerobic exercise (e.g., with an upper/lower limb ergometer, stepper, or treadmill) after a 10-minute warm-up in each session. The initial exercise intensity was based on the result of the Chester Step Test (predicted maximum heart rate) and the ratings of perceived exertion

using modified Borg scale (0–10). The training zone and exercise intensity (resistance of ergometer, speed, or inclination of treadmill) were at 60–75% (up to 80–85% for fit subjects) of predicted maximum heart rate and rating of perceived exertion of 4–6/10, progressed accordingly (ACSM 1998). The resistance training consisted of 3 sets of a 10–15 repetition maximum load with a 1–2 minute rest interval, for each large muscle group of upper and lower limbs. Each set of resistance training was fatiguing and progressed by 5–10% increments in each successive session (ACSM 1998).

A self-administered exercise logbook was also given to these patients and evaluated by the physiotherapists regularly during the training program. Regular phone follow-ups (twice weekly) were made to both groups of subjects in order to reinforce their compliance in home exercises. It was hypothesised that once the patients in the exercise group were taught how to improve their physical and cardiopulmonary fitness level they could regain a better physical profile and quality of life than those in the control group (Gauchard et al 2003).

Main outcome measures *a) Cardiorespiratory fitness* Maximal oxygen uptake (VO_{2max}) has usually been used to measure cardiorespiratory endurance (ACSM 1998) but the use of maximal exercise tests to measure VO_{2max} was not feasible in this study as it required sophisticated equipment and the participants had to exercise to the point of volitional fatigue under the supervision of a physician. Submaximal exercise testing was therefore an alternative to determine and predict the cardiorespiratory fitness of the patients (ACSM 1998). Cardiorespiratory fitness was assessed by a 6-minute walk test (ATS Committee 2002, Donner and Howard 1992) and the Chester Step Test (Sykes 1998).

Table 2. Mean change (post – pre) in physical function and SF-36 scores over the 6-week program (n = 133) and the results of independent t-tests for comparison between the two groups.

	Control (n = 62)	Exercise (n = 71)	Between-group mean difference (95% CI)
6-minute walk distance (m)	20.7 ± 98.6	77.4 ± 71.3	–56.7 (–86.7 to –26.8)*
Predicted VO_{2max} (ml/kg/min)	1.0 ± 7.3	3.6 ± 5.4	–2.6 (–5.1 to –0.1)*
Anterior deltoid strength (total) (kgf)	5.5 ±10.1	7.5 ± 6.1	–2.0 (–5.0 to 0.9)
Gluteus maximus strength (total) (kgf)	8.8 ± 14.7	10.4 ± 12.3	–1.6 (–6.4 to 3.1)
Handgrip strength (right) (kgf)	1.7 ± 5.2	4.7 ± 6.0	–2.3 (–4.7 to 0.1)*
Handgrip strength (left) (kgf)	2.2 ± 4.8	4.2 ± 5.9	–1.2 (–3.5 to 1.1)*
Curl up (repetitions in one minute)	3.6 ± 5.7	7.1 ± 9.6	–3.5 (–6.3 to–0.8)*
Push up (maximum number of repetitions in one trial)	3.6 ± 5.5	8.6 ± 6.8	–5.0 (–7.2 to –2.8)*
SF–36			
Physical functioning	3.7 ± 16.1	3.7 ± 15.4	0.0 (–5.5 to 5.5)
Role physical	14.6 ± 37.2	14.4 ± 40.2	0.2 (–13.3 to 13.6)
Role emotional	8.9 ± 42.0	1.9 ± 38.2	7.0 (–6.9 to 20.9)
Bodily pain	–5.0 ± 24.1	0.0 ± 24.9	–5.1 (–13.5 to 3.5)
Social functioning	14.2 ± 24.2	12.9 ± 22.8	1.3 (–6.9 to 9.5)
General health	–2.5 ± 18.6	–0.76 ± 17.5	–1.8 (–8.0 to 4.5)
Mental health	–0.3 ± 16.9	–1.6 ± 11.7	1.4 (–3.5 to 6.4)
Vitality	2.50 ± 14.2	1.3 ± 18.0	1.2 (–4.5 to 6.8)
Return to work	85.5%	88.6%	

Values are mean ± standard deviation * Statistically significant at $p < 0.05$

The 6-minute walk test is a simple functional assessment that has been applied in long-term follow-up studies of chronic obstructive pulmonary disease (COPD) (Berry et al 2003, Yoshikawa et al 2001) and survivors of acute respiratory distress syndrome (ARDS) (Herridge et al 2003, Neff et al 2003, Schelling et al 2000).

The Chester Step Test is an incremental five-level step test, commencing at a relatively slow pace of 15 steps per minute and then increasing every two minutes to 20, 25, 30 and 35 steps per minute. The test is terminated when approximately 80% maximum heart rate or rating of perceived exertion of 6 (moderately hard) of the subject is reached. VO_{2max} can then be predicted by drawing a graph of the corresponding heart rate at different step levels with a minimum of 3 points (level 3) (Sykes 1998).

b) Musculoskeletal fitness Clinically, many SARS survivors appear to suffer from certain degrees of steroid-induced weakness involving central, proximal, and distal muscles. A digital handheld dynamometer[a] was used to assess the isometric muscle strength of anterior deltoid and gluteus maximus objectively, whereas a hydraulic grip dynamometer[b] was used to measure distal muscle strength as it has been reported to be a reliable and valid instrument for measuring handgrip strength (Bohannon 1997, Peolsson et al 2001). In our study, only one assessor was assigned to measure the muscle strength (i.e. shoulder flexor and hip extensor) to avoid inter-observer variance. One-minute curl-up and push-up tests were adopted to evaluate the endurance of abdominal and upper limb muscles of the patients (Heyward 2002).

c) Health-related quality of life Health-related quality of life was assessed using the SF-36 which consists of 36 questions divided into eight subscales/health concepts (Lam et al 1998):

physical functioning, role physical, role emotional, bodily pain, social functioning, general health, mental health, and vitality. The scores of each domain range from 0 to 100, with higher scores indicating better functional status (Lam et al 1999, Ware et al 2000).

Statistical analysis Descriptive data were reported for variables of interest. The baseline characteristics of the two groups were compared with independent t-tests in order to determine the possible predictors. Predictors influencing changes in physical performance and health-related quality of life were evaluated using stepwise linear regression models. Alpha was set at 0.05 for statistically significant predictors (group, sex, age, post-SARS duration, total dosage of prednisolone, and resume duty status). Differences between groups in within-group changes (6-week post training minus baseline) were tested with independent t-tests with the significance level set at $p < 0.05$.

Results

A total of 171 patients were approached at baseline assessment but 38 of them were unable to participate in the subsequent training sessions. Thus 133 patients remained and were randomised in the current study. Sixty-two of them were in the control group and 71 were in the exercise group. Attendance was monitored through our hospital computer system and all 133 patients completed the training program with over 85% attendance rate achieved. The completion rate of the study was 100%.

The control group and the exercise groups did not differ at baseline for age, days of hospitalisation, post-SARS duration, total prednisolone consumed, 6-minute walk distance, muscle strength, muscle endurance, or SF-36 scores (Table 1).

Table 3. Stepwise linear regression models for change in physical functions and SF-36 scores including unstandardised β coefficients, standard error, model R square and *p* value.

6-week change in the variable	Predictor	Unstandardised coefficients	Standard error	R^2	*p* value
6-minute walk distance (m)	Group	49.6	15.3	0.123	0.002
	Post-SARS duration	−0.8	0.4		0.05
VO_{2max} (ml/kg/min)	Group	2.7	1.3	0.04	0.04
Anterior deltoid strength (total) (kgf)	Sex	−5.4	1.51	0.09	0.001
Gluteus maximus strength (total) (kgf)	NS	−	−	−	−
Handgrip strength (right) (kgf)	Group	3.2	1.0	0.07	0.002
Handgrip strength (left) (kgf)	Post-SARS duration	−0.067	0.024	0.06	0.005
Curl-up	Group	3.6	1.5	0.05	0.02
Push-up	Group	5.2	1.1	0.15	< 0.001
Physical functioning	Return to work	−12.1	5.9	0.03	0.04
Role physical	Sex	−25.2	7.5	0.15	0.001
	Age	−0.7	0.3		0.05
	Return to work	−32.6	10.8		0.003
Role emotional	Sex	−19.3	7.7	0.09	0.01
	Return to work	−28.2	11.1		0.01
Bodily pain	NS	−	−	−	−
Social functioning	Return to work	−20.7	6.9	0.07	0.003
General health	Age	−0.4	0.2	0.07	0.02
	Return to work	−12.5	5.6		0.03
Mental health	Age	−0.3	0.1	0.08	0.02
	Return to work	−10.4	4.1		0.01
Vitality	Return to work	−14.3	5.1	0.06	0.006

Variables entered: group (1 = control, 2 = exercise), sex (1 = male, 2 = female), age (years), post-SARS duration (number of days being diagnosed as SARS before joining the program), total dosage of prednisolone (mg), resume duty (0 = no, 1 = yes), NS – all covariates excluded. Statistically significant at *p* < 0.05.

However, predicted VO_{2max} was higher in the control group. Although most of the differences were not significant, variables were considered as potential covariates in the analyses.

The differences between the pre- and post-6 week intervention data, collected after 6 weeks of exercise training, on 6-minute walk distance, predicted VO_{2max}, muscle strength, muscle endurance, and the SF-36 scores are summarised in Table 2. There were significant differences in the 6-minute walk distance, VO_{2max}, handgrip strength, and the curl-up and push-up performances between the two groups. The exercise group showed more improvement than the control group in the 6-minute walk distance (77.4 vs 20.7 m, *p* < 0.001), VO_{2max} (3.6 vs 0.97 ml/kg/min, *p* = 0.04), right handgrip strength (4.7 vs 1.7 kg, *p* < 0.001), left handgrip strength (4.2 vs 2.2 kg, *p* = 0.04), and the curl-up (7.1 vs 3.6 repetitionsl, *p* = 0.01) and push-up (8.6 vs 3.6 repetitions, *p* < 0.01) performances. However, there was no significant difference in the isometric strength and any of the domains in SF-36. In addition, more than 80% of the patients in both groups had resumed work duties after the 6-week program.

Table 3 shows the predictors (covariates) of physical fitness outcomes and domains in SF-36. The group variable was shown to have significant positive effects on 6-minute walk distance, predicted VO_{2max}, and deltoid and handgrip strengths, as well as on curl-up and push-up performances. In

addition, sex, age, post SARS duration, and resumption to previous work also contributed in different degrees to physical functions outcomes and domains in SF-36. SARS survivors who experienced longer post-SARS duration, and hence a longer delay in starting an exercise program, demonstrated weaker left handgrip strength. Age showed negative correlation to certain domains of health-related quality of life, implying that younger patients showed better role physical (β = −0.69, *p* = 0.05), general health (β = −0.42, *p* = 0.02) and mental health (β = −0.32, *p* = 0.02) than older patients. In addition, patients who had already resumed duty experienced higher scores in physical functioning (*p* = 0.04), role physical (*p* = 0.003), role emotional (*p* = 0.01), social functioning (*p* = 0.003), general health (*p* = 0.02), mental health (*p* = 0.01) and vitality (*p* = 0.006) than those who had not returned to work as shown in the linear regression models depicted in Table 3. Again, males performed better in VO_{2max}, left handgrip strength and role physical than females in both groups.

Discussion

After the previous study on the physical performance and health-related quality of life of post-SARS patients (Lau et al 2005), a 6-week supervised training program was implemented after the baseline assessment. All patients were re-assessed at about 6 weeks after the baseline assessment. 85.5% of the control group and 88.5% of the exercise group had returned to work at the time of re-assessment.

This prospective, single (assessor)-blinded, controlled study has shown that a 6-week exercise training program for SARS survivors, conducted and supervised by a group of physiotherapists, could lead to a greater improvement in both cardiovascular and musculoskeletal performances. The exercise group had 13.1% improvement in the 6-minute walk distance whereas the control group had an increment of only 3.4%. Baseline VO_{2max} was significantly higher in the control group when compared with the exercise group; a possible explanation for this observation might be that the total prednisolone consumed was lower in the control group than in the exercise group at baseline (though not statistically significant). Nevertheless, the exercise group had a 10.4% improvement in predicted VO_{2max} compared to a 0.3% increment in the control group. One of the possible explanations for the difference might be that supervision and reinforcement given by physiotherapists during the training sessions (exercise group) facilitated the progression of the subjects in the exercise group. Similar results were shown in the study by Walther et al (2004); significant improvement was shown when training was provided, but there was no significant difference identified between the self-trained and supervised training groups. In addition, those patients with longer post-SARS duration walked less in the 6-minute walk test, probably due to more deconditioning during the 6 weeks after the initial baseline assessment.

Although the 6-minute walk test improved significantly more in the training group in the current study, both the control (635 m) and the exercise groups (668 m) performed better than patients with COPD (474 m) (Sciurba et al 2003) which shows that recovery of the SARS patients on exercise tolerance was a lot better than those patients with COPD. In addition, both groups had a higher predicted VO_{2max} value when compared to patients suffering from ARDS (24 ml/kg/min, Neff et al 2003) and COPD (12 ml/kg/min, Yoshikawa et al 2001). This implies that the aerobic capacity of SARS patients was more responsive to exercise training than ARDS and COPD patients. Thus the effect of SARS on subjects' cardiovascular fitness and exercise tolerance performance is less than ARDS and COPD. The impaired physical fitness was due mainly to deconditioning and steroid-induced short-term myopathy and tachycardia (which was not as chronic as in COPD patients).

All post-SARS patients had a similar 6-minute walk distance after the 6-week training when compared to normal population (Coordinating Committee of Physiotherapy 2003). Similar results in predicted VO_{2max} were also obtained from both groups, and these results were categorised as 'average' when compared with normal individuals (Sykes 1998). These indicated those post-SARS patients' cardiovascular fitness and exercise tolerance could be recovered and resumed with the 6-week exercise training (self and supervised).

The muscular performance of the exercise group also improved significantly when compared to the control group after the 6 weeks of intensive training as listed in Table 3. Both the proximal and distal muscle strength improved as reflected by right handgrip strength and the curl-up and push-up tests. This is probably due to the training program. In general, patients with longer post-SARS duration showed weaker handgrip strength while male patients were stronger than females in isometric deltoid muscle strength. Hence the decrease in isometric muscle strength in the control group might be due to the effect of deconditioning and poor home

exercise compliance after being discharged from the hospital. Thus the training program adopted in the current study is deemed necessary and effective in improving both the cardiopulmonary and musculoskeletal performance in post-SARS patients. It might prevent further deconditioning after patients were discharged from hospital.

The apparent better improvement of the isometric strength of anterior deltoid and gluteus maximus in the exercise group might be a positive effect of the current training program. The improvement was not statistically significant, possibly because of the adverse effect of the steroid (prednisolone) administered which induced short-term myopathy (which counter-balanced the positive effect of the training program).

There was no significant difference in any domain of the health-related quality of life questionnaire (SF-36) between the two groups. However, the outcome of certain domains appeared to be associated with some factors. In general, older patients scored lower in role physical, general health, and mental health when compared to younger survivors. This could probably be explained by the ageing process (see Table 3). Male subjects also scored higher in role physical and role emotional when compared with female subjects as in other studies (Rothenhausler et al 2001, Schelling et al 2000), which was not due to the impact of SARS. In addition, patients (mostly health care workers) who had not yet resumed duty had a lower score in almost all physical and mental domains (except bodily pain) than those who had resumed duty before the end of the training program. It was likely that resumption of normal duty had helped restore the self-esteem and job satisfaction of the post-SARS patients. However, no difference was found between training and the control group in physical domains, probably meaning that return to work was not affected by post-SARS patients' physical ability.

Health-related quality of life of post-SARS patients (role physical, role emotional and social functioning) improved over the 6-week period irrespective of the exercise training. However, such improvements were not statistically significant. In addition, the social functioning domain was lower in post-SARS patients compared to survivors of ARDS (Herridge et al 2003, Neff et al 2003, Schelling et al 2000) which implies that post-SARS patients were still experiencing subjective deficit in their roles over physical and emotional aspects throughout the 6 weeks after the baseline assessment.

Conclusion

We have shown that a 6-week intensive physical training program, supervised by a group of physiotherapists, was effective in improving both the cardiorespiratory and musculoskeletal performances in patients recovering from SARS. Nevertheless, physical training during the intervention period had no impact on health-related quality of life. Further controlled study is needed to evaluate the long-term effects of the current training program among SARS survivors.

Footnotes [a]Nicholas manual muscle tester (Lafayette Instrument, Lafayette, IN, USA) [b]Jamar (Sammons Preston Rolyan Inc, Bolingbrook, IL, USA)

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