Fatigue and Functional Capacity in Persons with Post-Polio Syndrome: Short-term Effects of Exercise and Lifestyle Modification Compared to Lifestyle Modification Alone

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ABSTRACT

Purpose: *Post-polio Syndrome (PPS) affects polio survivors many years after the initial attack, and causes new musculoskeletal symptoms and decline in physical function. This study aims to compare the effect of exercise and lifestyle modification versus lifestyle modification alone, on fatigue and functional capacity in persons with PPS.*

Method: *An experimental study was conducted at the physiotherapy department of VS Hospital in Ahmedabad. As per the criteria of Halstead (1985), 21 PPS subjects who were between 18 and 65 years of age, and able to walk indoors and outdoors, with or without assistive aids, were included. They were randomly allocated into 3 groups using the envelope method. Those with physician-diagnosed respiratory or cardiac insufficiency, disabling co-morbidity which interfered with the intervention programme or influenced the outcome, and those unable to cooperate due to cognitive impairment or use of any psychotropic drugs, were excluded. Fatigue and functional capacity were measured using Fatigue Severity Scale (FSS) and 2-minute walk distance, respectively. Physical and psychological functions were assessed using Patient Reported Outcome Measurement Information System (PROMIS) questionnaire and Patient Health Questionnaire (PHQ-9) respectively. Intervention was given for 5 days a week, over 4 weeks. Group A received exercise and lifestyle modification, group B received lifestyle modification alone and group C continued their usual routine for 1 month.*

Results: *There was a significant difference in fatigue and functional capacity within groups A and B, with group A showing better reduction in fatigue*

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than groups B or C. Physical function improved only within group A, and a significant difference was seen compared to groups B and C. Psychological function showed no difference within or between the groups.

Conclusion: *There was improvement in fatigue, functional capacity and physical function in PPS subjects after 4 weeks of exercise and lifestyle modification. Lifestyle modifications alone for 4 weeks improved fatigue and functional capacity in PPS subjects. There is significant reduction in fatigue and improvement in functional capacity when lifestyle modification advice is given along with exercise.*

Limitation: *Long-term follow-up of the subjects was not undertaken, blinding was not possible, and confounders such as the number of body sites with residual paresis, duration and number of new neuro-musculoskeletal symptoms, and level of physical activity were not considered.*

Key words: *physical function, psychological function, aerobic exercise, strengthening, activity pacing, energy conservation*

INTRODUCTION

Post-polio Syndrome (PPS) is a condition that can affect survivors many years after the initial paralytic attack caused by the polio virus. It is characterised by progressive or new muscle weakness, or decreased muscle endurance in muscles that were previously affected by the polio infection and in muscles that seemingly were unaffected, as well as generalised fatigue and pain (Halstead, 1991). These symptoms often lead to a decline in physical functioning. Prevalence of PPS ranges between 20-85% among polio survivors (Nollet et al, 1999). It usually begins very slowly, although it can appear suddenly with events like fall, surgery or immobility seeming to be trigger factors. PPS occurs irrespective of age and in people who had paralytic or non-paralytic polio (Halstead and Rossi, 1985). Exclusion diagnosis is followed as there is no diagnostic test for PPS. Hence, diagnosis is based on a proper clinical work-up where all other possible explanations for the new symptoms are ruled out.

Rehabilitation is considered the mainstay of management in PPS, with an emphasis on physical therapy (Dalakas, 1995). This rehabilitation differs from the approach employed to provide relief during the recovery phase of poliomyelitis. The aim is to reach a functional balance by increasing capacities and reducing demands. Several different approaches can be followed, as there is no specific treatment for PPS. Frequent periods of rest, energy conservation, and work simplification skills are also useful, and general lifestyle modifications including weight control, physical activity, adaptation to assistive devices, and modification of daily activities are advocated to diminish fatigue (Howard, 2005). Properly fitted orthoses can improve the biomechanical movement pattern and be energy-saving (Farbu, 2005). Aerobic exercise using the treadmill improves fatigue, functional capacity and quality of life in persons with PPS (Oncu et al, 2009). Cup et al (2007) reviewed studies dealing with exercise therapy for clients with PPS and found evidence for the effectiveness of strengthening or aerobic exercise to be insufficient. Grimby and Stalberg (1994) suggested endurance and resistive training to be effective in increasing muscle strength and endurance in subjects with PPS. Lygren et al (2007) noted that clients with PPS who had regular physical activity had fewer symptoms and a higher level of functioning than those who were not often physically active.

Acute polio is no longer a constant threat to people in the polio-free areas of the world, but there are still thousands of polio survivors who are at risk of developing late manifestations of the disease. India is a country with a large number of polio survivors (Polio India fact sheet, 2012). There is no published evidence on the epidemiology of PPS in India so far; however a study by Sheth et al (in-press) identifies the prevalence of PPS to be around 80% among polio survivors in Gujarat, India. So far there have been very few research studies that address the problems of PPS and the possible treatment options. It is important to highlight the need to carefully screen all clients with PPS, to study the effect of various treatment options and to evaluate the benefits of each, so that a set of appropriate and effective interventional strategies are implemented promptly. Therefore, this study aims to evaluate and compare the outcome of exercise and lifestyle modifications versus lifestyle modification alone, on the fatigue, functional capacity, physical and psychological function of PPS subjects.

Objectives

The study aimed to determine the effect of exercise and lifestyle modification on fatigue, functional capacity, physical and psychological function in subjects with PPS, using Fatigue Severity Scale, 2-minute walk distance, and PROMIS and PHQ-9 questionnaires, respectively. With the same tools, the study also aimed to determine the effect of lifestyle modification alone on fatigue, functional capacity, physical and psychological function in subjects with PPS, and tried to compare the effect of exercise and lifestyle modification versus lifestyle modification alone on all the variables under study.

METHODS

An experimental study was conducted from December 2012 to October 2013 at the out-patient physiotherapy department of Vadilal Sarabhai General Hospital in Ahmedabad, India. Ethics approval was obtained from the Institutional Review Board of the college (PTC/IEC/52/2012-2013).

Participants

Subjects with PPS were recruited from various parts of Gujarat, the OPDs of general hospitals of Ahmedabad, and from camps conducted for persons with disabilities. They were also contacted with the help of previous hospital records. As per the Halstead criteria (1985), 21 persons were included in the study. They were between 18 and 65 years of age, diagnosed with PPS, and able to walk indoors and outdoors, with or without assistive aids. They were randomly allocated into one of the 3 groups by the envelope method. The nature and purpose of the study was explained to them in the language they could understand, and informed written consent was obtained. Individuals were excluded if they had any physician-diagnosed respiratory or cardiac insufficiency, were unable to cooperate due to cognitive impairment, had disabling co-morbidity that interfered with the intervention programmes or influenced the outcome, or if they were using any psychotropic drugs. A complete neuromuscular examination was done and demographics along with baseline assessment of outcome measures were taken. Intervention was given on 5 days a week, for 4 weeks.

Tools

Fatigue was measured using Fatigue Severity Scale (FSS) which is a self-administered questionnaire, developed to measure fatigue in medical and neurological diseases. It has also been used to measure general fatigue in PPS. It has a good internal consistency (Cronbach's alpha=0.81 to 0.95). FSS consists of 9 statements that are scored on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), to explore severity of fatigue symptoms. A low value indicates that the statement is not very appropriate whereas a high value indicates agreement (Horemans et al, 2004a). Subjects were asked to encircle a number from 1 to 7, depending on how they felt the statement applied during the preceding week.

2-minute walk distance (2MWD) was used to measure functional capacity. It is a recommended measure of functional capacity in PPS (Horemans et al, 2004b) and has good validity (r=0.69) and reliability (ICC=0.92 to 0.94). Participants were asked to walk as far as they could at a comfortable speed for 2 minutes. The distance was recorded in metres. The test was terminated if subjects reported any discomfort, fatigue or increase in pain.

Physical function was assessed using Patient Reported Outcome Measurement Information System (PROMIS). It assesses an individual's ability to perform a range of physical activities. There are 12 questions and the average ability to engage in various tasks over the past week is measured on 5-point scales that range from "without any difficulty" to "unable to do". The higher the raw score of PROMIS, the better the physical function.

Psychological function was assessed using Patient Health Questionnaire (PHQ-9). This is a 9-item measure in which respondent's rate how frequently they experienced 9 symptoms of depression during the past 2 weeks, by using a 4-point scale where 0 is "not at all" and 3 is "nearly every day." The total score can range from 0 - 27 and a higher score represents higher levels of depressive symptoms. It has been widely used to assess depression severity and has a great deal of support for its validity in populations with physical disabilities (Jenson et al, 2011).

Intervention

Subjects in group A received exercise and lifestyle modification. Exercises were divided into 4 phases. Phase 1 consisted of warm up, in the form of gentle, active range-of-motion exercises in the pain-free range of any 8 possible joints of 4 limbs. The subject performed 5 repetitions. Phase 2 consisted of strengthening exercises (Feldman and Soskolne, 1987) of any 8 possible muscle groups of 4 limbs, out of the 12 muscle groups mentioned in Table 1 on the right and left extremities. These were performed by means of dumbbells, weight cuffs or limb weight. Gravity-minimised positions were used for large muscles having power <3 on MMT (manual muscle testing), and anti-gravity body positions were used for large muscles >3 on MMT. Subjects actively performed 2 sets of 5 repetitions each. A 30-second rest period was given between each set and also between the exercises of each muscle group. If subjects reported any symptoms of pain aggravation or fatigue, exercises were discontinued immediately during the session. Phase 3 was the aerobic exercise phase during which subjects performed 10 minutes static cycling on a regular lower extremity cycle ergometer. They were asked to maintain their exertion at moderate intensity (i.e. RPE of 13-15 on modified Borg's scale). Phase 4 was the cool down phase consisting of gentle, passive range of motion exercises of all the muscles actively exercised in the warm up phase. The therapist performed 5 repetitions.

Table 1: Muscles Exercised

1.	Shoulder flexors	7.	Hip extensors
2.	Shoulder extensors	8.	Hip abductors
3.	Shoulder abductors	9.	Knee flexors
4.	Elbow flexors	10.	Knee extensors
5.	Elbow extensors	11.	Ankle dorsi-flexors
6.	Hip flexors	12.	Ankle plantar-flexors

Group B subjects received lifestyle modification alone. Lifestyle modification remained common for groups A and B and consisted of:

1) Activity pacing - Balancing of activity with rest periods interspersed throughout the day.

2) Energy conservation technique - Adoption of strategies that reduce overall requirements of the task and overall level of fatigue. It also included modifying the task or the environment for successful completion of daily activities.

3) Advice on use of assistive devices - Crutches, canes, sticks, calipers, footwear modification based on their needs.

4) Advice on maintaining health body weight - Eating less fat and high fibre diet.

5) Advice on adequate rest – Getting 7 - 8 hours of uninterrupted sleep.

6) Management of pain - Application of hot/cold packs to the painful area for 10 minutes, once a day.

The subjects were also given a handout listing the instructions to be followed; in a language they could understand (Appendix 1).

Group C subjects continued their usual routine. None of their activities were restricted. They were asked to continue their routine schedule and activities of daily living, and to wait until called for the exercise intervention, at 4 weeks. Compliance to intervention was monitored and was categorised as 'Daily' (20 sessions), 'Mostly' (15-20 sessions), 'Partly' (10-15 sessions), and 'Never' (<10 days).

Data analysis

Level of significance was set at 5% and data were analysed using Graph-Pad Prism version 5 and SPSS version 20. Variables were checked for normal distribution using Histogram and Kolmogorov Smirnov test, and appropriate test of analysis was applied. Changes in the outcome measures were examined within and between the groups. Mean difference in FSS score was analysed using Wilcoxon signed-rank test within each group, and Kruskal-Wallis test between the groups. Mean difference in 2MWD was analysed within each group using paired t- test, and Kruskal-Wallis test between the groups. Mean difference in PROMIS and PHQ-9 was analysed within the groups using Wilcoxon signed-rank test and Kruskal-Wallis test was used for analysis between the groups.

RESULTS

There were 8 males and 13 females, with a mean age of 41.71 + 5.12 years. Age and body mass index (BMI) were normally distributed and one-way ANOVA was applied for comparison between the groups. There was no difference in between the groups with respect to age ($F2,18 = 1.035$; $p= 0.376$) or BMI ($F2,18 = 0.458$; $p= 0.640$).

Compliance to programme was assessed for subjects in group A and group B. 20 subjects completed the study. One subject in group A who participated for <10 days was considered as a dropout (for social reasons), and 1 subject in group B participated for 15-20 sessions.

Tables 2 and 3 show within-group and between-group analysis of outcome measures respectively. There was a statistically significant difference in FSS within group A ($Z= -2.375$; $p <0.018$) and group B ($Z= -2.207$; $p=0.027$) but not within group C ($Z= -0.577$; $p=0.577$). Between the groups, there was a statistically significant difference in FSS score ($p<0.003$).

Table 2: Mean Difference in Outcomes within the Group

Outcome	Statistics	Group A	Group B	Group C
FSS	Pre- FSS	5.5 + 0.34	5.1 + 0.37	5.3 + 0.19
	Post-FSS	4.9 + 0.40	5.1 + 0.35	5.3 + 0.15
	P value	0.018*	0.027*	0.577
	Z value	-2.375	-2.207	-0.577
2 MWD	Pre-2MWD	93.91 + 9.68	100.14 + 10.59	107.26 + 2.14
	Post-2MWD	94.60 + 9.67	100.57 + 10.71	106.60 + 3.28
	P value	< 0.001*	0.003*	0.276
	t value	-6.00	-4.804	0.197
PROMIS	Pre-PROMIS	39.60 + 5.31	43.50 + 5.88	43.50 + 4.65
	Post-PROMIS	42.00 + 4.92	42.00 + 6.13	43.50 + 5.45
	P value	< 0.014*	1.00	0.18
	Z value	-2.456	0.00	-1.342
PHQ-9	Pre-PHQ9	3.85 + 1.06	5.29 + 1.97	5.42 + 1.61
	Post-PHQ9	3.83 + 1.06	5.59 + 2.07	5.57 + 1.51
	P value	0.317	0.157	0.317
	Z value	-1.00	-1.42	-1.00

*Significant

Table 3: Mean Difference in Outcomes between the Groups

Group	FSS (Median + SD)	2 MWD (Mean + SD)	PROMIS (Median + SD)	PHQ-9 (Median + SD)
A	0.50 + 0.12	0.63 + 0.17	2.40 + 0.61	0.02 + 0.06
B	0.17 + 0.15	0.41 + 0.32	0.00 + 0.68	1.00 + 0.00
C	0.05 + 0.11	1 + 1.13	0.00 + 0.94	-0.29 + 0.4880
P value	0.003*	0.206	0.008*	0.810
F/ $\chi 2$ value	12.734	3.156	9.945	0.444

*Significant

Table 4 shows that Dunn's multiple comparison test was applied for multiple comparisons between the groups. Group A had a statistically significant difference over group B ($p<0.05$) and group C ($p<0.05$). Group B had no significant difference over group C ($p>0.05$).

For 2MWD, there was a statistically significant difference within group A (t=-6.00; p=0.001) and group B (t=-4.804; p=0.003) but no difference in group C (t=0.197; p=0.276). There was no significant difference between the groups.

Table 4: Dunn's Multiple Comparison Test for FSS between the Groups

COMPARISON	Difference in rank sum	p <0.05
GROUP A vs B	7.7	Yes *
GROUP B vs C	2.2	No
GROUP C vs A	9.8	Yes *

*Significant

Physical function as measured by PROMIS, showed a statistically significant difference in group A (Z= -2.456; p=0.014) and no difference in group B (Z= 0.00; p= 1.00) and group C (Z=-1.342; p=0.18). Also, there was a statistically significant difference between the groups (p=0.007) and Dunn's multiple comparison test was applied between the groups as shown in Table 5. Group A had a statistically significant difference over groups B and C. Group B had no significant difference over group C (p=1.000). Psychological function as assessed by PHQ-9 revealed no difference within or between the groups.

Table 5: Dunn's Multiple Comparison Test for PROMIS between the Groups

COMPARISON	Difference in rank sum	p <0.05
GROUP A vs B	8.214	Yes *
GROUP B vs C	0.286	No
GROUP C vs A	8.500	Yes *

*Significant

DISCUSSION

The results of this study showed positive findings, with significant improvement in fatigue, functional capacity and physical function in group A. In group B also, fatigue and functional capacity showed significant improvement. Improvement in fatigue and functional capacity was significantly better in group A as compared to group B.

Subjects in groups A and B showed a significant difference in fatigue from the baseline. This reduction in fatigue can be attributed to lifestyle modification, which balances the physical demands and energy utilisation. Lifestyle modification in the form of pacing has been shown to be effective in minimising muscle aching and cramping (Jones et al, 1989). Group A subjects showed significant improvement in comparison to group B subjects, which can be explained by changes in response to exercise causing increase in maximal oxygen consumption at tissue level with capillary organisation, one of the peripheral mechanisms of fatigue. An aerobic exercise programme can break the circle of inactivity, impaired performance and increased fatigability (Kilmer, 2002). In a randomised control trial, Klein et al (2002) observed a significant decrease in the mean number and mean severity of the shoulder symptoms following a 16-week non-fatiguing strengthening exercise and lifestyle modification programme for PPS subjects. Oncu et al (2009) also noted improvement in fatigue after an exercise programme consisting of flexibility exercises and aerobic exercises. Jones et al (1989) found improvement in fatigue, work capacity and aerobic power following a 16-week thrice-weekly aerobic programme for 16 subjects with PPS.

Various studies have concluded that non-fatiguing strengthening exercise at sub-maximal levels can be beneficial for polio survivors to improve their aerobic capacity (Agre and Rodriguez, 1997). In keeping with this, group A subjects in the present study showed significant improvement in functional capacity. Improvement in functional capacity in group B can be explained by reduction of fatigue-causing increased aerobic performance and hence, the functional capacity. Central and peripheral mechanisms are responsible for exercise adaptations leading to greater functional capacity. Increased myocardial contractility, improved venous return, increased maximum minute volume; increased tidal volume and increased stroke volume facilitate increase in the cardiopulmonary performance. Greater pulmonary diffusion is another favourable change that may be expected (Wilmore and Costill, 2004).

Group A subjects showed a significant difference in physical function, which could be because of increased motivation and empowerment of the clients after exercise. Fatigue and decrease in functional capacity, the most important features of PPS, cause restrictions in daily activities such as walking and climbing stairs, and this affects quality of life. Willen et al (2001) reported significantly lower pain and increased wellbeing with non-swimming dynamic exercise. Group B subjects showed reduction in fatigue and increase in functional capacity; however there was no improvement in physical function.

Psychological function showed no difference from baseline in all the 3 groups. This is in contrast to various studies in the literature (Rekand et al, 2004; Bertelson et al, 2009), which suggest improvement in various domains of quality of life and mental health following exercises and lifestyle modification advice. One possible reason could be that the short 4-week duration of the study may have been insufficient to benefit psychological health. Another reason could be because of fewer disturbances in psychological function in all the 3 groups at baseline.

Group C showed decline in fatigue, functional capacity, physical and psychological function, but this was not statistically significant. This suggests that PPS subjects may experience a gradual deterioration in their overall functional status if given no exercise or lifestyle modification. Consistent with these findings, various long term observational studies (Ghahari et al, 2010) have shown that there was a significant decrease in physical functioning and walking capacity and a significant increase in co-morbidity and extent of paresis, whereas continuous rehabilitation seems to maintain physical independence in polio clients, improves their ability to earn their own income, and lessens the need for disability pensions (Trojan et al, 2009).

CONCLUSION

After 4 weeks of exercise and lifestyle modification, there was improvement in fatigue, functional capacity and physical function in PPS subjects. Lifestyle modification advice followed over a period of 4 weeks led to improvement in fatigue and functional capacity among them. Reduction in fatigue and improvement in functional capacity was significantly more when lifestyle modification advice is given along with exercise. Both exercise and lifestyle modification and lifestyle modification alone had no effect on psychological function.

Implications

Administration of a regular exercise programme can be beneficial to clients with post-polio syndrome. It would be appropriate to give those with distinct impairment in functional capacity an exercise programme along with lifestyle modification. Those who cannot follow an exercise programme can be advised lifestyle modification only.

Limitation

Long-term follow-up of the subjects was not undertaken, blinding was not possible, and confounders such as the number of body sites with residual paresis, duration and number of new neuro-musculoskeletal symptoms and level of physical activity were not considered. Future studies could bear these in mind.

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APPENDIX 1: INSTRUCTIONS

ACTIVITY PACING:

1. You can set your baseline by timing how long you can do a task before you begin to tire.

   For example, the next time you climb the stairs count the number of steps it takes you to get tired. If you get tired after 10 steps you can work out your activity baseline – half of 10 steps = 5 steps.
2. While doing any activity, stop and rest before you begin to feel tired. After rest, continue your activity. When you feel tired, you stop and rest again.

ENERGY CONSERVATION:

1. Prioritise a task:
- Does it all need to be done today?
- Can I get someone to help me?
- Does it need to be done at all?

2. Planning:
- Can I break the job down into different stages?
- What do I need to carry out the job?
- What basic activities does each stage involve, e.g. walking/sitting/standing?
- Is there too much to do on any one day?
- Could easier/lighter tasks be alternated with more difficult/heavier tasks?
- Have I scheduled enough rest periods?

3. Work areas should be arranged in the most effective way:

   For example, in the kitchen have the most frequently used items in the most easy to reach places. Sit down when preparing a meal as this uses 25% less energy.

4. For heavy tasks, plan the whole schedule on a daily/weekly basis.