PURSED LIP BREATHING INCREASES UNSUPPORTED UPPER EXTREMITY EXERCISE ENDURANCE AND REDUCES DESATURATION IN COPD

RESPIRAȚIA PRINTRE BUZELE STRÂNSE CREȘTE REZISTENȚA LA EXERCIȚIILE EXECUTATE CU MEMBRELE SUPERIOARE ȘI REDUCE DESATURAȚIA, ÎN BPOC

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Key words: pursed lip breathing, unsupported upper extremity exercise, oxygen saturation, exercise endurance, chronic obstructive pulmonary disease (COPD).

Abstract:
Introduction: Patients with chronic obstructive pulmonary disease (COPD) report reduced arm exercise capacity, increased fatigue and dyspnea when performing activities of daily living (ADLs) that require the use of upper limbs. Also, arm activity has been noted to result in abnormal dysynchronous breathing patterns. PLB (pursed lip breathing) works to improve expiration, by requiring active and prolonged expiration and by preventing airway collapse.
The objective of this study was to evaluate the influence of PLB on upper extremity exercise endurance, oxygen saturation, and dyspnea in patients with moderate to severe COPD. **Method:** An experimental cross-over study was conducted at the Physiotherapy Department, Seth GSMC and KEMH, Mumbai, India. Sixty patients with moderate to severe COPD were selected. All patients performed unsupported upper extremity exercise with and without PLB in random order. Upper extremity exercise endurance, oxygen saturation, heart rate, blood pressure, respiratory rate, patients' estimated dyspnea, and rate of perceived exertion were recorded before, immediately after, 3 minutes, and until recovery to the baseline on a Borg Category Ratio 10 scale.
Result: Wilcoxon matched-pairs signed rank test was done to compare means of any two variables. Statistical significance was set at $p < 0.05$.The difference between the exercise endurance (number of sets and duration) with spontaneous breathing (SB) and PLB was found to be significant, showing that the patients could exercise more with PLB. The drop in oxygen saturation with PLB is significantly less as compared to SB. The average drop in oxygen saturation was 1.6% less when spontaneous pursed lips breathing was employed. The increase in rate pressure product, respiratory rate, rate of perceived exertion, and dyspnea were significantly less with PLB. **Conclusion:** Pursed lip breathing can be a useful technique to increase unsupported arm exercise endurance and reduce oxygen desaturation during exercise in patients with moderate to severe COPD.

Cuvinte cheie: respirație printre buzele strânse, exerciții cu membrele superioare, saturația de oxigen, rezistența la exerciții, boală pulmonară cronică obstructivă (BPOC).

Rezumat:
Introducere: Pacienții cu boală pulmonară cronică obstructivă (BPOC) acuză scăderea rezistenței la executarea exercițiilor cu membrele superioare (MS), oboseală marcată și dispnee la realizarea activităților zilnice (ADL) care necesită folosirea membrelor superioare. De asemenea, s-a constatat că folosirea MS determină paternuri de desincronizare respiratorie. PLB (respitația cu buzele strânse) îmbunătățește expirația, deoarece necesită un expir activ și prelungit, prevenind astfel colapsul căilor respiratorii. **Obiectivul** acestui studiu este de a evalua influența PLB asupra rezistenței la executarea exercițiilor cu (MS), a saturației de oxigen și a dispneei, la pacienții cu BPOC moderat spre sever. **Metodă:** Studiul experimental s-a realizat la Departamentul de Fizioterapie, Seth GSMC și KEMH, Mumbai, India. Au fost luați în studiu un număr de 60 de pacienți cu BPOC sever sau moderat. Toți pacienții au executat exerciții cu MS folosind sau nu PLB, în ordine aleatorie. S-au evaluat inițial, la 3 minute și final, până la atingerea pragului 10 pe scala Borg: rezistența la executarea exercițiilor cu MS, saturația în oxigen, frecvența cardiacă, tensiunea arterială, rata respiratorie, gradul de dispnee, rata percepției exortului. **Rezultate:** S-a efectuat testul Wilcoxon pentru eșantioane pereche, pentru a compara mediile variabilelor. Semnificația statistică s-a stabilit la $p < 0.05$. Diferența dintre rezistența la exerciții (numărul de seturi și durata) cu resprație spontană (RS) și PLB a fost semnificativă, demonstrând faptul că pacienții au putut executa mai multe exerciții folosind PLB. Scăderea saturației de oxigen cu PLB este semnificativ mai redusă în comparație cu RS. Media reducerii saturației de oxigen a fost mai mică cu 1.6% față de RS. Creșterea ratei presoare, respiratorii și a percepției efortului și dispneea au fost semnificativ mai reduse cu PLB. **Concluzii:** PLB poate fi o tehnică utilă pentru creșterea rezistenței la executarea exercițiilor cu MS și reducerea saturației de oxigen în timpul executării exercițiilor, la pacienții cu BPOC moderat spre sever.

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Introduction

Chronic obstructive pulmonary disease (COPD) is defined as a group of lung diseases characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible (World Health Organization, 2013). India contributes very significantly to mortality from COPD 102.3/100,000 and 6,740,000 Disability adjusted life years (DALYs) out of world total of 27,756,000 DALYs; thus significantly affecting health related quality of life in the country. COPD is surpassing malaria and tuberculosis numbers and it is expected that the gap would get wider in the near future [1].

Patients with COPD report reduced arm exercise capacity, fatigue, and dyspnea when performing activities of daily living (ADLs) that require the use of upper limbs. [2] They acquire an irregular, superficial, and rapid respiratory pattern when performing activities requiring the upper limbs, such as tying a pair of shoes and combing hair. [2] Arm activity had been noted to result in abnormal breathing patterns during common daily activities. Dysynchronous breathing patterns in some patient with severe Chronic Airflow Obstruction with Unsupported Arm Exercise but not lower extremity activity. [3] The same authors noted that most patients with Chronic Airflow Obstruction shifted a portion of ventilatory burden from the inspiratory muscles of the rib cage to the diaphragm and to the expiratory muscles during unsupported arm activity [4]

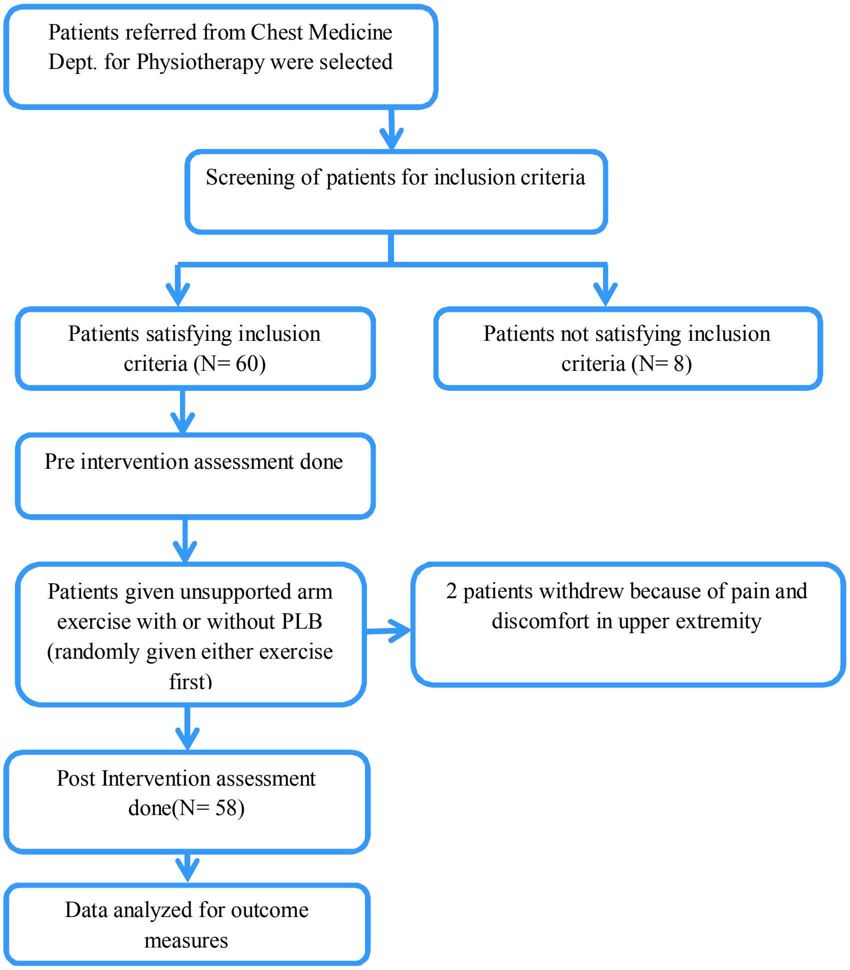
PLB works to improve expiration, both by requiring active and prolonged expiration and by preventing airway collapse. A study done by G Faager concluded that, spontaneous PLB can be a useful technique to increase walking endurance and reduce oxygen desaturation during walking in patients with moderate to severe COPD. [5] PLB during exercise and recovery results in lower post exercise respiratory rate (RR) and speeds return to pre-exercise breathlessness, compared with exercise and non-PLB. [6] However, there is a knowledge gap on the effect of PLB on unsupported upper extremity exercise.

Purpose

The present study aimed to find out the effect of PLB on Unsupported arm exercise endurance, oxygen saturation, rate pressure product, dyspnea, respiratory rate and rate of perceived exertion in patients with COPD.

Material and Methods

The study was carried out at Outpatient Pulmonary Rehabilitation Centre, Physiotherapy Department, Seth GSMC & KEMH. This is an Experimental Cross – over study approved by the ethics committee of the institute. Clinically stable patients between 30 to 70 years of age, of either gender, receiving optimal medical therapy with moderate to severe COPD according to GOLD Classification system for severity of COPD (2006) were included in this study. Patients with dyspnea at rest [Grade 4 on NYHA scale], any musculoskeletal disorder limiting arm exercises, and other cardiac disease potentially contributing to dyspnea were excluded. Also, patients included in upper extremity exercise, and who are already trained to perform PLB were excluded from the study.Patients were allowed to discontinue from the study in case of exacerbation of dyspnea or RPE on Borg's Scale during exercise of more than 5 or 6 points, upper extremity fatigue (inability to continue further), pain in arms and unwillingness to continue. A written informed consent was obtained after explaining the procedures.



Baseline parameters were recorded. Patients were randomly allocated to either Session (A) – no PLB, or Session (B) – with PLB first. They were trained to perform pursed lip breathing for Session (B). Both the sessions were completed in their two consecutive visits with a gap of maximum 3 days.

Session (A): Patients were in sitting position. The following set of unsupported arm exercises were given;

1. Bilateral shoulder flexion and extension.
2. Bilateral shoulder abduction and adduction.
3. Unilateral shoulder circumduction on right and left side.

Patients performed 5 repetitions of each exercise on rhythmic beats at frequency of 1 per two seconds with spontaneous breathing (SB). The protocol was repeated until patient requests to stop. A mouth piece was used to prevent pursed lip breathing. Post exercise parameters were recorded immediately after, 3 minutes, and until recovery to the baseline. Total number of repetitions and time taken were recorded.

Session (B): Subjects performed the same exercises in the same sequence and the difference was performance of pursed lip breathing during the exercise. Post exercise parameters were again recorded immediately after, 3 minutes, and until recovery to the baseline

The following outcome measures were recorded:

1. Upper extremity exercise endurance
2. SpO_2
3. Rate pressure product
4. Respiratory rate
5. Dyspnea on Borg's scale
6. Rate of perceived exertion on Borg's scale

Result

Data was analysed using GraphPad Prism version 6 (La Jolla, CA, USA). Normality of the data was tested using Kolmogorov-Smirnov test. As it did not follow normal distribution, Wilcoxon matched-pairs signed rank test was done to compare means of any two variables. Data of 58 subjects was analysed. Statistical significance was set at $p < 0.05$. The power of sample size for hypothetical difference between pre and post SpO_2 values with PLB was determined using GraphPad StatMate 2.0.

The power of the experiment was computed using paired t-test, standard deviation difference of pre and post SpO_2 values with PLB (1.27), and significance level ($\alpha = 0.05$). [24] The sample size in our experiments had a 95% power to detect a smallest average difference of 0.60 between pairs with a significance level of $\alpha=0.05$ (two-tailed). [24]

The demographic data of the subjects are shown in Table 1 and results in table 2(a) and 2(b)

Table 1: Demographic information of the subjects

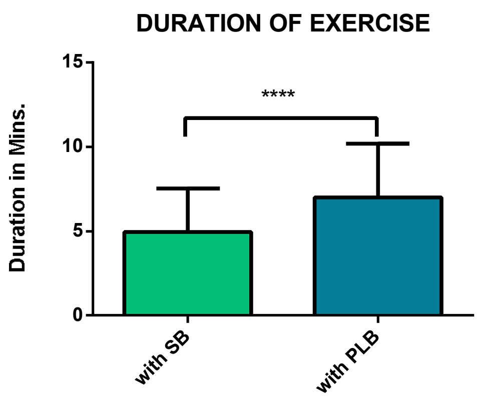
	Maximum	Minimum	Mean	Standard Deviation		Total (%age)
Age (years)	60	42	56	5.3		
Gender					Males	45 (77.58%)
					Females	13 (22.41%)
Height (cms)	168	145	159	6.6		
Weight (kgs)	102	31	53	12		
BMI (kg/m^2)	36.57	11.52	20.85	4.44	under wt.	13 (22.41%)
					Normal	28 (48.27%)
					Over wt.	6 (10.34%)
					Obese	10 (17.24%)
% FVC (%)	137.12	33.96	68.85	20.83		
%FEV_1 (%)	78.64	25.36	49.42	15.28		
FEV_1/FVC	0.69	0.19	0.51	0.12		
GOLD Classification					Moderate	33 (56.89%)
					Severe	25 (43.10%)

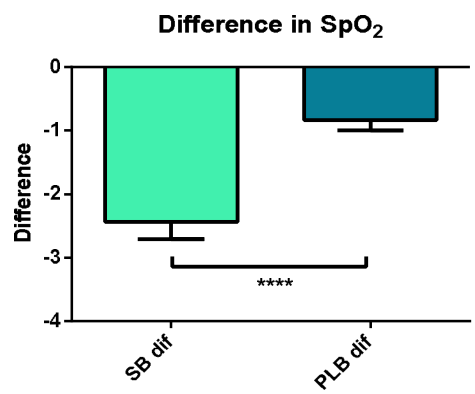
Table 2(a): Number of sets and duration

	SB	PLB	Test used	P value	Sig.
No. of sets	7.45 ± 0.50	10.52 ± 0.62	Wilcoxon Signed rank test	< 0.0001	****
Duration	4.97 ± 0.33	7.01 ± 0.41		< 0.0001	****

Table 2(b): SpO2, Rate pressure product, Respiratory rate, Dyspnea, and Rate of perceived Exertion

	SB (Mean ± SEM)		PLB (Mean ± SEM)		SB Dif (Mean ± SEM)	PLB Dif (Mean ± SEM)	P value	Sig.
	Pre	Post	Pre	Post				
SpO_2	97.1 ± 0.20	94.6 ± 0.33	97.19 ± 0.20	96.36 ± 0.27	-2.43 ± 0.27	-0.82 ± 0.16	<0.0001	****
RPP	10437 ± 217.6	13091 ± 361.6	10359 ± 220.6	12372 ± 358.8	2654 ± 281.3	2012 ± 286.1	0.0008	**
RR	25.69 ± 0.65	33.28 ± 0.69	25.34 ± 0.73	29.79 ± 0.74	7.58 ± 0.78	4.44 ± 0.64	<0.0001	***
Dyspnea	0.64 ± 0.11	3.51 ± 0.22	0.56 ± 0.11	2.43 ± 0.21	2.87 ± 0.19	1.87 ± 0.19	<0.0001	***
RPE	0.56 ± 0.12	3.41 ± 0.23	0.49 ± 0.10	2.50 ± 0.21	2.84 ± 0.24	2.01 ± 0.21	<0.0001	***





Discussion

Pursed lip breathing is a pattern of breathing employed spontaneously by many patients with chronic obstructive pulmonary disease during physical activity. It appears that this technique improves control of breathing and for many, but not all patients, relieves dyspnea.

Pursed lip breathing is used in most pulmonary rehabilitation. In this study we have excluded the effect of spontaneously employed PLB during the activity and therefore considered the clinical benefits in this population.

The data of 58 patients was analyzed as two patients withdrew because of pain and discomfort in the upper extremity. Power test was conducted for all parameters, using standard deviation of the mean difference between pre and post values. Results for all power tests demonstrated 95% power with the current 58 sample size. [7]

The most important finding was -most of the patients could do more number of sets of unsupported arm exercise and for longer duration with less decrease in oxygen saturation when using PLB compared with SB. Also, there was a significant difference with regards to respiratory rate, rate pressure product, rate of perceived exertion and dyspnea when using PLB; the difference was higher with spontaneous breathing for all of these parameters when compared to pursed lip breathing (Tables 2a and 2b).

Upper limb activities commonly require unsupported arm exercise, which poses a unique challenge for patients with COPD whose upper limb muscles also may be required to act as accessory muscles of respiration. Hence, the focus of the study was on how pursed lip breathing may influence unsupported arm exercise endurance. Also, these unsupported arm exercises reflect the activities of daily living with an average intensity on patients with COPD, hence endurance testing was chosen instead of any incremental upper limb endurance test that correlates with maximum of physical capacity.

All patients in the present study employed pursed lips breathing volitionally when they performed the unsupported arm exercise in one of the sessions. In order to prevent the use of pursed lip breathing during session (A), patients held a mouthpiece. This type of breathing was the closest breathing pattern could be obtained to simulate normal open mouth breathing. Since the device was placed inside the mouth and just prevented the patients from closing the mouth it should cause no significant change in anatomical dead space. Nevertheless, such a device might evoke a sensation of uncomfortable breathing or discomfort in holding it. However, none of the patients reported such inconvenience.

The present study showed a significant improvement in the number of sets of unsupported arm exercise and the duration of exercise with PLB. Breathing techniques, such as PLB may reduce progressive hyperinflation in severe COPD. [8,9] Gandevia B. observed that in patients with severe lung emphysema and tracheobronchial collapse, the expired volume during a relaxed expiration increased, on average, by 20% in comparison to a forced expiration. This suggests that relaxed expiration produces less 'air trapping' which resulted in a reduction of hyperinflation. [10] Also, there is a thoracoabdominal dyssynchrony associated with the shift of respiratory work to the diaphragm during unsupported arm exercise due to decreased participation of accessory muscles of respiration in ventilation. [3,4] In addition, since the muscles that move the arms and stabilize the trunk are attached to the rib cage, this increases chest wall impedance, which limits the ability to increase tidal volume during arm activities. [11]

A study suggests that transverse abdominis is continually and increasingly active during an upper limb task in both younger and older asymptomatic subjects. [12] These impairments in ventilatory mechanics result in the termination of arm exercise at low workloads for people with COPD compared to healthy subjects. [13] Pursed lip breathing leads to increased rib cage and accessory muscle recruitment during inspiration and expiration, increased abdominal muscle recruitment during expiration, decreased duty cycle of the inspiratory muscles and respiratory rate, and improved SpO_2. In addition, PLB resulted in no change in pressure across the diaphragm and a less fatiguing breathing pattern of the diaphragm. Self-imposed rhythmic respiration with PLB may favorably affect coordination of respiratory muscle recruitment. [14]

All these changes would lead the COPD patients to breathe more efficiently and consume less oxygen which might have improved the endurance of exercise.

G. Faager et al found that when spontaneous pursed lips breathing was used, patients walked on an average for 37 seconds (16%) longer than when pursed lip breathing was prevented[5]. Fateme S et al found that PLB assisted the patients towards optimal capabilities in carrying out their activities of daily living and improved their overall quality of life. [15]

In patients with COPD, there is a fall in oxygen saturation during exercise. Soguel Schenkel N et al. concluded that daily activities, such as walking, washing, and eating, are associated with transient oxygen desaturation in patients with moderate-to-severe COPD, even without marked resting hypoxemia. [16] The causes for exertional desaturation in patients with COPD are multifactorial with ventilation-perfusion mismatching, diffusion-type limitation, shunting, and reduced oxygen content of mixed venous blood all contributing to some degree. [17] Unsupported arm exercise is associated with dyssynchronous breathing patterns and diaphragm loading and a drop in oxygen saturation of blood is expected. Pursed lip breathing reduces respiratory rate, dyspnea and arterial carbon dioxide tension, and improves tidal volume and oxygen saturation in resting conditions. [18,14] This is supported by E H Breslin who found that the changes in respiration with PLB resulted in improved ventilation denoted by the increase in VT and SpO_2. [14] We found that the drop in oxygen saturation was 1.6% more with SB as compared to PLB.

Rate pressure product is a direct indication of the energy demand of the heart and thus a good measure of the energy consumption of the heart. Our study showed that the change in RPP with SB was higher as compared to PLB. Individual differences in HR and SBP were also found to be significantly higher for SB as compared to PLB. There is abundant evidence of abnormal cardiovascular responses to exercise in COPD. Pulmonary vascular resistance and pulmonary artery pressures are increased; the right ventricular ejection fraction fails to increase even though right ventricular end-diastolic volume is increased [19, 20]; and left ventricular end-diastolic, endsystolic and stroke volumes are decreased [21], presumably secondary to the failure of the right ventricular ejection fraction to increase, or competition for space between the two sides of the heart within the pericardium. The exercise limitation in chronic obstructive pulmonary disease occurs as a result of the dynamic interaction between disordered right heart function and ventilation [22]. Unsupported arm exercises accentuate the exercise limitation. Pursed lip breathing on the other hand, reduces the cost of breathing. AY Jones in a comparison of the oxygen cost of breathing exercises and spontaneous breathing in patients with stable chronic obstructive pulmonary disease found that the mean VO_2 was consistently lower during PLB than during spontaneous breathing. [23] This reduces the oxygen demand and in turn the myocardium is less taxed which might be the reason behind reduced change in RPP with PLB.

Dyspnea reflects afferent activity from muscle spindles and tendon organs associated with length tension and force velocity characteristics of the respiratory muscles and chemoreceptor stimulation; which contribute to an uncomfortable urge to breathe. [24] Exercise-induced dyspnea has been associated with the increased intensity and duration of respiratory muscle force generation as well as with an increased amplitude and velocity of muscle shortening. [24] Dynamic hyperinflation or an increase in the end-expiratory lung volume (EELV), as typically occurs during exercise in patients with COPD, can reduce the pressure-generating capacity of the respiratory muscles and has been associated with increased breathing effort and dyspnea [25, 26]. Respiratory rate is also a determinant of ventilatory efficiency.

Bianchi (2004) found changes in end expiratory volume of chest wall (VCWee) are related to baseline airway obstruction but not to hyperinflation (FRC). By lengthening of expiratory time and total time of respiratory cycle, PLB decreases VCWee and reduces breathlessness. [27] Several researchers reported that PLB and some other breathing exercises could prolong expiration and would decrease the EELV, leading to lower respiratory rate and higher tidal volume. [28, 29] Present study, reports a less increase in respiratory rate post exercise with PLB and a mean fall of 1 unit in dyspnea on Borg Scale with PLB which was statistically significant. Reis AL in 2005 recommended a minimally clinically important difference of 1-unit for the Borg scale; hence the improvement in dyspnea is clinically significant[30]. However, Spahija[31] and Mueller [28] have found variable effects of pursed lip breathing on dyspnea during exercise. G Faager found no significant differences in rated degree of dyspnea while walking with PLB. [5] Garrodl et al. concluded that a significant reduction in respiratory rate occurred at the end of the walking test and that recovery time was shorter when nonspontaneous PLB was used and there was no difference in dyspnea. [6]

Rate of perceived exertion was also found to be scored significantly less with PLB as compared to SB by the patients (mean difference being 0.83) though it might not be clinically significant.This is consistent with the findings of G Faager who did not find significant difference between scores of leg fatigue on Borg scale. [5]

Conclusion

Pursed lip breathing is a useful technique to increase unsupported arm exercise endurance and reduce oxygen desaturation during exercise in patients with moderate to severe chronic obstructive pulmonary disease.

Clinical implication:

- Unsupported arm exercise is typical of activities of daily living in patients with COPD and the changes seen in these exercises with PLB may be of greater clinical significance. Hence, PLB should be incorporated with unsupported arm exercises.
- Training patients for unsupported arm exercise with PLB would give better outcomes and eventually improve their quality of life.

Limitations

The effect of PLB on unsupported arm exercise is studied in sitting position only, while many of the activities of daily living require arm movements in standing or while walking. This study shows the effect of volitionally performed pursed lip breathing on unsupported upper extremity exercises hence the effect of spontaneously performed PLB on the same can be studied. The actual oxygen consumption can be assessed. Also, the effect of PLB on activities of daily living can be studied which would be more beneficial to assess functional impairments.

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