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Changes in Balance after Rehabilitation Program in Patients with COPD and in Healthy Subjects

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Abstract

Background: Deficits in balance are increasingly recognized among the important secondary impairments in COPD.

Aims: The aim of this study was to examine the effect of rehabilitation program on balance in COPD patients compared to healthy subjects.

Methods: A prospective longitudinal study was conducted. The balance of COPD patients and healthy subjects was assessed by the Timed up and go test (TUG), the Tinetti test, the Berg Balance Scale (BBS) and the Unipodal stance test (UST) test with measurement of balance confidence using ABC scale. Exercise tolerance was determined from the 6-minute walk test (6MWT).

Results: We noted a significant difference between the two groups in all measures of balance at baseline. Following the period of PR, it was found no significant difference in the confidence of COPD patients and healthy subjects in their balance. However, for the TUG, BBS score and UST, a statistically significant improvement in the COPD group was found ($p<0.001$). There is also a modest increase score test TINETTI in this group ($p<0.01$) but not for the control group after the period of PR.

Discussion: Physical activity increases muscle strength and compensate the loss of muscle mass associated with age and causing deficit in balance in COPD patients.

Conclusion: PR improves scores of some balance tests, although the clinical effect of these changes remains debatable.

Keywords: Postural balance; Chronic obstructive pulmonary disease; Rehabilitation

Introduction

Chronic obstructive pulmonary disease (COPD) is one of the most important causes of death worldwide and is projected to rank third in 2020 in global burden of disease [1]. The systemic nature of this disease is increasingly recognized by the scientific community [2]. Impairments in peripheral muscle function, mobility, and exercise capacity are well established in these patients [3-6]. Thus, different systems are affected during the course of COPD: muscle damage, metabolic, nutritional, cardiovascular, neurological abnormalities and osteoporosis [4,5]. One of the main consequences for the patient with COPD is the functional limitation. Participating in the functional limitation, exercise intolerance is caused by complex mechanisms, mixing dyspnea, muscle damage, reduced activity or patient anxiety [4]. However, emerging evidence also suggests that older adults with COPD show important reductions in balance control that may be associated with an increased fall risk in this population [7]. Although information regarding postural control in persons with lung disease is limited, evidence suggests that balance deficits constitute an important secondary impairment in older adults with COPD [2,7-9]. Recently, several authors have shown that the balance of COPD patients was altered compared to healthy subjects [10,11]. According to Beauchamp et al. [11], it seems that all the elements involved in balance (receptors, integrators and effectors) are altered in patients with COPD. One study examining the impact of fatigue on physiologic measures of postural sway found that patients with COPD showed impaired static postural control after a 6MWT in the absence of visual input (eyes closed condition) [9] In addition, it was reported that standard clinical balance measures discriminated between fallers and non-fallers with COPD, despite similar pulmonary function and 6MWT distances in the two groups [7]. The American Geriatrics Society recommends exercise with balance training as an essential component of a multifactorial falls intervention strategy for community-dwelling older adults who are at risk for falling [12]. Although the exercise component of PR is considered the cornerstone of rehabilitation for patients with COPD, it is directed predominately to training peripheral muscles. Until august 2013, balance training and fall prevention strategies are not included in international guidelines for PR, and very few programs include standardized balance assessment [13]. Although exercise can improve balance and decrease fall risk in older adults, interventions that include exercises to challenge balance have greater effects on fall risk and balance [14-16]. Up to now, only two studies have been interested to show the effect of PR on the balance in COPD patients without introducing control group and one study which compared two groups of COPD patients (with or without balance training) [13]. Our study was the first that used a healthy subjects group for comparison with the COPD subjects. we have as hypothesis that muscle training has beneficial effects on postural balance of COPD subjects so reducing their risk of falling. Therefore, the aim of the study was to examine the effect of PR on balance in COPD patients compared to healthy subjects.

Methods

Study subject

Eighteen COPD subjects' males from the department of physiology of the Academic Hospital of Sousse, Tunisia, and sixteen healthy volunteers' subjects recruited in this study that lasted 12 weeks. The subjects were selected according to the inclusion criteria defined as follow: (1) COPD diagnosed by pulmonary function, (2) stable clinical condition, (3) absence of other obstructive disease (asthma, bronchiectasis) and (4) lack of recent cardiac or neuromuscular pathologies. Individuals who smoke and those who run significant response to bronchodilators, defined as an increase in FEV1 over 12% or they presented a cognitive deficiency, a neurological or locomotive condition were excluded from our study. On the basis of these criteria, 3 patients from 21 were excluded. Finally, 18 patients were included in subsequent analysis.

The sixteen healthy subjects were all nonsmokers and had no significant cardiovascular, metabolic, and musculoskeletal disorders that could limit exercise capacity.

Prior to the study, the subjects had been fully informed of the aim of the research, the protocol and the procedure of the investigation before signing a written consent, which was in accordance with legal requirements and the Declaration of Helsinki, and was approved by the Research Ethics Committee of Farhat Hached Hospital (Sousse).

Study design

Subjects were evaluated on two days at baseline and at the end of the twelve weeks training program. On the first day of the study, subjects were informed about the purpose of the study and had agreed to participate in pulmonary function test using a body plethysmograph and balance assessement was performed. On the second day, for organization reasons, subjects were assessed using a standard 6-min walk test.

Balance assessement

TUG test: The TUG was used to provide a timed measure of balance and functional mobility in our patients [17]. The test requires the patient to rise from a standard armchair, walk 3 m at a comfortable pace, walk back to the chair, and sit down. A practice trial was performed (not recorded) and individuals were permitted to use a gait aid if required. Normative data are available for elderly individuals who reside in the community [18]. The TUG has high intra- and inter-tester reliability and predictive validity for falls in community living adults [17,19]. A cut-off score of 16 s or more has been shown to predict falls in community-dwelling elderly [20].

Berg balance scale: Functional balance was measured using the 14-item BBS [21]. Activities such as transfers, reaching, turning around and single legged stance were graded on a scale ranging from 0 (unable/unsafe) to 4 (independent/efficient/safe), with higher scores indicating greater balance control. The measurement derived using the BBS has demonstrated internal consistency, intra-rater and inter-rater reliability, content validity, construct validity and predictive validity for determining fall risk in older adults [19]. A cut-off score of 46 and below has been identified as a useful score to successfully identify those at risk of falling [22,23]. Age- and gender specific scores are available in healthy populations [18].

Unipedal stance test: Patients chose the leg they preferred for the test. They were instructed to keep their legs from touching and to maintain unipedal stance for as long as possible. "Failure" was defined as shifting the stance foot or placing the lifted foot on the floor. The test was stopped and considered normal if the UST reached 45 seconds [24]. Although some investigators have used 30 seconds as a standard [25], Briggs and associates [26] believed that a 45-second time limit would reduce any ceiling effect and provide a more normal distribution of times. Subjects were given three trials, unless they achieved 45 seconds on the first or second trial, finally, the best time was taken.

Tinetti test: The Tinetti is a reliable clinical test for measuring balance and gait in older individuals. It has 16 items divided into two sections: balance (9 items) and gait (7 items), for a total score of 28. Individuals scoring less than 26 points have a risk for falling [27-30].

ABC scale: The ABC scale requires patients to indicate their confidence in performing 16 activities without losing their balance or becoming unsteady on an 11-point scale (0%– 100%) [30]. Each item describes a specific activity that requires progressively increased balance control. Higher scores indicate higher balance confidence or less fear of falling. The ABC scale has good test-retest reliability, internal consistency, and predictive capacity for falls in older adults who reside in the community [19,28]. A change of 13% has been shown to reflect an MDC for this measure [29].

Pulmonary function test: All subjects underwent a pulmonary function test with determination of forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC). Their measurement was performed using a constant volume plethysmograph (ZAN 500 Body II Meßgreräte ZAN GmbH, Germany) according to the "European Respiratory Society" recommendations [30].

Six-Minute walking test: The 6MWT was performed before and after the rehabilitation program. It was conducted in accordance with international recommendations [31]. Subjects were instructed to walk at their own maximal pace along a hospital corridor which is 40m long as far as possible for 6 min. No encouragement was given, and subjects were informed each minute of the time remaining. The subjects were allowed to stop, but they could start again, if possible. Chairs were placed along the corridor.

Dyspnea was measured using Borg scale before the start of 6MWT and at the end of the test. Heart rate (HR) and Oxygen saturation (SO2) were recorded continuously throughout the 6MWT by portable Spiropalm COSMED. At the end of the 6MWT, the total covered distance was recorded.

Intervention: PR

All the subjects were required to participate in the rehabilitation program 3 days per week during 12 weeks. The program was monitored by health professionals. It involves setting the intensity of effort on a target heart rate corresponding to 60-70% of maximum

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heart rate reached during the six minutes walking test. This intensity of training does not lead to excessive symptoms of dyspnea and fatigue. During the sessions, the subject can monitor the intensity of training by means of a cardiofrequency meter (Polar, S810) which alarms are set to + - 5 beats per minute around the target heart rate.

The training consists of a five minute warm-up followed by 10 minutes of work (cycling or walking on a treadmill) and five minutes of active recovery, repeated over a 45 minutes session. Then, the subjects performed strength exercises (legs and arms) for 30 minutes. Finally, the session ends with relaxation exercises and stretching.

The patients also received a therapeutic education program of two sessions of 30 minutes/week of seminars and discussions covering the following topics: relaxation, disease education, benefits advice, energy conversation, medication advice, chest clearance, and breathing control techniques [32].

Statistical analysis

The results of the study are presented as mean ± standard deviation (SD). The nonparametric Mann–Whitney U test was used to compare baseline characteristics and training related changes in patients with COPD and healthy subjects, Wilcoxon's matched pairs test was used to assess the effect of training within the group. The statistical program Statistica was used for the analysis (Statistica Kernel Version 10; Stat Soft, France). The level of significance was set as P<0.05

Results

Eighteen COPD patients and sixteen healthy subjects completed all training and evaluation sessions.

Anthropometric characteristics and pulmonary function parameters of patients with COPD and healthy subjects before and after the rehabilitation program are provided in Table 1. Body mass indexes (BMI) were different in both groups. The main differences were observed in pulmonary function where the patients with COPD showed moderate to very severe airflow obstruction. There was no significant change in FEV1 and FVC in the two groups after rehabilitation program.

	Healthy subjects (n = 18)		Patients with COPD (n = 16)	
	Before PR	After PR	Before PR	After PR
Age, years	58,06 ± 2,91	-	56,22 ± 4,12	-
BMI, kg.m-2	26,16 ± 1,59	26,36 ± 1,68	26,47 ±1,78‡‡‡	26,07 ± 1,58§§§
FEV1 ,L	2,78 ± 0,16	2,81 ± 0,17	1,27 ± 0,10‡‡‡	1,26 ± 0,09§§§
FEV1, % Predicted	90,27 ± 5,76	91,90 ± 3,87	49,75 ± 2,56‡‡‡	49,63 ± 2,49§§§
FVC, L	3,19 ± 0,13	3,22 ± 0,11	2,07 ± 0,16‡‡‡	2,11 ± 0,18§§§
FVC, % Predicted	88,56 ± 1,93	89,06 ± 2,26	51,11 ± 2,84‡‡‡	51,04 ±2,96§§§
FEV/FVC ratio	87,17 ± 6,13	87,49 ± 5,98	61,54 ± 7,91‡‡‡	60,22 ± 7,02§§§

Table 1: Anthropometric characteristics and pulmonary function parameters of healthy subjects and patients with Chronic Obstructive Pulmonary Disease before and after rehabilitation program. Unit: Mean ± SD. Notes: Comparisons between patients with COPD and healthy subjects before rehabilitation program: ‡‡‡P< 0.001; Comparisons between patients with COPD and healthy subjects after rehabilitation program: §§§P< 0.001. COPD: Chronic Obstructive Pulmonary Disease; BMI: Body Mass Index; FEV1: Forced Expiratory Volume in One Second; FVC: Forced Vital Capacity; PR: Pulmonary Rehabilitation.

The measures in tests of balance before and after the RR program are presented in Table 2. We noted a significant difference between the two groups in all measures of balance at baseline. Following the period of PR, it was found no significant difference in the confidence of COPD patients and healthy subjects in their balance. However, for the TUG, BBS score and UST, a statistically significant improvement in the COPD group was found (p <0.001). There was also a modest increase in TINETTI test scores in this group (p <0.01) but not for the control group after the period of PR.

The 6MWD increased significantly after the rehabilitation program in COPD group and healthy subjects (52 meters; P <0.001, 16 meters ; P <0.01 , respectively), as shown in Table 3. The dyspnea and heart rate at the peak of 6MWT decreased significantly after the rehabilitation program in both groups (P < 0.01). Any change in SO2% was marked at the peak of 6MWT in both groups compared with values before rehabilitation program.

	Healthy subjects (n = 18)		Patients with COPD (n = 16)	
	Before PR	After PR	Before PR	After PR
TUG , sec	12,47 ± 0,80	11,95 ± 0,82**	15,70 ± 0,74‡‡‡	12,63 ± 0,83†††§
TINETI score	26,88 ± 0,96	27,13 ± 0,81	25,33 ± 0,97‡‡‡	26,39 ± 0,70††§
BBS score	51,31 ± 1,40	52,38 ± 1,20 *	46,17 ± 1,79‡‡‡	50,22 ± 1,11†††§§§
ABC score , %	86,63 ± 5,68	88,19 ± 5,15	71,44 ± 6,84‡‡‡	72,89 ± 3,98§§§
UST, sec	35,25 ± 7,24	36,88 ± 6,20 *	24,50 ± 2,28‡‡‡	28,56 ± 3,09†††§§§

Table 2: balance scores before and after rehabilitation programin healthy subjects and in patients with COPD.. Unit: Mean ± SD, Notes: Notes: Comparison in healthy subjects with values before and after rehabilitation program, *P<0.05, **P<0.01,; Comparison in patients with COPD with values beforeand after rehabilitation program, ††P<0.01, †††P<0.001; Comparison between patients with COPD and healthy subjects before rehabilitation program; ‡‡‡P<0.001;Comparison between patients with COPD and healthy subjects after rehabilitation program, §P<0.05, §§§P<0.001. TUG: Timed Up and Go test; BBS: Berg Balance Scale; ABC: Activity Balance Confidence; UST: Unipedal Stance Test; PR: Pulmonary Rehabilitation.

Discussion

This study aims to analyze the effect of a pulmonary rehabilitation program on postural balance in COPD patients and healthy subjects. The rehabilitation program that we used was well tolerated by most patients. Its benefits on dyspnea, exercise tolerance and quality of life of COPD patients have been clearly shown [33]. No adverse effects were noted during the training program.

The 6MWT is easy to perform, reproducible, well standardized and patients with COPD walk at a speed close to their maximum capacity [34]. The 6MWT and the incremental cardiopulmonary exercise test (also used in COPD evaluation in many studies) are not interchangeable exercise tests from a physiological point of view. However, from the clinical point of view, when the 6MWT is performed in a standardised manner and verbal incentive is used, it shows the maximum sustainable exercise capacity and effi ciently refl ects the maximum capacity obtained from the cycle ergometer [35].

Our results showed reduced scores in all measures of balance in patients with COPD compared with healthy subjects. Significant differences of 3.2 seconds in TUG, 1.5 points in the TINETTI test, 5.16 points in the BBS score, 15.19 % in the ABC scale and 10.7 seconds in the UST were observed before the start of PR. These results are consistent with previous studies that have put in evidence the alteration of postural balance in COPD patients [36,37].

	Healthy subjects (n = 18)		**Patients with COPD (n = 16)**	
	Before PR	**After PR**	**Before PR**	**After PR**
6MWD, m	668,50 ± 36,50	684,38 ± 35,72**	474,11 ± 24,3‡‡‡	526,94 ± 23,7†††§§§
6MWD, %	89,63 ± 2,78	92,31 ± 3,82**	72,82 ± 5,42‡‡‡	83,13 ± 6,02†††§§§
SO2, %				
Rest	96,06 ± 1,18	96,38 ± 0,89	94,00 ± 1,68‡‡‡	93,89 ± 1,91§§§
Peak	95,25 ± 1,34	95,44 ± 1,21	93,00 ± 2,38‡‡	92,06 ± 2,58§§§
Dyspnea				
Rest	1,81 ± 0,66	1,25 ± 0,45*	3,33 ± 0,84‡‡‡	1,67 ± 0,49†††§
Peak	3,19 ± 1,05	2,06 ± 0,93**	5,06 ± 0,94‡‡‡	3,67 ± 1,03†††§§§
HR				
Rest	72,13 ± 3,72	71,56 ± 2,97	73,78 ± 3,93	72,22 ± 4,33†
Peak	89,69 ± 3,09	87,63 ± 3,52**	132,78 ± 6,80‡‡‡	128,89 ± 5,35††§§§

Table 3: Six-minute walking test parameters before and after rehabilitation program in healthy subjects and in patients with COPD. Unit: Mean ± SD. Notes: Comparison in healthy subjects with values before and after rehabilitation program, *P<0.05, **P<0.01, ***P<0.001; Comparison in patients with COPD with values beforeand after rehabilitation program, †P<0.05, ††P<0.01, †††P<0.001; Comparison between patients with COPD and healthy subjects before rehabilitation program; ‡‡‡P<0.001;Comparison between patients with COPD and healthy subjects after rehabilitation program, §P<0.05, §§P<0.01, §§§P < 0.001. 6MWD: Six-Minute Walking Distance; HR: Heart Rate; SO2: Oxygen Saturation; PR: Pulmonary Rehabilitation.

The first investigation in this area was conducted by Grant and colleagues, who reported that nearly half of a sample of 203 older individuals with advanced COPD exhibited deficits in motor speed, strength and coordination, compared to controls [38]. Recent work has also considered the influence of balance on fall risk in COPD. Beauchamp et al. [7] investigated clinical measures of balance and the retrospective incidence of falls in 39 older adults with COPD (FEV1 42% predicted.The author noted that 46% (n = 18) of subjects reported at least one fall in the preceding year and that performance on clinical balance tests (Berg Balance Scale and Timed Up and Go) discriminated between self-reported fallers and non fallers. The underlying mechanisms for the increased postural sway observed in people with COPD are currently unknown. Although vestibular deficits are unlikely [39,40], somato sensory deficits could contribute to impaired balance in this population [41].

The improvement of TUG score after PR was 3.07 sec in COPD patients (vs. 0.52 sec in the control group). This significant improvement is superior to the minimum clinically important difference (MCID) for the TUG evaluated by Wright et al. [42] by three different methods for patients with hip osteoarthritis: the MCID is estimated between 0.8 and 1.4 seconds. To our knowledge, no study has described the MCID in patients with COPD. The improvement of TUG score in our study was higher than that found by the two previous studies of Beauchamp and Pichon (1.5 sec in both studies) [43,44].

We also noted that patients included in our study improve significantly their Tinetti score (no significant change for the control group). This improvement (1.05 points, 4.18%) is close to the results found in a previous study with a group of 17 COPD patients after a program of exercise training [44]. A study by Lin et al. [45] showed an increase of the Tinetti test score by 1.8 points after a practice of Tai Chi in elderly subjects. However, the change seems small and there is no tool showing clinically interesting changes for this test.

The significant improvement in BBS score in the COPD group was superior to that in control subjects (4.05 points vs. 1.07 points). This increase seems important although there is no published work that showed the minimum detectable change (MDC) value for this score. However, MDC scores have been reported for these measures in community-dwelling older adults and other populations with balance impairment[46]. A recent investigation of elderly patients undergoing general physical rehabilitation found that the MDC for BBS scores depended on the patient's starting score [46].

In accordance with previous study of Beauchamp, PR did not have an effect on fear of falling, measured using the ABC scale in both groups. Similarly, Pichon showed that participants' confidence on their balance does not vary significantly using an EVA scale after training [43].

The UST score increased significantly in both groups (1.6 vs. 4sec sec respectively), this improvement is inconsistent with the French study of Pichon which found no significant increase after 21 days of exercise training in completed hospitalization. Esculier et al. [47] found that the duration of unipodal stance increased after a period of training in patient with Parkinsons disease. The Unipodal Stance Test is a simple test and a good predictor of fall in older people [48].

Along the same lines, Lord et al. [49] showed that among elderly fallers with an average age of 71 years, physical activity based on balance and strength training improves the static balance and reduced falls. The improvement of static balance could come from an increase in muscle strength through resistance exercises [49]. Indeed, Sudarsky [50] and Nashner [51] demonstrated that postural instability is due to a decrease in muscle strength of the lower limbs. This decrease may result from a shift of the center of gravity in front of the axis of the ankles, which promote balance problems and falls [51]. The increase in muscle strength would put the center of gravity to the axis of the ankles, giving a better balance to seniors.

Physical activity increases muscle strength and compensate the loss of muscle mass associated with age [52]. Moreover, a resistance training increases the strength but also the speed of muscle contraction [53]. The training decreases the activation of antagonistic muscles [54] and improves activation of restabilisators muscles (especially the core muscles) [55] when they are solicited by an imbalance. The practice of physical activities can change postural strategies by developing the ability to quickly switch from the use of a sensory system to another or strengthening a preference for use of a particular type of information [56].

Our results showed no significant change in weight and body mass index in both groups. The short duration of the protocol can explain this stability. Studies that use long periods of training (over 6 months) indicated a decrease in the weight of obese subjects COPD [57]. As demonstrated in other studies [58], no significant modification of pulmonary function was marked after a training program. The six-minute walking test results showed a significant increase in walking distance after the rehabilitation period. Some of studies have shown that the distance covered in six minutes increased after a program of rehabilitation training, the recent study of Ben Cheikh Rejbi et al. [59] clearly showed an increase in this distance in Tunisian COPD patients after pulmonary rehabilitation program. A significant effect of individualized training on dyspnea peak and the maximal heart rate in 6MWT was shown after rehabilitation program. This could be explained, firstly by improved physical conditions and by very good response to exercise, which supports a decreased sensation of dyspnea [33], Secondly, by some physiological changes, like better cardiac adaptation, decrease in lactic acid production and reduction in metabolic cost of exercise [60].

A major limitation of this study was the small number of included subjects. Also, we evaluated the ability of balance in our population without investigating the history of falling before, during and after the period of PR. In addition, the short period of training may be a reason of the poor improvement of some parameters. Finally, we only investigated balance control and exercise capacity immediately after rehabilitation. It is not clear how long this improvement will last.

Conclusion

Pulmonary rehabilitation has an improvement effect on postural balance in patients with COPD. Balance scores after PR are higher in these patients compared to control group, even there is no significant change in balance confidence in the two groups. Future studies higher number of subjects are needed to better show the clinical effects of pulmonary rehabilitation on various parameters of balance. In addition, the integration of specific balance training in PR in COPD patients remains to be explored.

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