Title

Is there a relationship between dyspnea with exercise in the laboratory and dyspnea with activities of daily living after exercise training?

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Publication Date

1995

Peer reviewed|Thesis/dissertation

Is There a Relationship Between Dyspnea with Exercise in the Laboratory and Dyspnea with Activities of Daily Living after Exercise Training?

by

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THESIS

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in

Nursing

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA

San Francisco

Date University Librarian

Degree Conferred: . . . . . .

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Exercise training (ET) has consistently been shown to improve exercise performance and decrease measures of dyspnea with laboratory exercise in patients with chronic obstructive pulmonary disease (Cockroft, Saunders, & Berry, 1981; McGavin, Gupta, Lloyd, & McHardy, 1977; Punzal, Ries, Kaplan, & Prewitt, 1991; Swerts, Kretzers, Terpstra-Lindeman, Verstappen, & Wouters, 1992; Webb, Bertley, McGuire, Samis, & O'Donnell, 1994). Recent studies have emphasized the reduction of dyspnea with activities of daily living (ADLs) as an important outcome after pulmonary rehabilitation, focusing on symptom management and improved quality of life as the foremost goals of treatment (Goldstein, Gort, Stubbing, Avendano, & Guyatt, 1994; Guyatt, Berman, Townsend, Pugsley, & Chambers, 1987; Reardon, Patel, & ZuWallack, 1993; Reardon et al., 1994; Simpson, Killian, McCartney, Stubbing, & Jones, 1992; Toshima, Kaplan, & Ries, 1990; Vale, Reardon, & ZuWallack, 1993; Wijkstra et al, 1994). A number of these studies, while demonstrating improvement in exercise performance and quality of life with rehabilitation, have shown no significant relationship between exercise performance in the laboratory and dyspnea at home (Reardon et al., 1993; Wijkstra et al., 1994). However, one study has reported a significant relationship between the change in dyspnea at maximal workload on the treadmill and the change in dyspnea with activities as measured with the transitional dyspnea index (TDI) after a comprehensive rehabilitation program (Reardon et al., 1994). Measurements of exercise performance in the laboratory may not be as important as measures of the dyspnea experienced with laboratory exercise for assessing the effects of rehabilitation. In an attempt to further understand the relative importance of laboratory measures of exertional dyspnea, the relationship between dyspnea with exercise in the laboratory and dyspnea with ADLs was examined before and after an exercise training program.

Specifically, it was determined, through secondary analysis of data gathered for a larger study, whether the rating of dyspnea during laboratory exercise is reflective of dyspnea in the home environment. In addition, laboratory measures were examined to establish which were the best predictors of dyspnea with ADLs in the home. Outcome measures included exercise performance, dyspnea ratings during and following exercise, and dyspnea with ADLs.

Methods

Sample

Prior to the evaluation of subjects, approval of the research protocol was granted by the UCSF Committee on Human Research. Patients with Chronic Obstructive Pulmonary Disease (COPD) who reported that their daily activities were limited by dyspnea were recruited at our medical center and from the surrounding community. Subjects were required to be medically stable for at least 30 days, and have pulmonary function compatible with moderate to severe COPD as determined by a Forced Expiratory Volume in One Second (FEV1) < 60% of predicted and an FEV1/Forced Vital Capacity (FVC) ratio < .6 after 3 puffs of albuterol. Subjects were also required to have a resting arterial partial pressure of oxygen (PaO2) > 60 mm Hg. Volunteers with active heart disease or other concomitant conditions that might have interfered with the ability to exercise were excluded, as were those who had been involved in formal pulmonary rehabilitation and/or maintenance programs during the preceding six months.

A total of 313 volunteers were interviewed for participation in the original study. Of these, 223 were excluded before exercise testing because they either did not meet the inclusion criteria, lived too far from the medical center or were not interested in participating. Of the 90 subjects who completed screening tests, 32 failed to meet the inclusion criteria. Eight of the remaining 58 patients failed to complete the study: 4 because of hospitalization; 2 because of failure to keep appointments; 1 due to illness in his family and 1 because of death prior to completion of the study. Of the remaining 50 participants, 48 completed the requisite evaluations for this analysis. The sample was comprised of an equal number of men and women, with an average age of 66.8 years. All participants suffered moderate to severe COPD with a mean FEV1 of .9L (38% predicted). Demographics for the total sample used in this analysis are summarized in Table 1.

Exercise Training Program

Subjects were randomly assigned, as part of the original study, to one of two treatment groups. Both groups participated in treadmill training 2-3 times per week for 4-6 weeks (total 12 sessions). In addition, all subjects were instructed to walk at home as often as required, usually 1-2 times per week to maintain a frequency of 4 walks weekly. The "coached" group (n = 23) received instruction on relaxation and breathing strategies prior to treadmill training, and were encouraged by the nurse coach to use these techniques during treadmill exercise. Coaches assisted these subjects with individual goal setting, and provided encouragement, feedback, and physical support during exercise training. The "monitored" group (n = 25) received only basic instruction on treadmill walking, and exercised at self-selected levels of speed

Table 1

Sample demographics. N = 48.

Demographic Variable	Frequency(%)	Mean ± SD
Gender		
Males	24(50)	
Females	24(50)	
Age (yrs.)		66.8 ± 8.2
FEV1 (L)		0.9 ± 0.2
FEV1 (% pred)		38.0 ± 10.3
FEV1/FVC (%)		41.9 ± 11.2
Smoking History	46(96)	
No. of years smoked		38.0 ± 14.2
Severity§		2.9 + 1.0

Note. FEV1 = Forced Expiratory Volume/1 second (L/sec)

FVC = Forced Vital Capacity (L)

§Severity = ATS Severity Score (range = 0-4)

and grade. If questioned further about desired performance, the nurse provided American Heart Association (AHA) recommendations for exercise training. Because there were no significant differences in any of the exercise or dyspnea variables measured between these groups, before or after exercise training, the groups have been combined for this analysis.

Procedure

Subjects came to the laboratory for baseline physical examination and spirometry, completed questionnaires and two 6 minute walks (6MW), and received instruction in the use of visual analog scales (VASs). Eligible subjects returned for incremental treadmill testing (ITT). Those who completed at least 3 minutes of warm-up at one mile per hour and one additional 90 second stage of exercise without cardiac or musculoskeletal problems were asked to participate in the study. All subjects then underwent exercise training as described and returned for repeat ITT, 6MW and questionnaires.

The 6MW was conducted over a 100 foot level course in a corridor with a nurse in attendance. Subjects were instructed to "cover as much ground as possible in 6 minutes so that at the end you feel you could not have covered more distance". No other encouragement was given. Oxygen saturation and dyspnea were measured before and after the 6MW. The longest walk on each occasion was used for analysis.

The incremental treadmill stress tests (ITTs) were performed by each participant prior to and following the exercise training program. Physiological measurements including heart rate (HR), respiratory rate (RR), minute ventilation (VE), oxygen consumption (VO2), and oxygen saturation

(O2Sat) were performed with a metabolic cart (Quinton Q55 or Marquette) and pulse oximeter (Nellcor N-200) while subjects breathed room air through a mouthpiece. The subjects were instructed to place only two fingers on the handrail for balance. Each ITT began with the subject waking for 3 minutes at 1.0 mph on the level. The speed was then increase every 90 seconds, as tolerated, to the following speeds: 1.5 mph, 2.0 mph, 2.5 mph, and 3.0 mph. At 3.0, speed was held constant and the grade was increased to the following levels: 2%, 4%, 6%, 8%, 10%, 12%, 14%, and 16%, until the subject signaled the need to stop. The ITT was followed by a 3 minute cool-down at 1.0 mph.

Dyspnea in the Laboratory

Subjects rated the intensity of their dyspnea before and after the 6MW, and before, every 90 seconds during, and after completion of the ITT. The subjects were asked, "How short of breath are you, that is, how intense or severe is your shortness of breath?" In response, to this question, the subjects rated their dyspnea by marking a separate 200 mm vertical VAS anchored by "not at all" at the bottom and "worst possible" at the top. A 200 mm VAS was chosen to facilitate subjects' rating during treadmill walking. The vertical VAS has been shown to be valid in both normal volunteers and subjects with COPD for measuring dyspnea (Adams, Chronos, Lane, & Guz, 1985; Gift, 1989).

Dyspnea with Daily Activities

Dyspnea with daily activities was assessed with two previously validated questionnaires. The Baseline Dyspnea Index (BDI) was administered before

the exercise training program, and the change in dyspnea over time was assessed with the Transitional Dyspnea Index (TDI) at the end of the program (Mahler, Weinberg, Wells, & Feinstein, 1984). At the initial evaluation, the subject's status was rated by an interviewer from 0 (severe) to 4 (unimpaired) for each of three categories including functional impairment, magnitude of effort required to perform activities, and the magnitude of the task that provoked difficulty in breathing. The ratings from each category were combined to derive a baseline "focal" or total score (range, 0-12). Transitions in a subject's condition were compared to the baseline condition through ratings obtained on a seven-point scale for each category. Possible scores ranged from -3 (major deterioration) to +3 (major improvement), and were totaled from each category to form a transitional total score (range -9 to +9). The BDI has been shown to be both valid and reliable, while the TDI is highly sensitive in demonstrating changes in dyspnea as a result of a specific therapy (Guyatt et al., 1987, Guyatt et al., 1985). Only total scores were used in this analysis.

The Chronic Respiratory Disease Questionnaire (CRQ) is a measure of quality of life in patients with chronic airflow limitation (Guyatt et al., 1987). The interview assesses physical and emotional function, and consists of four domains including dyspnea, fatigue, emotions and mastery. A total of 20 items are rated using a seven-point Likert scale. The dyspnea subscale measures dyspnea with self-selected activities. Subjects are asked to rate their dyspnea with 5 activities that are frequently performed and important in their daily lives. The dyspnea with activities scale has been shown to be valid and responsive to changes in dyspnea following therapeutic intervention (Guyatt, Townsend, Keller, Singer, & Nogradi, 1989).

Data Analysis

Sample demographics are presented in Table 1., with categorical data shown as frequencies and percentages and interval data as means and standard deviations. Slopes expressing the relationship between dyspnea intensity and minute ventilation during incremental treadmill testing were determined for each subject and were based on the number of stages completed. Each subject's slope was weighted evenly when calculating the sample mean. Differences between baseline and post exercise training values were tested for significance using paired t-tests. Relationships between 'same time' laboratory and ADL dyspnea measurements were determined using Pearson's correlations. Laboratory dyspnea variables that were significantly correlated with the dyspnea with activity measures were subsequently entered into a simultaneous multiple regression to determine the overall predictive power of the set, as well as the unique contributions of each variable (Cohen & Cohen, 1984). Statistical tests were performed using the CRUNCH4® Statistical Package.

Results

As outlined in Table 2, exercise performance increased and dyspnea decreased significantly for the total sample after the treatment. There was a significant correlation between dyspnea with exercise in the laboratory as measured with the VAS and dyspnea with activities as measured by the CRQ after exercise training as shown in Table 3. The BDI/TDI measurements, made before and after the exercise program, were not significantly related to

Table 2

Outcome measures at baseline and after exercise training with calculated change scores. N = 48.

Outcome Variable	Baseline (Mean ± SD)	After Treatment (Mean ± SD)	Change (Mean ± SD)
Spirometry			
FEV1 (L)	0.9 ± 0.2	0.9 ± 0.3	0 ± 0.2
FEV1 (% pred.)	38.0 ± 10.3	37.7 ± 12.0	-.4 ± 8.6
FEV1/FVC (%)	41.9 ± 11.2	40.5 ± 9.6	-1.4 ± 8.6
Performance			
ITT VEmax (L/min)	34.2 ± 10.2	35.1 ± 11.4	0.9 ± 7.2
ITT Peak VO2 (cc/min)	940.6 ± 381.6	991 ± 381.3	50.4 ± 208.5
ITT Total Exercise Time (min.)**	8.5 ± 3.2	11.0 ± 3.4	2.5 ± 1.8
6MW Total Distance (ft)**	1381 ± 262.3	1518 ± 273.6	136.6 ± 158.1
Dyspnea with Exercise			
ITT DImax (mm)**	147.3 ± 50.6	121.5 ± 63.2	-25.8 ± 56.1
ITT DI/VE (slope)**	6.2 ± 4.4	4.31 ± 3.1	-1.9 ± 3.4
DI After 6MW (mm)	102.2 ± 59.5	94.5 ± 62.9	-7.7 ± 65.5
6MW DI/Distance (mm/ft)*	7.9 ± 5.1	6.5 ± 4.4	-1.4 ± 4.6
Dyspnea with Activities			
CRQ Dyspnea Subscale (5-35)**	17.5 ± 3.9	19.6 ± 5.5	2.1 ± 4.6
Baseline Dyspnea Index Total Score	4.7 ± 1.5		
Transitional Dyspnea Index Total Score			+2.2 ± 1.6

Note. FEV1 = Forced Expiratory Volume/1 Second, FVC = Forced Vital Capacity, 6MW = Six Minute Walk

ITT = Incremental Treadmill Testing, max = maximum workload during ITT

DI = Dyspnea Intensity (200mm VAS), VE=Minute Ventilation (L/min), VO2 = Oxygen Consumption (ml/min)

CRQ = Chronic Respiratory Questionnaire Dyspnea with Activities Score

*Paired T-test, $p < .05$, **Paired T-test, $p < .01$

Table 3

Pearson's r values for correlations between laboratory variables and measures of dyspnea with activities before and after exercise training (ET). N = 48.

	Measures of Dyspnea with Activities				
Laboratory Measure	BDI	TDI	CRQ Pre	CRQ Post	CRQ Δ
Spirometry					
FEV1 (% predicted) - pre	.38 *	- .04	- .13	.06	.04
FEV1 (% predicted) - post	.28	.04	.03	.07	.06
FEV1 (% predicted) - change	.06	.11	.20	.18	.04
FEV1/FVC - pre	.44 *	.07	- .10	- .13	- .07
FEV1/FVC - post	.30 *	.24	.00	.07	- .06
FEV1/FVC - change	- .23	.17	.13	.25	.19
Performance					
ITT VEmax (L/min) - pre	.19	.31 *	.04	.03	.07
ITT VEmax (L/min) - post	.21	.46 *	.01	.15	.17
ITT VEmax(L/min) - change	.05	.29 *	.07	.19	.17
ITT Peak VO2 (cc/min) - pre	.14	.30 *	.07	.12	.08
ITT Peak VO2 (cc/min) - post	.25	.37 *	.10	.19	.14
ITT Peak VO2 (cc/min) - change	.20	.13	.05	.12	.11
ITT Exercise Time (min) - pre	.25	.10	.03	.09	.08
ITT Exercise Time (min) - post	.41 *	.26	.05	.15	.13
ITT Exercise Time (min) - change	.33 *	.32 *	.04	.12	.11
6MW Distance (ft) - pre	.27	.06	- .06	.03	.09
6MW Distance (ft) - post	.40 *	.18	- .18	.01	.14
6MW Distance (ft) - change	.24	.22	- .19	- .06	.10
Dyspnea					
ITT DImax (mm) - pre	.05	- .09	- .06	- .15	- .13
ITT DImax(mm) - post	.04	.01	- .27	- .35 *	- .19
ITT DImax (mm) - change	- .01	.09	- .25	- .26	- .10
ITT DI/VE Slope - pre	- .22	- .21	.13	- .06	- .18
ITT DI/VE Slope - post	- .01	- .23	- .12	- .30 *	- .26
ITT DI/VE Slope - change	.28	.06	- .28	- .21	- .01
DI After 6MW (mm) - pre	- .16	.02	- .06	- .04	.00
DI After 6MW (mm) - post	.08	- .12	- .22	- .33 *	- .21
DI After 6MW (mm) - change	.07	- .13	- .16	- .28	- .21
6MW DI/Distance (mm/ft) - pre	- .20	.03	- .05	- .06	- .03
6MW DI/Distance (mm/ft) - post	- .16	- .18	- .19	- .34 *	- .24
6MW DI/Distance (mm/ft) - change	.07	- .20	- .13	- .26	- .20

Note. Shaded areas include baseline correlations, post-ET correlations, and change score correlations.

FEV1 = Forced Expiratory Volume/1 Second, FVC = Forced Vital Capacity, 6MW = Six Minute Walk

ITT = Incremental Treadmill Testing, max = maximum workload during ITT

DI = Dyspnea Intensity (200mm VAS), VE=Minute Ventilation (L/min), VO2 = Oxygen Consumption (ml/min)

BDI/TDI = Baseline/Transitional Dyspnea Index Focal Score, CRQ = CRQ Dyspnea with Activities Score

* $p < .05$

any measures of dyspnea in the laboratory. The TDI, however, was significantly related to the change in minute ventilation and oxygen consumption, as well as the change in total treadmill exercise time after the exercise training program.

Correlations between laboratory variables and each measure of dyspnea with activities are shown in Table 3. Shaded areas highlight correlations between 'same time' measures (e.g. baseline laboratory measures and baseline assessments of dyspnea with activities).

Exercise Performance and Dyspnea

The distance walked during the 6-minute walk increased significantly ($p < .01$) after the exercise training program, as did the total exercise time during incremental treadmill testing ($p < .01$). There were no significant changes from baseline maximum workload values for HRmax, RRmax, peak VO2 or VEmax after exercise training. Dyspnea intensity at maximum workload (DImax) decreased significantly from 147.3 mm to 121.5 mm ($p < .01$) and the mean DI/VE slope for the group also decreased from 6.2 to 4.3 ($p < .01$). Dyspnea intensity at the end of the 6MW decreased from a mean of 102.2 mm to 94.5 mm (7.5%), which was not a statistically significant change. However, when dyspnea was adjusted for work by dividing dyspnea by feet walked during the 6MW, the dyspnea index (DI/Distance) decreased by 18% ($p < .05$).

Dyspnea with ADLs

The CRQ dyspnea with activities scores increased significantly after exercise training in the total sample. The increase from a mean score of 17.5

to a score of 19.6 after exercise was statistically significant ($p < .01$). Although the average change of the group did not meet the 2.5 point increase determined to be clinically important by one group of investigators (Jaeschke, Singer, & Guyatt, 1989), twenty-two (43 %) of the subjects achieved an increase of 2.5 or more points. The mean TDI total score of 2.2 for the total group indicates "moderate to major improvement" of dyspnea with daily activities (Mahler et al., 1984).

Relationships

There was no significant relationship between exercise performance and dyspnea with ADLs before or after exercise training as measured with the BDI or the CRQ as shown in Table 3. However, the change in total treadmill exercise time from baseline correlated with TDI values following treatment ($p < .05$) The mean focal TDI score also correlated with VEmax and peak V02 as demonstrated in Table 3.

There was no significant correlation ($r = - .27$, ns) between dyspnea with exercise in the laboratory and dyspnea with ADLs at baseline as measured by the CRQ. However, after exercise training, the CRQ dyspnea with activities subscale scores were significantly correlated with dyspnea at maximum exercise during ITT ($r = -.35$, $p < .05$), the slope of dyspnea related to ventilation during ITT ($r = -.30$, $p < .05$), dyspnea intensity at the end of the 6MW ($r = -.33$, $p < .05$) and the 6MW DI/Distance ($r = -.34$, $p < .05$). When these variables were entered into a simultaneous multiple regression, the overall model explained 16% of the variance, but was not statistically significant ($r^2 = .16$, ns). None of the variables provided a significant unique explanation of variance in CRQ dyspnea scores as demonstrated by squared

Table 4

Correlation coefficient matrix: CRQ dyspnea with activity scores and four laboratory measures of dyspnea with exercise. N = 48.

	Pearson's r values			
Independent Variable	ITT DImax	ITT DI/VE Slope	DI After 6MW	6MW DI/Distance
CRQ Dyspnea	-.35*	-.30*	-.33*	-.34*
ITT DImax	--	.54**	.79**	.75**
ITT DI/VE Slope		--	.38**	.33*
DI After 6MW			--	.96**

Note. CRQ = Chronic Respiratory Disease Questionnaire Dyspnea with Activities Scale

ITT = Incremental Treadmill Testing, DI = Dyspnea Intensity (0-200mm VAS)

max = maximum ITT workload, VE = Minute Ventilation (L/min), 6MW = Six Minute Walk (ft)

*$p < .05$, **$p < .01$

Table 5

Simultaneous multiple regression of laboratory measures of dyspnea with exercise on CRQ dyspnea with activities scores. N = 48.

Source	R2	sr2	beta	df	F	p
Overall	.16			4,43	2.04	0.1
ITT DImax (mm)		.00	-.12	1,43	0.23	0.6
ITT DI/VE slope		.02	.19	1,43	1.23	0.3
DI After 6MW (mm)		.00	.12	1,43	0.05	0.8
6MW DI/Distance (mm/ft)		.01	-.30	1,43	0.39	0.5

Note. CRQ = Chronic Respiratory Disease Questionnaire Dyspnea with Activies Scale

ITT = Incremental Treadmill Testing, DI = Dyspnea Intensity (0-200mm VAS)

max = maximum ITT workload, VE = Minute Ventilation (L/min), 6MW = Six Minute Walk (ft)

semi-partial (sr^2) values that ranged from 0 - .02 (ns). The contributions of the dyspnea variables were not unique, most likely because intercorrelations between them were moderate to high ($r = .33$ $p < .01$ to $r = .96$, $p < .01$). The correlation matrix used for the regression analysis is presented in Table 4, and regression results are summarized in Table 5.

Limitations

This study is limited by a small sample size, which reduces the generalizability of the findings. Although there were no significant differences between the two treatment groups, the effects of combining them for this analysis is not entirely known. Finally, some have recommended against using the CRQ dyspnea subscale score in comparative research, as it has been demonstrated to have a low internal consistency and measures dyspnea with individually selected activities (Wijkstra, TenVergert, et al., 1994).

Discussion

In this study, subjects showed significant improvement in exercise performance, significant reduction in dyspnea with laboratory exercise, and significant reduction in dyspnea with ADLs following exercise training. There was a moderate and significant relationship between dyspnea with exercise in the laboratory and dyspnea with activities of daily living as measured by the CRQ after the 12-session exercise training program. There was a low non-significant relationship between exercise performance as measured by ITT

total time or 6MW distance and dyspnea with activities as measured by the CRQ.

Contrary to the findings from studies which have compared exercise performance in the laboratory with dyspnea at home, when dyspnea with exercise in the laboratory is compared to dyspnea with activities at home, a significant relationship has been demonstrated between measurements of the same phenomenon. Relating "dyspnea" to "dyspnea" avoids the "apples to oranges" issue which may threaten the previous assumption that a relationship exists between endurance and breathlessness. Although the idea that improved endurance should relate to improved function and decreased symptoms is intuitively appealing, studies have repeatedly demonstrated this assumption to be flawed. While improvements in exercise performance are easily assessed and provide objective data, it is essential that the focus of research remain the reduction of symptoms and improvement in quality of life, despite the overwhelming challenge in defining and measuring these parameters.

Another important finding in this study is the insignificance of the unique predictive value among the laboratory measures of dyspnea with exercise. The forced multiple regression demonstrated the predictive abilities of these variables to be largely redundant. Measures of dyspnea with the 6MW were as effective as measures of dyspnea during treadmill exercise in predicting dyspnea with daily activities. These findings are clinically important as they provide scientific rationale for using the simpler and less expensive method of assessment.

Although a significant relationship between dyspnea with exercise in the lab and dyspnea with ADLs was evident following exercise training, no relationship between these variables was observed at baseline or when change

scores were analyzed. Therefore, this correlation is limited in clinical application. The lack of correlation between change scores is not surprising, as change scores are derived from baseline values. Why the relationship between exertional dyspnea in the laboratory and dyspnea with ADLs was evident following exercise training, and not at baseline, is unknown. Increased experience with dyspnea scoring during the 12 treatment sessions, may have improved the validity of subjects' ratings over time.

The lack of relationship between exercise performance and dyspnea with daily activities is corroborated by findings in three published reports (Toshima et al., 1990; Reardon et al., 1994; Wijkstra, Van Altena, et al, 1994). An early study by Toshima and colleagues (1990), hypothesized that improvements in exercise tolerance would be associated with significant changes in health-related quality of life. They randomized 119 adults with COPD to an 8-week comprehensive rehabilitation program or to an 8-week education control program. This study used the Quality of Well-Being Scale (QWB) as a measure of health-related quality of life which includes one scale which measures the perception of symptoms (Kaplan, Atkins, & Timms, 1984). The treatment group showed significant improvement in exercise performance at the end of eight weeks, while the control group achieved only nonsignificant increases. There were however, no related changes in QWB scores in either group.

Reardon and associates (1993) evaluated 44 patients consecutively enrolled in an outpatient pulmonary rehabilitation (OPR) program in order to determine the relationship between improvements in exercise endurance and quality of life measures.[10] The 12-minute walk (12MW) was used to determine exercise endurance and all four dimensions of the CRQ were used to assess quality of life. At the end of the 6-week program, substantial

increases in both 12MW distance and CRQ scores were achieved. Despite these gains, there was no significant relationship found between the change in exercise performance and the change in the quality of life score or any of its dimensions, including the dyspnea with activities scale. Despite a modest correlation with the pre-OPR 12MW, improvement in dyspnea subscale score was unassociated with improvement in exercise endurance.

Wijkstra and colleagues (1994) reported similar findings from a study in which 43 patients with chronic lung disease were stratified according to spirometric values and exercise capacity then randomly assigned to a 12-week home rehabilitation program or a no-treatment control group. In this study, cycle ergometry was used to assess exercise performance, and the CRQ was used to measure quality of life. Findings demonstrated a highly significant improvement in the rehabilitation group compared to the control group for the CRQ dimensions of emotion, mastery, and dyspnea, as well as exercise tolerance. The improvement in quality of life measures, including the dyspnea subscale score, did not correlate with the improvements in exercise performance.

Only one study has examined the relationship between "laboratory" and "home" measures of dyspnea. Reardon and associates (1994) demonstrated a significant relationship between dyspnea with exercise in the laboratory and dyspnea with daily activities. Using a randomized controlled trial, these investigators evaluated the effect of out-patient rehabilitation (OPR) on dyspnea in patients with COPD . Dyspnea was measured with the VAS during laboratory exercise and with the BDI/TDI to examine dyspnea with activities. The treatment group was tested before and after OPR while the control group was tested before and after a waiting period. Baseline assessments included pre-exercise HR, VE, oxygen consumption (VO2),

ventilatory rate (VR), oxygen saturation (SaO2), and dyspnea (D). Maximum workload values for the exercise variables (HRmax, VEmax, VO2max, VRmax, SaO2max) and the dyspnea measures (Dmax and calculated ratios for Dmax/VEmax and Dmax/VO2max) were also assessed and no significant differences were found between the groups. A decrease in dyspnea at maximal workload was observed only in the group completing OPR, with Dmax decreasing from 74 percent (VAS scores were converted to per cent line length) at baseline to 50 percent at repeated testing. Similar improvement was seen in Dmax/VEmax and Dmax/V02max values. The change in each patient's overall level of dyspnea with activity outside the laboratory was determined with the TDI. The focal score of $+2.3 \pm 1.06$ in the treatment group was significantly greater than the $+.20 \pm 1.75$ score in the control group, indicating decreased overall dyspnea following out-patient rehabilitation. The change in Dmax from baseline to repeated testing was inversely related to the change in TDI score, leading the authors to conclude that improvement in exertional dyspnea from baseline to repeated testing was partially related to improvement in overall clinically assessed dyspnea over this period.

There was no similar relationship between ITT DImax and the TDI scores in the study reported here. In fact, there were no significant correlations between the BDI and TDI total scores and any variables used to assess dyspnea in the laboratory setting. Instead, BDI/TDI scores were found to correlate significantly with spirometry, VE, VO2, and total exercise time variables, leading the author to question the construct validity of this instrument. The results indicate that perhaps the BDI/TDI measures functional status, rather than dyspnea.

Although several studies demonstrate improvements in dyspnea after exercise training, much remains unknown about the mechanism by which

exercise training reduces dyspnea (Stulbarg & Adams, 1994). In those patients able to exercise beyond their anaerobic threshold, true conditioning may occur (Casaburi et al., 1991). A decrease in lactic acid production will reduce ventilatory demand and is therefore presumed to reduce dyspnea. Improvements in performance technique and self-confidence are also believed to reduce the work performed thus decreasing oxygen consumption, ventilation and dyspnea (Belman, 1986; Gormley, Carrieri-Kohlman, Douglas, & Stulbarg, 1992; Stulbarg & Adams). As many patients are unable to increase maximal aerobic capacity and level of conditioning, psychological benefits of exercise training may be the only mechanism by which dyspnea is reduced. One such benefit has been demonstrated to be desensitization to the distress or discomfort of breathing associated with relaxation and improved self-confidence (Carrieri-Kohlman, Douglas, Gormley, & Stulbarg, 1992). Individual improvement may be achieved as a result of any one or combination of these processes. This variability in response mechanisms may be partially responsible for the lack of consistent relationships among various outcome measures.

The mean DI/VE slope decreased significantly with exercise training, and was demonstrated for the first time to correlate with dyspnea with daily activities. This decrease in slope may indicate that desensitization to dyspnea (or an increased tolerance to dyspnea) has occurred, as dyspnea is decreased for a given minute ventilation (Stark, 1988). By calculating the slope of DI over VE, we have controlled for a decrease in VE and demonstrated a proportionately greater reduction in exertional dyspnea.

The findings in this study indicate that exercise performance is not a reliable indicator of dyspnea with daily activities in the home. The more valid approximation of dyspnea in the home is dyspnea in the laboratory.

Dyspnea with exercise in the laboratory is significantly related to dyspnea with activities after exercise training, and should, therefore, be considered a primary outcome in the laboratory setting.

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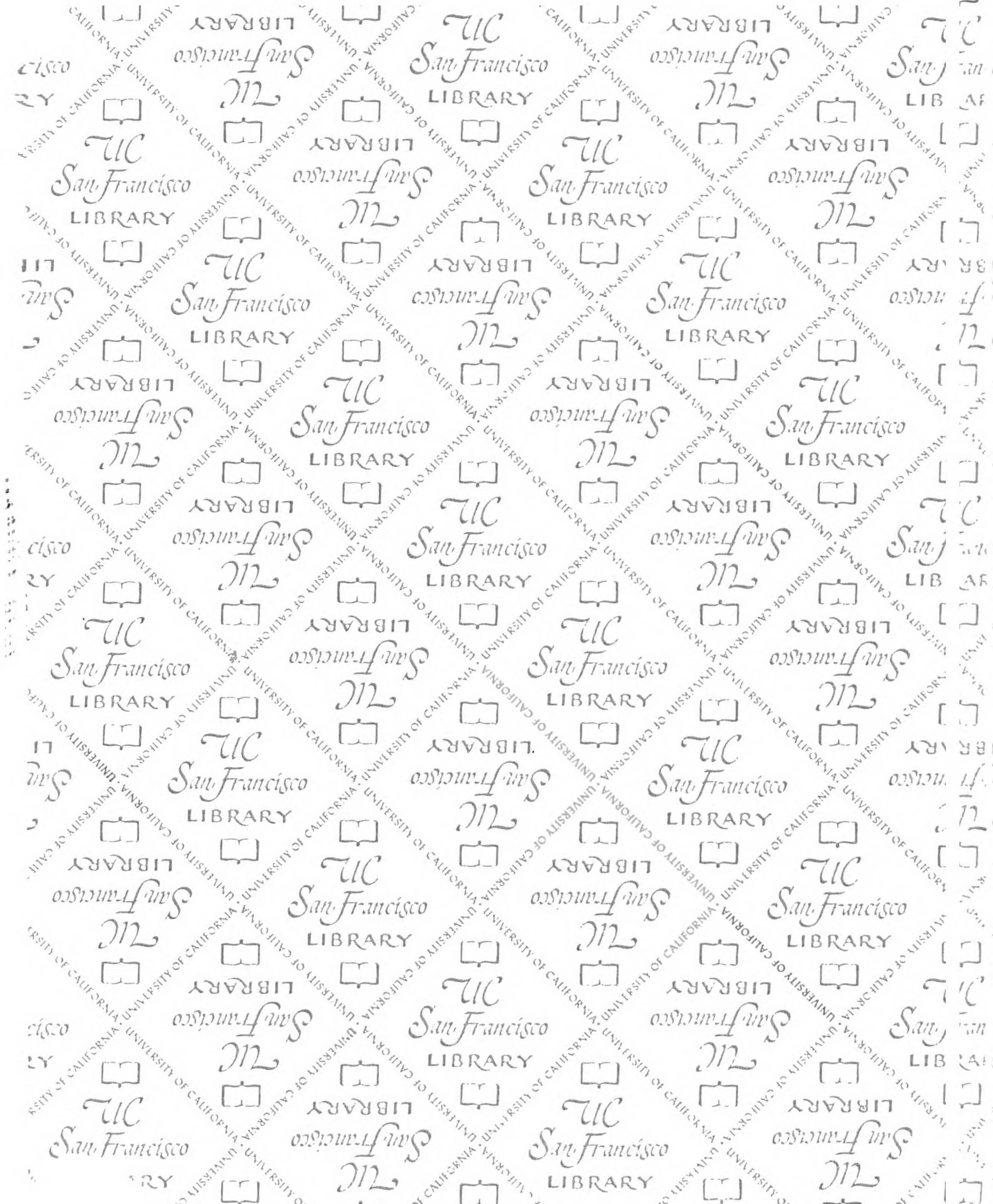
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