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Original Article

# Comparison of Inspiratory Muscle Strength Training Effects Between Older Subjects With and Without Chronic Obstructive Pulmonary Disease

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**Background/Purpose:** Inspiratory muscle strength training (IMST) has been traditionally recommended for patients with chronic obstructive pulmonary disease (COPD) to improve respiratory strength. Respiratory strength is reduced as age increases. However, few studies have focused on the effects of IMST on older adults without COPD.

**Methods:** Subjects were divided into training non-COPD (TNC, $n=24$) and training COPD (TC, $n=12$) according to their forced expiratory volume in 1 second (% predicted). Both groups received 6 weeks of IMST, with training at 75–80% of maximal inspiratory pressure using pressure threshold trainers. A second group of COPD subjects served as controls (CC, $n=24$), which received no training. Dyspnea was measured using the basic dyspnea index. Health-related quality of life was measured using the SF-36. The SF-36 subcategories, physical component summary and mental component summary were compared. A 6-minute walk test was performed to determine functional status. Two-way repeated measures analysis of variance was used to compare group effects and training effects of IMST.

**Results:** Maximal inspiratory pressure was increased in both training groups (TNC: 59.1 $cmH_2O$ pre-IMST to 82.5 $cmH_2O$ post-IMST; TC: 53.2 to 72.6), but not in the CC group. Therefore, the basic dyspnea index was improved in both training groups (TNC: 9.6 to 10.8; TC: 6.2 to 7.3). Functional status was improved in the TNC group (TNC: 392.1 m to 436.3 m), but not in the TC or CC groups. Quality of life was improved in the physical component summary in both training groups.

**Conclusion:** IMST increases maximal inspiratory pressure, relieves dyspnea and improves health-related quality of life in older adults. IMST especially improves functional status in subjects without COPD. IMST benefits subjects with COPD and those without COPD. Therefore, IMST as a treatment tool is not confined to patients with COPD.

**Key Words:** dyspnea, maximal inspiratory pressure, quality of life, SF-36, 6-minute walk test



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Aging causes decreases in the strength of respiratory muscle, accompanied by a decrease in elastic recoil of the lung and compliance of the chest wall.[1] The combination of the above changes results in increased work of breathing, which often leads to the sensation of dyspnea. Patients with chronic obstructive pulmonary disease (COPD) experience increased resistance to airflow, air-trapping and lung hyperinflation. Lung hyperinflation leads to the inspiratory muscle having a mechanical disadvantage, which causes further weakness in addition to the aging process.

Dyspnea is an unpleasant sensation of breathing. Once the respiratory muscle becomes weaker, respiratory motor drive is heightened to maintain effective ventilation.[2] Increased drive can lead to the sensation of dyspnea. The relationship between increased motor drive and respiratory sensation has been investigated and a positive correlation found.[3] Research has shown that after inspiratory muscle strength training (IMST), subjects show a decreased inspiratory drive, which is correlated with an increase in maximal inspiratory pressure (PImax).[4] These results suggest that changing inspiratory muscle strength does not change pulmonary mechanics, but that it can alter respiratory sensations, which is believed to be beneficial to older adults, especially subjects with COPD.

To date, IMST has for the most part been performed in patients with COPD to improve inspiratory muscle strength to relieve the sensation of dyspnea.[5,6] We consider that IMST could benefit older adults without COPD as well. We designed a high intensity/low repetition training program to improve muscle strength. Dyspnea was evaluated using the basic dyspnea index (BDI). The 6-minute walk test (6MWT) was conducted to determine whether functional walking performance would change with IMST. Since health-related quality of life (HRQOL) is the ultimate goal for individuals with and without disease, we also compared quality of life using the SF-36. A group of age- and sex-matched subjects with COPD were recruited.

## Materials and Methods

### *Subjects*

The study subjects were 36 patients with moderate to severe COPD and 24 age- and sex-matched subjects with normal lung function. Subjects with COPD were recruited from previously diagnosed patients, under regular treatment from one hospital in eastern Taiwan. The study was approved by the Institutional Review Board in Tzu Chi Medical Center. Informed consent was obtained from each subject.

The inclusion criteria for subjects with COPD were those who were previously diagnosed with COPD, with a forced expiratory volume in 1 second ($FEV_1$) less than 80% of predicted, stable medication and no infection in the month prior to entering the study. Subjects with COPD were divided into training or control groups. Subjects without COPD were mostly recruited from a local senior recreation center, and some were from a physical therapy clinic. The inclusion criteria for subjects without COPD were normal $FEV_1$ (%predicted) and $FEV_1$/forced vital capacity (FVC). All the participants were required to be able to walk during the experiment. Therefore, there were three groups in the current study: training non-COPD (TNC), training COPD (TC) and control COPD (CC). Throughout the study period, subjects were informed not to change their medication and lifestyle. Baseline characteristics of the three groups are shown in Table 1.

### *Outcome measurements*

Weight and height were measured and the body mass index was calculated. Body composition was assessed by bioelectrical impedance (Biospace Inbody 3.0 Body Composition Analyzer, Singapore) to give a body fat percentage.

#### *Inspiratory muscle strength*

PImax was measured at the mouth by a pressure manometer (RPM, Micro, Cardinal Health, Basingstoke, UK). Subjects were seated in a comfortable chair upright with nose clips on. After exhaling to residual volume, subjects placed their lips around a mouthpiece and inspired as forcefully as possible. Repeated measurements were taken at least five times, with a 60- to 120-second rest between trials, until three measurements within 10% variation were obtained. The average of these three measurements was recorded as the subjects' PImax.

*Pulmonary function*

Spirometry was performed according to American Thoracic Society guidelines.[7] Pulmonary function tests were assessed after the inhalation of bronchodilators was withheld for at least 12 hours.

*Dyspnea*

Resting dyspnea was evaluated with the BDI. The BDI includes three domains (functional impairment, magnitude of task, and magnitude of effort) with each measurement from 0 to 4, with 0 being the strongest breathlessness at rest to 4 being breathlessness only at the most strenuous activity. The scores from each domain were added together to form a BDI score. Exercise dyspnea was evaluated using the visual analogue scale (VAS) as explained below.

*Functional walking*

The 6MWT was conducted according to guidelines recommended in an official ATS statement.[8] Dyspnea, as measured with the VAS, oxygen saturation ($SaO_2$) and pulse rate were measured at the start and end of the 6MWT. VAS was measured using a horizontal line, 100 mm in length, anchored by the word descriptors "no dyspnea at all" and "very severe dyspnea" at each end. Subjects were asked to mark on the line the point that represented their perception of their state. The VAS score was determined by measuring in millimeters from the left hand end of the line to the point that the patient marked. The distance that the subjects covered in 6 minutes was recorded as the 6MWD.

*HRQOL*

HRQOL was evaluated using the SF-36 Chinese version, a general health profile commonly used in clinical settings.[9] The instrument includes 36 questions in eight dimensions of health. The SF-36 can be self-administered or conducted by the researcher. We chose to conduct the SF-36 ourselves to avoid situations such as missed questions or illiteracy. All subjects were questioned by the same interviewer. The totals were then transformed into a score from 0 to 100, with 0 and 100 assigned to the lowest and highest possible scores, respectively. The SF-36 has been factor analyzed and reduced to two summary scores. The physical component score (PCS) represents the four physical health scales (i.e. physical functioning, role physical, bodily pain, and general health perceptions), while the mental health score (MCS) reflects the four mental health scales (i.e. mental health, role emotional, vitality, and social functioning). We used both individual scale scores and summary scores (PCS and MCS) in our analysis.

### IMST protocol

The subjects received 6 weeks of IMST. The training was conducted 5 days per week. Every Monday, Wednesday and Friday, subjects performed IMST under supervision. The training was performed individually under supervision by the same experimenter (CH) through the whole training period. The other 2 days (Tuesday and Thursday) subjects performed IMST at home by themselves and were asked to keep a diary. Each subject used a custom-designed pressure threshold inspiratory muscle trainer, a device that provides a pressure threshold load to inspiration between 14 $cmH_2O$ and 80 $cmH_2O$. The trainer permits unimpeded exhalation. Each daily IMST session consisted of four sets of six training breaths. Every Monday the experimenter measured the subjects' PImax and adjusted the pressure threshold to 75% of the current PImax.

### Data analysis

Baseline pre-IMST data were evaluated with descriptive statistics to characterize group differences. Changes after IMST were evaluated by two-way repeated analysis of variance (group × pre-training/post-training) for dyspnea, 6MWD, and HRQOL

(PCS and MCS). For all statistical analyses, a critical value for $p$ less than 0.05 was considered statistically significant.

## Results

All subjects completed 6 weeks of IMST and post-IMST tests. There were no differences in height, weight, age, body mass index, body fat percentage, and PImax among the three groups (Table 1). There was no difference in lung function between the two COPD (TC and CC) groups.

Six weeks of IMST resulted in a significant increase in PImax in both training groups, but not in the control group (Figure 1), which amounted to a 39% ($p < 0.01$), 36% ($p < 0.01$) and 6% ($p > 0.05$) increase in the TNC, TC, and CC groups, respectively.

The BDI in TNC was significantly higher than that in the TC and CC groups before the IMST began, indicating that the dyspnea level was higher in subjects with COPD than those without COPD. IMST improved BDI (less dyspnea) in the TNC and TC groups, but not in the CC group (Figure 2).

There was no difference in 6MWD pre-IMST among the groups. After IMST, 6MWD was improved only in the TNC group (Figure 3). IMST significantly decreased the VAS in the TNC group, but not in the TC group.

The SF-36 was completed by all subjects. Within eight domains of the SF-36, there were three domains where the TNC group was significantly better than both the TC and CC groups, and these were physical function, role limitations and general health. IMST improved five domains in the TNC group, four domains in the TC group and

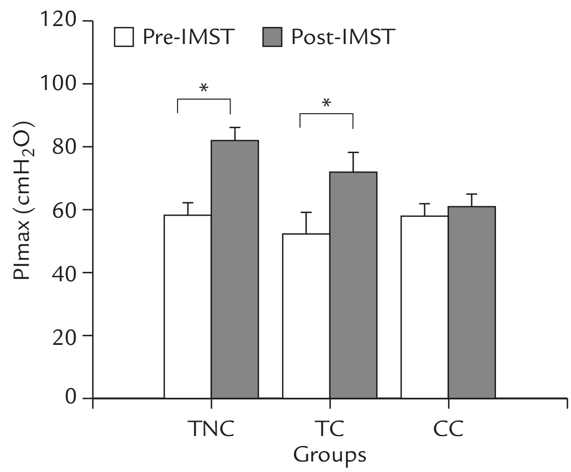


**Figure 1.** Effect of IMST on PImax among the groups. Data are shown as mean ± SEM. *$p < 0.01$. TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease; IMST = inspiratory muscle strength training; PImax = maximal inspiratory pressure.

**Table 1.** Anthropometric and clinical characteristics of the subjects[a]

| | TNC | TC | CC |
|---|---|---|---|
| Age (yr) | 70.6 ± 4.8 | 73.0 ± 6.3 | 70.8 ± 9.1 |
| *n* (F:M) | 24 (2:22) | 12 (1:11) | 24 (2:22) |
| Height (cm) | 164.4 ± 6.9 | 159.5 ± 6.3 | 160.6 ± 5.1 |
| Weight (kg) | 67.5 ± 10.3 | 58.3 ± 13.1 | 58.8 ± 10.8 |
| BMI (kg/m$^2$) | 24.7 ± 3.1 | 23.0 ± 5.5 | 22.8 ± 4.3 |
| Body fat (%) | 25.5 ± 7.7 | 22.2 ± 8.6 | 25.3 ± 4.5 |
| $FEV_1$ (% predicted) | 103.8 ± 21.2 | 47.9 ± 9.0[b] | 43.4 ± 19.3[b] |
| FVC (% predicted) | 99.6 ± 18.3 | 67.1 ± 12.6[b] | 60.8 ± 18.6[b] |
| $FEV_1$/FVC | 102.2 ± 10.6 | 69.8 ± 9.8[b] | 65.9 ± 12.5[b] |
| Smoking (yes: no: ex) | 3:12:9 | 1:2:9 | 5:2:17 |
| PImax (cm/$H_2O$) | 59.1 ± 19.2 | 53.2 ± 23.6 | 58.8 ± 19.1 |

*[a]Data are presented as n or mean ± standard deviation; [b]significant difference compared with TNC ($p < 0.05$). F = female; M = male; BMI = body mass index; $FEV_1$ = forced expiratory volume in 1 second; FVC = forced vital capacity; PImax = maximal inspiratory pressure; TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease.*

one domain in the CC group (Table 2). Two-way repeated measures analysis of variance showed a significant interaction between groups and pre/post IMST in PCS ($p < 0.001$). PCS, but not MCS, calculated from the SF-36, was improved in both training groups (Figure 4). PCS in the TNC group was significantly higher than that in the CC and TC groups before IMST.

## Discussion

Our study showed that 6 weeks of IMST increased PImax, and this was accompanied by an increased 6MWD, lowered dyspnea and better HRQOL in subjects without COPD. For subjects with moderate to severe COPD, IMST also results in a comparable increase in PImax, accompanied by a

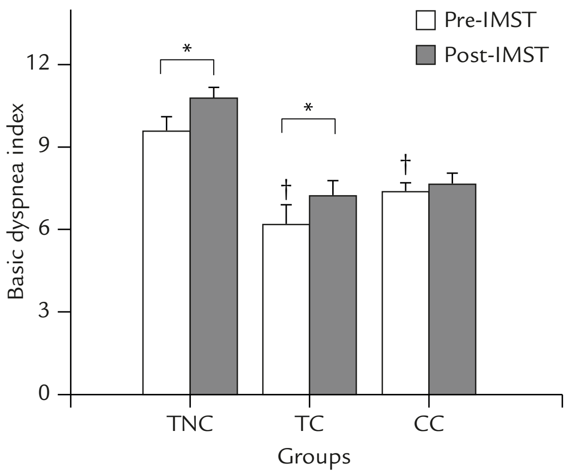


**Figure 2.** Effect of IMST on the basic dyspnea index among the groups. Data are shown as mean ± SEM. $^*p < 0.01$, $^\dagger p < 0.05$ compared with pre-IMST in the TNC group. TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease; IMST = inspiratory muscle strength training.

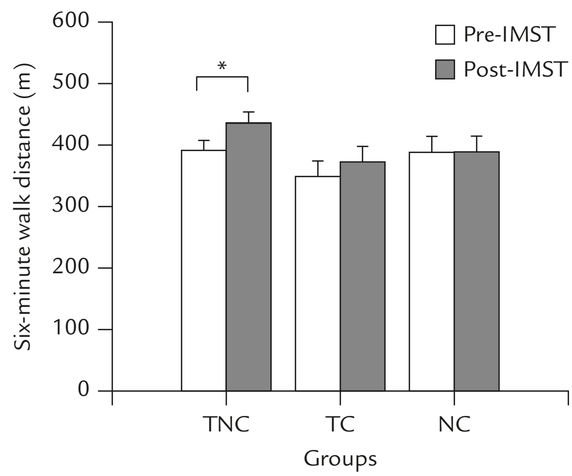


**Figure 3.** Effect of IMST on the 6-minute walk distance among the groups. Data are shown as mean ± SEM. $^*p < 0.01$. TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease; IMST = inspiratory muscle strength training.

**Table 2.** The SF-36 domain scale pre- and post-inspiratory muscle strength training among the groups[a]

| | TNC | | TC | | CC | |
|---|---|---|---|---|---|---|
| | Pre-IMST | Post-IMST | Pre-IMST | Post-IMST | Pre-IMST | Post-IMST |
| Physical function | 83.3 ± 21.0 | 0.89 ± 19.1[b] | 46.7 ± 31.2[d] | 65.8 ± 23.6[c] | 66.0 ± 22.0[d] | 67.50 ± 21.9 |
| Role physical | 76.0 ± 41.4 | 87.5 ± 33.8 | 29.2 ± 43.7[d] | 54.2 ± 49.8 | 43.8 ± 43.1[d] | 47.9 ± 35.3 |
| Bodily pain | 66.2 ± 22.5 | 85.2 ± 17.8[c] | 43.0 ± 27.0[d] | 65.2 ± 22.8[b] | 66.4 ± 24.0[d,e] | 65.5 ± 18.9 |
| General health perception | 70.2 ± 18.8 | 75.6 ± 15.1[b] | 44.6 ± 25.3[d] | 57.5 ± 21.5[b] | 49.8 ± 22.8[d] | 51.0 ± 19.0 |
| Vitality | 74.4 ± 19.0 | 80.2 ± 20.5[b] | 52.9 ± 25.6[d] | 62.5 ± 17.0 | 64.6 ± 27.8 | 67.5 ± 25.2[b] |
| Social function | 75.0 ± 25.0 | 87.0 ± 17.9[b] | 66.7 ± 30.8 | 81.3 ± 22.3[b] | 83.3 ± 21.4 | 83.3 ± 19.4 |
| Role emotional | 79.2 ± 39.1 | 83.3 ± 35.4 | 41.7 ± 47.4[d] | 55.6 ± 49.9 | 52.8 ± 46.0 | 56.9 ± 43.4 |
| Mental health | 78.0 ± 16.5 | 82.5 ± 14.2 | 59.0 ± 29.6 | 62.7 ± 23.2 | 71.5 ± 24.2 | 72.5 ± 21.7 |

*[a]Data are presented as mean ± standard deviation; [b]significant difference compared with pre-IMST within groups ($p < 0.05$); [c]significant difference compared with pre-IMST within groups ($p < 0.01$); [d]significant difference compared with TNC pre-IMST ($p < 0.05$); [e]significant difference compared with TC pre-IMST ($p < 0.05$). IMST = inspiratory muscle strength training; TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease; SD = standard deviation.*

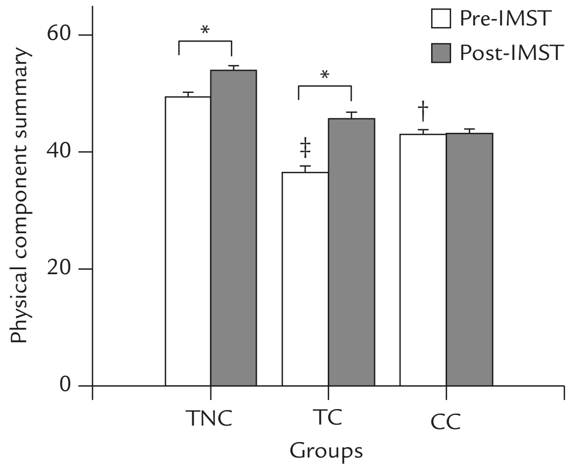


**Figure 4.** Effect of IMST on the physical component summary among the groups. Data are shown as mean ± SEM. *$p < 0.01$, †$p < 0.05$ compared with pre-IMST in the TNC group, ‡$p < 0.01$ compared with pre-IMST in the TNC group. TNC = training non-chronic obstructive pulmonary disease; TC = training chronic obstructive pulmonary disease; CC = control chronic obstructive pulmonary disease; IMST = inspiratory muscle strength training.

better HRQOL. Because they are different health indicators, each of these results will be discussed separately.

### *The effect of IMST on PImax*

The inspiratory muscle group is usually under a higher demand but with lower capacity to perform in patients with COPD. The PImax in our TC and CC groups was 53.2 and 58.8 $cmH_2O$, respectively, while PImax in the TNC group was 59.1 $cmH_2O$ before IMST. It is difficult to determine a reasonable PImax level for patients with COPD, because every individual has a different disease severity and level of activity. For people without COPD in the TNC group, it was found that PImax was lower than that in subjects of a similar age but different ethnicity as reported previously.[10,11] This is consistent with other studies in which respiratory muscle strength in Asians appears to be lower than that in Caucasians,[12,13] although a definitive comparative study has not yet been conducted. A study involving 13,005 African-American and Caucasian subjects suggested that there was no race effect (Caucasian *vs*. African American) on PImax.[14] A database of PImax among Taiwanese needs to be established, followed by similar international comparative research involving Taiwanese and other ethnicities.

The present training protocol used 75–80% PImax as the training intensity and 24 breaths/day over 6 weeks of training. This resulted in a PImax increase of 39% and 36% in the TNC and TC groups, respectively. The current study was equally effective compared with the majority of studies that used a lower PImax as training intensity and with subjects training for 6–18 weeks. Overload, specificity and reversibility are three principles in designing training regimes to obtain a desired training response. Leith and Bradely[15] concluded that these principles are important in respiratory muscle training as well. Pressure-threshold loading, as used in the current study, requires the user to generate a preset threshold (pressure) load to open a valve system, and it therefore provides an effective stimulus for increasing maximal pressure generating ability. One study of Taiwanese subjects demonstrated that 8 weeks of two 15-minute sessions a day could result in a similar 39% increase of PImax.[16] Considering the total training time spent, our study was more efficient (6 weeks, ~10 minutes a day).

Most of the literature on IMST for subjects without COPD focuses on improving athletic performance.[17] There are very few applications of IMST for counteracting the physiological changes of aging among elderly subjects. Watsford and Murphy[18] concluded that 8 weeks of threshold respiratory muscle training improved PImax by 20% among a group of women aged 60–69 years. This finding showed that older people are capable of responding to inspiratory strength training. Our study demonstrated that even older subjects (> 70 years old), and those under high intensity training (75–80%), can respond in a very favorable direction to IMST.

### *The effect of IMST on dyspnea*

Dyspnea appears to arise from the mismatch between inspiratory motor command and afferent feedback from mechanoreceptors.[1] Therapies capable of reducing this mismatch may ameliorate dyspnea. Our results showed that dyspnea was decreased in both training groups. IMST improves inspiratory muscle strength via the hypertrophy of muscle and neural adaptation. It has been reported in healthy subjects that strength gained from IMST correlates with a reduction in inspiratory motor commands.[4] Consistent with this finding, in our study, the TNC and TC groups had reduced dyspnea levels after IMST. In a review paper by Hill et al,[19] the authors found that IMST that induces substantial improvements in PImax may also result in substantial reductions in dyspnea. However, in our study, when we further analyzed the relationship between the difference in PImax and the difference in BDI in either training group, we found no significant correlation ($r = -0.17$ for TNC; $r = -0.13$ for TC). This is probably explained by the ceiling effect, given the fact that the BDI values reported in our subjects were relatively high pre-IMST (TNC: 9.6; TC: 6.2). We believe that this is because we recruited a group of subjects who had either COPD or normal lung function; we did not specifically recruit subjects experiencing dyspnea. In our study, the significant improvement in BDI after IMST was small but clinically relevant.

Exertion during exercise discourages people from pursuing physical activity, which is especially critical to preserving fitness in older adults. We found that IMST significantly decreased the VAS in the TNC group (before walking, 5.9; after walking, 17.0 pre-IMST; before walking, 2.7; after walking, 7.6 post-IMST). We found that there was a significant main effect of training in the TNC group ($p = 0.006$) and an interaction ($p = 0.021$), which suggests that subjects in the TNC group not only felt less breathlessness after walking, but also felt less breathlessness before walking post-IMST. This significant interaction was not found in the TC group ($p = 0.09$); however, we believe that this insignificant result is probably due to the small number of subjects in this group ($n = 12$ in TC *vs.* $n = 24$ in TNC). Studies using threshold devices have been shown to increase the velocity of shortening and reduce inspiratory time during loaded breathing tasks.[20,21] This could contribute to less dyspnea during exertion, because a reduced inspiratory time during exercise would increase expiratory time if the total respiratory cycle time is the same. The increase in expiratory time could also reduce dynamic hyperinflation that an aging lung may experience.[22] We demonstrated that both at rest and after exertion, dyspnea was decreased after IMST in the TNC group.

### *The effect of IMST on 6MWD*

The 6MWT is frequently used to assess the functional status and exercise capacity for patients with COPD because it is inexpensive, safe, and valid. In addition, the 6MWD has been shown to be a good predictor of survival in patients with COPD.[23] However, mean improvements of 44 m and 24 m in the TNC and TC groups, respectively, meant that only TNC significantly improved 6MWD in our study.

According to the equations proposed by Enright and Sherrill[24] and by Troosters et al,[25] subjects in the TNC group obtained 83.7 ± 14.7% and 89.8 ± 16.2% of the predicted distance pre-IMST and 93.3 ± 17.3% and 100.3 ± 20.0% post-IMST, respectively, suggesting that our Taiwanese healthy adults walked less distance during the test (compared to the publishing data which the subjects were mainly Caucasians). The factors that contributed to their below average performance are unknown.

Improvement in the 6MWD in the TNC group is compatible with previous studies. Puhan[26] concluded that for patients with COPD, an improvement of at least 35 m represents an important effect, which corresponds to a 10% change of baseline 6MWD. In the current study, the TC group improved by only 6.88%, which did not meet the recommended minimal important difference. Considering that the only intervention was IMST and no other exercise program was offered, it is not surprising that the TC group had limited improvement. Recently Cote et al[27] followed 1,379 COPD patients for 55 months and found a threshold value for 6MWD. They concluded that a value less than 350 m is associated with increased mortality and should be considered as abnormal. In our TC subjects, after receiving IMST, subjects reached the standard of 350 m.

### *The effect of IMST on HRQOL*

Since no cure is possible for most COPD patients, the goal of clinical management is to improve patients' HRQOL. HRQOL also reflects a treatment's effect on the patient's well-being that is not reflected in physiological measures. Generic HRQOL, the SF-36 Health Survey, was chosen instead of disease specific QOL, because not all our subjects had COPD. Nevertheless, the SF-36 has been demonstrated to be reliable[28] and responsive in COPD subjects.[29] IMST, which is a valuable intervention intended to relieve the chief complaint of COPD, improved HRQOL in both training groups. There was a significant difference in all but two domains (social function and mental health) between the TNC and TC groups before IMST, indicating subjects with COPD felt less healthy, with the exception of social function and mental health, compared with subjects without COPD of same age and sex. Previous research has shown that the domains that exhibit the greatest linear trend with dyspnea scores are role physical, physical function and general health scales.[30,31] Our results confirmed that these three domains were significantly different between subjects with and without COPD. For the two COPD groups, there was no difference in seven out of eight domains. The only difference found was in bodily pain, where the CC group scored higher than the TC group. Since the major complaint for COPD patients is dyspnea and the grouping decision was made mainly in accordance with the subjects' preference, it is possible that CC subjects felt less dyspnea than TC subjects and chose not to participate in IMST.

TNC improved five domains of HRQOL in the SF-36, and these were physical function, bodily pain, general health, vitality, and social function. TC subjects improved in the same domains as TNC subjects with the exception of vitality. In contrast, CC subjects only improved in vitality.

In the component scales, PCS was improved in both training groups after IMST, which is consistent with previous findings. Scherer et al[32] found that PCS improved after respiratory muscle endurance training. This was the first study to demonstrate that hyperpnea training has a positive effect on QOL. Our study was aimed at improving respiratory strength, but it also showed improvement in PCS. Similar results were observed by Hill et al,[33] who applied high intensity inspiratory muscle training in patients with COPD and found that QOL was improved. Therefore, this is one more positive effect of IMST.

We should mention two limitations of the present study. First, our study included very few women, because we had difficulty in recruiting female patients for COPD groups. Second, we only recruited stable patients from the outpatient clinic; therefore, the study sample may not be representative of patients with moderate to severe COPD who are incapable of making regular visits.

In conclusion, IMST has been used primarily on pulmonary patients, and it has been shown that IMST provides a positive effect on inspiratory muscle strength, sensation of dyspnea, functional capacity and quality of life in patient populations. Our study confirms this conclusion for older people. In addition, for older people without pulmonary disease, the current study showed that IMST also improves inspiratory muscle strength, sensation of dyspnea, functional capacity and quality of life. We conclude that the strength training type of inspiratory muscle training can be recommended to older adults with or without obstructive symptoms to relieve dyspnea and improve QOL.

## Acknowledgment

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