A Comparison between Two Types of Resistive Inspiratory Muscle Training Devices in Normal Subjects in Regards to Pulmonary Functions

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Abstract

Introduction: Inspiratory muscle training (IMT) devices improve respiratory muscle strength, endurance and exercise capacity on healthy subjects. Because of the limited availability of the effect of IMT devices on healthy subjects with minimal activity level, this study was conducted to evaluate the effects of POWERbreath-plus® and Threshold IMT® on healthy subjects by measuring pre and post Maximal inspiratory pressure (MIP), Maximal expiratory pressure (MEP), Peak Expiratory Flow Rate (PEFR) and Mandatory Voluntary Ventilation (MVV) and to compare their effectiveness.

Method: In this quantitative comparative pilot study, 17 female subjects from Imam Abdulrahman Bin Faisal University were randomly assigned into four weeks of IMT program and were distributed into three groups: Threshold Group (TG) (n=5), POWERbreath-plus Group (PG) (n=7) and Control Group (CG) (n=5). MIP, MEP, PEFR, MVV were measured prior and following training. Subjects were taught to use the device twice daily with 30 repetitions at 60% of their MIP at the first two weeks with gradual increase by 10% for the remaining two weeks, until reaching load of 80% of MIP.

Results: MIP was improved significantly in both, TG and PG (p=0.005 and p=0.006, respectively), while no change was noticed in CG. For MEP, both TG and PG improved significantly with a p-value of (p=0.034 and p=0.208, respectively) while no improvements were observed in CG. PEFR proved to be significantly increased in PG (p=0.012), while there was no improvement in TG and CG. MVV showed improvement in both, TG and PG (p=0.023 and p=0.006, respectively), while no change was noticed in CG. Regarding MNOVA test, Threshold IMT® device showed to be superior to POWERbreath-plus® in increasing MIP significantly (p=0.000).

Conclusion: In conclusion, this study suggests that Threshold IMT® and POWERbreath-plus® devices improve MIP and MVV, however, threshold devices may have the superiority in improving MIP but still more studies are needed.

Keywords: Pulmonary function test; Inspiratory muscle training; Endurance; Asthma; COPD; Portable device

Introduction

Respiratory system works to balance the production of carbon dioxide and the consumption of oxygen within the pulmonary circulation to maintain homeostasis and minimize disturbances such as exercise intolerance and hypoxia. This mechanism is usually managed by inspiratory and expiratory muscles. Moreover, the diaphragm is the main respiratory muscle of the respiratory system; it acts like a barrier between the thoracic and abdominal cavities, and has an important role in expanding the thorax, by retracting towards the abdominal cavity during inspiration. In addition, it leads to the movement of the lower ribs upwards and forwards. This process will create a negative pressure to increase the thoracic volume. For that, the diaphragm is strongly resistant to fatigue because of its continuous function [1]. The mechanism of fatigue is usually managed by inspiratory and expiratory muscles by expanding the thorax maximally and increasing the minute ventilation (Ve) [1]. Muscle fatigue has a major role in affecting exercise tolerance among healthy individuals.

Therefore, muscle training devices play a very distinguished role in improving muscle activities [2]. Respiratory muscle training devices enhance respiratory muscle strength, endurance and exercise capacity. It is divided into two main categories: inspiratory muscle training devices (IMT) and expiratory muscle training devices (EMT). IMT devices improve both inspiratory and expiratory muscle strength [3]. In contrast, EMT devices improve the strength of the expiratory muscle [4]. IMT devices have two different modes, each for a specific use A) Voluntary isocapnic hyperpnea which enhances the inspiratory muscle endurance. B) Resistive inspiratory muscle training which enhances the inspiratory muscle strength [1]. This mode is divided into two types: Pressure resistive IMT devices (PR-IMT) and flow resistive devices. Pressure resistive IMT devices are usually handheld devices with a spring load that is impeded with different intensities [5]. These intensities can be adjusted by the resistive load knob (varying from low to high) [6]. In addition, the normal mechanism of PR-IMT devices requires the initiation of a negative pressure (breath) done by the subjects to overcome the load resistance [5]. The effectiveness of these devices has been proved in Turner et al., [7,8] which stated that the PR-IMT devices work on improving the maximal inspiratory pressure (MIP). In
addition, proved that there is an improvement in MIP [3], maximal expiratory pressure (MEP), diaphragm mobility and thickness.

There are several types of PR-IMT such as (POWERbreath plus®) and (Threshold IMT®) which has wide ranges of features for instance; muscle strengthen, endurance training and improvement of perception of dyspnea [5,9]. Such devices can be used with different intensities: high, moderate and low intensities. Thus, each will be discussed separately [10]. On the other hand, flow resistive devices have two types passive and dynamic. Passive flow resistive devices require inhaling through a fixed orifice which can be changed to increase the training load and the smaller the diameter, the higher the load is. However, one of the disadvantages the flow resistive devices have, that they are affected by the inspiratory flow which is initiated by the subject. Thus, breathing patterns should be monitored during training when using these devices. While, dynamic flow resistive devices require to inhale through a variable orifice within the breath, which makes the dynamic flow resistive devices superior than passive flow resistive devices [1].

For pressure resistive IMT devices, high intensity exercise in general results in improving maximum oxygen uptake (VO2 max) and aerobic performance in healthy subjects. In addition, according to [11,12] high intensities that ranged between (80%-90%) of MIP in PR-IMT devices, improve the respiratory muscle strength, work capacity, power output and lung volumes but this range of intensities is difficult to be maintained for a long period of time. Based on Mathur et al. [13], PR-IMT devices are safe for healthy adults, at the same time, high intensities will not induce diaphragmatic fatigue and muscle damage, but they may cause inspiratory muscles soreness [14]. In addition, proved that PR-IMT positively affects both maximal inspiratory and expiratory pressures, in comparison to EMT devices which affect maximal expiratory pressure [4].

Low and moderate intensities that ranged between (40%-60%) have no effect on lung volumes. 60% of MIP improves muscle strength, work capacity and power output. While, 40% of MIP improves muscle strength, work capacity and power output [12]. According to Souza et al. [3], there is an improvement in muscle strength, MEP, MEP and diaphragm thickness in elderly females with duration of eight weeks duration with a moderate intensity of 40% of MIP. On the other hand, Albuquerque et al., [15] demonstrates that six weeks of PR-IMT training was enough to improve the inspiratory muscle strength and functional capacity in physically active elderly subjects with intensity of 40%-70% of MIP. Both Souza et al., [3] and Albuquerque et al., [15] showed no change in lung volumes as stated by Enright and Unnithan [12]. In contrast, TURNER et al. [8] reported that six weeks training period using PR-IMT in asthmatic patients with a moderate load of 50% improved MIP, tolerance and perception of dyspnea. But no significant changes were noted in the following pulmonary function variables; peak expiratory flow rate, forced expiratory flow, neither forced vital capacity nor forced expiratory volume during the first second.

Pressure resistive inspiratory training devices showed improvements in different parameters with several cases such as; Asthma [8], chronic obstructive pulmonary disease (COPD), Cystic Fibrosis [16], Hypertensive [17] and ventilator dependent patients [18]. Since COPD patients have daily limitations triggered by respiratory muscle fatigue, many authors have established their studies on them. For that, researchers found that PR-IMT devices had an impact on their health status by strengthening their respiratory muscles and improving daily life activities. Regarding applying high intensities of PR-IMT on COPD patients, two studies [19,20] had a sample of nearly 35 subjects; the intensities were highly similar (nearly up to 80% of MIP in both) and applied six weeks training period. Huang et al., [19] the investigators applied daily training twice a day, each session lasts for 15 minutes. While, Madariaga et al. [20] applied five days of training per week. However, both studies revealed an increase in MIP and quality of life, but when it comes to Huang et al. [19], it is more updated and its training load is individualized to each participant that made it look stronger, unlike [20], which had a generalized load for each participant.

Pressure resistive inspiratory training devices showed improvements on healthy subjects both older adults and athletes, including; Triathlons, rowing, running, cycling HajGhanbari et al. [21]; Kilding et al. [22] reported an increase in MIP, a decrease in swimming time and perception of dyspnea in 16 competitive swimmers over six weeks with a moderate intensity of 50% MIP. While MILLS et al., [23] observed improvements in MIP, diaphragm thickness and inspiratory flow when using an initial load of 50% MIP in older adults for eight weeks, but unchanged inspiratory muscle endurance, spirometry measures, physical daily activity level were observed.

Because of the limited availability of the effects and benefits for both POWERbreath Plus® and Threshold IMT® devices on healthy individuals with low activity level. This study aims to: Assess the effects of POWERbreath plus® and Threshold IMT® on healthy subjects by measuring pre and post MIP, MEP, Peak Expiratory Flow Rate (PEFR) and Mandatory Voluntary Ventilation (MVV), compare the effectiveness between POWERbreath Plus® and Threshold IMT® devices on healthy subjects. We hypothesized that there is no effect of both POWERbreath plus® and Threshold IMT® on pulmonary function with normal subjects and there is no device superior than the other.

Method

This study is a quantitative comparative pilot study which was conducted between February 16, 2016 and May 2016 on 101 female subjects who were recruited from Imam Abdulrahman Bin Faisal university by using flyers and posters around the campus, healthy subjects (n=21) were enrolled in the study. The inclusion criteria were as follow: Age of 18 to 30 years, body mass index (BMI) of 18.5-24.9 kg/m² and minimal daily activities measured by an IPAQ questionnaire [24]. All subjects with smoking history, cardiopulmonary diseases, neuromuscular diseases, pregnant women and any recent thoracoabdominal surgeries were excluded (68.35%) out of the excluded sample, 40.7% were overweight, while 12.9% were under weight. 31.5% had moderate/high level of activity. 1.9% passive smoker, 1.9% pregnant, 1.9% cardiac diseases, 3.7% pulmonary diseases, 1.9% blood diseases, while 3.7% had recent thoracoabdominal surgeries. The Institutional Review Board committee of Imam Abdulrahman Bin Faisal University (IRP) UGS 2016-03-003 as an unfunded research, where the company has no relation or connection with the researchers, by any means.

Procedure

A sample size of 21 healthy subjects was divided into three groups using simple random sampling. Threshold Group (TG) (n=7): they will be given a pressure-threshold IMT device (Threshold Inspiratory Muscle Trainer, Healthscan Products, Cedar Grove, New Jersey, USA). POWERbreath plus Group (PG) (n=7): inspiratory resistive training device (IRT) (POWERbreath®, Galam, UK). Control Group (CG)
The normal controlled group out of the 21 participants 4 of them were withdrawn at the middle of the study. The first two participants in the threshold group were withdrawn from the study due to their busy schedule. While the other two participants in the control group withdrawn because of unexplained reasons. The flow of participants in the study is illustrated in Figure 1.

The Physical characteristics and anthropometric measurements of the enrolled subjects are illustrated in Table 1.

| Groups  | TG (n=5) | PG (n=7) | CG (n=5) |
|---------|----------|----------|----------|
| Age (years) | 20.2 ± 1.3 | 19.6 ± 1 | 20.6 ± 1.1 |
| Height (cm)   | 156.4 ± 7.5 | 156.6 ± 4.7 | 159.3 ± 8.1 |
| Weight (kg)   | 53.2 ± 5.3 | 52.4 ± 8.4 | 56.8 ± 6.4 |
| BMI (kg/m²)   | 21.0 ± 1.7 | 21.2 ± 2.3 | 22.3 ± 1.3 |

Values are reported as Mean ± SD. TG: threshold group; PG: POWERbreath plus group; CG: control group. BMI: body mass index.

Table 1: Baseline characteristics of the participants from groups studied.

### Inspiratory muscle training protocol

Experimental groups (Threshold and POWERbreath plus) were instructed to use the device twice daily with 30 repetitions at 60% of MIP at the first two weeks. With gradual increase by 10% for the remaining two weeks, until reaching a load of 80% of MIP. The duration of the training is four weeks (56 sessions). The subjects were instructed to follow these instructions while using the device. 1) Sit in a comfortable position and put the nose clips on the nose so that all of the breathing is done through the mouth. 2) Place the lips around the mouthpiece, making a good seal. 3) Take a larger breath, than normal (but not to total lung capacity). 4) Exhale slowly at an inhalation to exhalation ratio of 1:3 or 1:4 (ensuring that exhalation is longer than the inhalation time). 5) Repeat these steps until completing 30 breaths or whenever you feel dizzy. 6) Record number of repetitions, load, training time and resting time during the session on the diary form (POWERbreathe Medic plus, 2015). To insure proper instructions; the procedure was explained verbally and a booklet of the proper instruction was provided to the participants. Also, the procedure was performed by the researcher in front of the participant and the first session was observed by the examiner for both experimental groups. While the other sessions were performed by the subjects at home and to ensure adherence, a dairy form was given, and a continuous contact was done via the social media apps (WhatsApp) as a daily reminder for the participants to stick to the training period which is four weeks.

### Pre and post training tests

Baseline measurements (MIP, MEP, PEFR, MVV) were taken in consideration at the beginning and at the end of the training program (before and after four weeks of training) in Pulmonary Function Testing laboratory at the college of applied medical sciences. Such parameters were chosen to be measured after careful analysis. MIP, MEP and MVV can reflect direct improvements when using muscle strengthening devices. While PEFR has been used to measure the maximum speed of airflow during expiration. Tests were explained and performed by the researchers on front of the participants to ensure proper instruction. These measurements include:
Maximal inspiratory/expiratory pressure (MIP, MEP)

MIP/MEP measurements were done using a hand held, manual pressure manometer (Smiths medical, Pos./Neg. Manometer, USA) and the participant was instructed to be seated, exhaled completely and slowly and placed the mouthpiece with a good seal within the mouth, inhaled as much as possible. Each maneuver was sustained for at least one second on the pressure gauge. The highest value was reported out of the five maneuvers and vice versa applies to the MEP. The highest and best value out of the three trials was reported as cm H₂O [25].

Mandatory voluntary ventilation (MVV)

This parameter was measured by Koko Trek computerized spirometer (Ferrari-Respirtory, Inc. Koko-Trek, USA). The participant sat in an upright position, placed a nose clip and ensuring a good seal around the mouthpiece. Starting with three normal tidal volumes, followed by 12 s of fast and deep breathing (panting). The highest and best value out of the three trials was reported as L/min [26].

Peak expiratory flow rate (PEFR)

This test is an effort dependent test. Therefore, to obtain valid results, cooperation and proper instructions should be guaranteed. A hand held peak expiratory flow meter from Philips Company was used. The participant was instructed to inhale deeply and rapidly as possible and then exhaled vigorously without hesitation or delay through the device in upright position without flexion or extension of the neck. Three trials were done and the best one was documented as L/min [26].

Statistical analysis

Data were analyzed using SPSS program version 16.0 statistical software (SPSS Inc., Chicago, USA). Descriptive statistics were obtained for the data referring to the physical characteristics between the groups to measure the dispersion. In order to calculate the difference within each pre-test and post-test measurements for a specific group and to report the mean of changes if statistically significant, paired sample t-test was used. MANOVA (Pairwise) test was used to test all probable combinations of the selected values for each pair of variables. Also it is referred to a two-way test. Statistical significance level was set at P<0.05. All values are presented as mean ± Standard deviation (SD) [27].

Results

17 Healthy female subjects with minimal activity level were divided into three groups: TG (n=5), PG (n=7) and CG (n=5). The groups were compared by using paired t-test before and after the training period. MIP, MEP, PEFR and MVV were the main parameters to be compared between the groups, based on a P-value of (p<0.05).

All subjects completed the training period as observed on the diary forms, the non-adherence was <5% of the training sessions. Based on paired t-test, MIP improved significantly in both, TG and PG (p=0.005 and p=0.006, respectively), while no change was noticed in CG Figure 2.

Additionally, PEFR proved to be significantly increased in PG (p=0.012), while no change was observed in TG nor CG Figure 4.

Figure 2: Comparison between pre and post training MIP values for Threshold group (TG), POWERbreath plus group (PG) and control group (CG). *Significantly different (p value<0.05)

Figure 3: Comparison between pre and post training MEP values for Threshold group (TG), POWERbreath plus group (PG) and control group (CG). *Significantly different (p value<0.05)
Figure 4: Comparison between pre and post training MVV values for Threshold group (TG), POWERbreathplus group (PG) and control group (CG). *Significantly different (p value<0.05).

Table 2: Change of respiratory muscle strength and pulmonary function prior and following IMT period.

|                | TG         |          | PG         |          | CG         |          |
|----------------|------------|----------|------------|----------|------------|----------|
|                | pre        | post     | P-value    | pre      | post       | P-value  |
| MIP (cmH\text{\textsubscript{2}O}) | 46.4 ± 13.3 | 74 ± 18.5 | 0.005\*   | 37.6 ± 11.7 | 58.3 ± 18.7 | 0.006\*  | 43.2 ± 11.3 | 49.4 ± 15.8 | 0.156     |
| MEP (cmH\text{\textsubscript{2}O}) | 40.6 ± 6.8  | 56.2 ± 5.7 | 0.034\*   | 40 ± 11.2 | 47.1 ± 9.7  | 0.208    | 49.6 ± 20.85 | 48.4 ± 7.2  | 0.913     |
| PEFR (L/min)   | 362 ± 68.3  | 378 ± 6.9 | 0.242      | 347.1 ± 60.2 | 375.7 ± 48.9 | 0.012\*  | 382 ± 40.2 | 374 ± 63.1 | 0.495     |
| MVV (L/min)    | 98.5 ± 16.5 | 115.7 ± 25.1 | 0.023\*  | 96.5 ± 25.3 | 112.2 ± 23.8 | 0.006\*  | 101.6 ± 11.5 | 102.2 ± 17.7 | 0.926     |

Values are reported as Mean ± SD; *p<0.05 indicate significant difference. TG=Threshold Group; PG=POWERbreath Plus Group; CG=Control Group; MIP=Maximal Inspiratory Pressure; MEP=Maximal Expiratory Pressure; PEFR=Peak Expiratory Flow Rate; MVV=Mandatory Voluntary Ventilation.

Table 2: Change of respiratory muscle strength and pulmonary function prior and following IMT period.

MVV, showed improvement in both, TG and PG (p=0.023 and p=0.006, respectively), while no change was observed in CG Figure 5. All data concerning paired t-test are listed in Table 2.

Regarding MANOVA test, Threshold IMT\textsuperscript{*} showed to be superior to POWERbreath plus\textsuperscript{*} in increasing the MIP significantly (p=0.000) while there is no difference observed in the MVV (p=0.843) Table 3.

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Comparison between TG and PG (P-value) | 0.000* | 0.182 | 0.843 | 0.843
---|---|---|---|---
TG= Threshold Group; PG=POWERbreath Plus Group; CG=Control Group; MIP=Maximal Inspiratory Pressure; MEP=Maximal Expiratory Pressure; PEFR=Peak Expiratory Flow Rate; MVV=Mandatory Voluntary Ventilation. *p<0.05 Indicate Significant Difference.

**Table 3:** The difference between Threshold and POWERbreath plus group using Pairwise.

**Discussion**

This study suggests that both training devices ‘Threshold IMT®’ and POWERbreath plus® were found to be effective and well tolerated by the subjects. In t-test, Threshold group revealed improvement in MIP, MEP and MVV. And no improvement was observed in the PEFR. While, MIP, PEFR and MVV had significant improvement in POWERbreath plus group. There were no improvements in all variables in control group. However, MNOVA-test showed that Threshold® device is superior to POWERbreath plus® device in improving the MIP parameter, while the MVV did not show any difference between the two devices. These findings answer the study’s questions regarding the effectiveness of Threshold IMT® and POWERbreath plus® devices with healthy subjects who have minimal daily activity and the comparison between the two devices concerning their effectiveness.

Inspiratory muscle strength increased significantly with the experimental groups after training period of four weeks (56 sessions) as it was applied by Paiva et al., [7]. In addition, Paiva et al., [7] studied the effectiveness of incentive spirometry (IS) and threshold on 40 healthy female subjects that confirmed significant improvement on MIP with Threshold group. This finding proved that four weeks of training period is applicable to improve inspiratory muscle strength and it can be useful to train the inspiratory muscles and improve their strength. Likewise, Enright and Unnithan [12] have conclude that using IMT with load of 60-80% of MIP on healthy subjects will increase their respiratory muscle strength which characterized by increase of both MIP and MEP. Not to forget to mention that other systematic review and meta-analysis Neves et al., [28] stated that IMT devices combined with EMT used with COPDs had a significant impact on both MIP and MEP which reflect muscle strength. This could be a strong indicator that improvement in muscle strength with COPDs might also reflect some improvements on healthy individuals with low activity level. Meanwhile, as being said before, minimal studies were done using POWERbreath plus® device-In particular, on healthy subjects with low activity level. Considering the manufacturer’s words, no effects on MEP could be observed (POWERbreathe Medic plus, 2015). For that reason, our research can conclude that threshold reflects changes on both MIP and MEP equally, rather than changes on MIP merely with POWERbreath plus® device.

Improvement in PEFR was observed in PG only which is in agreement with the feature that the POWERbreath Plus company developed to improve the air flow [29]. Turner et al., [8] which studied the influence of IMT on exercise tolerance with asthmatic patients; it was applied on Fifteen asthmatic patients (seven males, eight females) seven as Threshold group while the other eight in the control group; and they proved that PEFR doesn't show any improvement after six weeks of training using IMT device (Training consisting of 30 breaths twice daily at 50% of MIP) and that's in harmony with our findings in Threshold group.

For the MVV parameter, there were improvements in Threshold group and POWERbreath plus group. This improvement indicates the efficiency of the respiratory mechanics and adequate effort. That led to an improvement in the overall physical activity and exercise performance. As Ray, Pendergast, and Lundgren [30] proved that the resistance respiratory muscle training on nine males divers for four weeks (30 min per day, 5 days per week) improved the MVV significantly. In contrast, Edwards and Cooke [31] stated that there was no change in MVV parameter on 18 males between both POWERbreath group (PG=10), the control group (CG=8) and even within the group itself. This could be referred to the low load used in their study, which was only 15% of the MIP. Another study Galvan and Cataneo [32] evaluated the influence of the respiratory muscle training on pulmonary function in 50 male tobacco smokers used a moderate load, which was up to 50% of MIP and this showed a significant improvement in the MVV. So moderate to high load of the MIP can reflect significant changes in the MVV parameter. In addition, Mickleborough et al., [33] had their study on 24 runners (12 male) who were divided into three groups: inspiratory flow resistive load (IFRL) group, Sham-IFRL group and the control group. Experimental
groups used their device three times a week for six weeks training period. Working load of 80% of their MIP was assigned for the IFRL group and 30% for Sham-IFRL group, and nothing for the control group. At the end, they concluded that no effects were noticed in the MVV in all groups (IFRL, Sham-IFRL and CG).

Regarding the training loads that had been applied on the subjects based on their initial MIP. The loads were set at 60% of MIP for two weeks, and then increased gradually to 70% in the third week and 80% in the last week. We started the first two weeks with 60% of MIP for better tolerance until reaching 80% for one week only because 80% of MIP is difficult to be maintained for a long period of time [12]. As shown in Table 4. Threshold group had a higher MIP from the beginning, which led to higher loads used by the subjects in comparison to POWERbreath plus group Figure 6. For Threshold® device, the load ranges are limited to 41 cmH2O and one of our subjects had exceeded 41 cmH2O when she reached her 70% and 80% of MIP (45.5-52 cmH2O respectively) so we have been forced to use a sustained load of 41 cmH2O for the remaining two weeks. On the other hand, POWERbreath plus® device had higher loads up to 78 cmH2O. For that, this can be considered a limitation for the Threshold device. So we recommend to Philips Company to upgrade the loads, to reach a wider range so it can be used with healthy subjects. Few limitations were noticed in our pilot study that should be considered. First, the sample size was relatively small, for that, we cannot generalize the results until applying our method on a larger sample size. This was because the majority of the recruited sample was not eligible to be enrolled in our study, based on our criteria. Second, lack of accessible facilities was a huge burden to us, this led to only female subjects were available to participate in the study. Moreover, the duration of the study was a barrier for some of the participants, because of their busy schedule. Finally, electrical devices to measure MIP, MEP and PEFR are recommended in further studies to have more precise measurements.

### Table 4: This table demonstrates the means of the training loads for Threshold and POWERbreath plus group.

| Effect | 60% of MIP (cmH2O) | 70% of MIP (cmH2O) | 80% of MIP (cmH2O) |
|--------|-------------------|-------------------|-------------------|
| O      | 27.8 ± 8          | 32.2 ± 9.4        | 37 ± 10.8         |
|        | 22.6 ± 7          | 26.6 ± 8.8        | 30 ± 9.5          |

Values are reported as Mean ± SD. TG=Threshold Group; PG=POWERbreath Plus Group; MIP=Maximal Inspiratory Pressure.

### Conclusion

In conclusion, this study proves that PR-IMT devices including Threshold® and POWERbreath plus® can show improvements in MIP and MVV. Improvement in MEP only was observed with Threshold group, while PEFR improved only with POWERbreath plus group. Moreover, Threshold® devices have the superiority in improving the inspiratory muscle strength.

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