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Effects of Aerobic and Inspiratory Muscle training on Pulmonary functions in Hemodialysis patients

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Present study was conducted to analyze the effect of 12 weeks of supervised aerobic training program combined with Inspiratory Muscle Trainer (IMT) on pulmonary functions in hemodialysis patients (HD). Pulmonary functions were measured by electronic spirometer including (Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC, peak expiratory flow (PEF) and Maximum Voluntary Ventilation (MMV). Fifteen patients from both genders enrolled in the study. They were received combined IMT with supervised program of aerobic training in the form of leg pedaling exercises. The results of this study showed remarkable improvement in all measured values of pulmonary functions. It was concluded that a combined IMT with supervised program of aerobic training for 12 weeks have significant improvement regarding pulmonary functions in hemodialysis patients.

Keywords: Hemodialysis; Inspiratory Muscle Trainer; Aerobic Training, Pulmonary function.

INTRODUCTION

Chronic kidney disease (CKD) is defined as increasing impairment of renal function over a period of months or years., the estimated annual incidence in Egypt for End Stage Renal Disease (ESRD) is around 74 per million and the total prevalence of patients who need hemodialysis as a replacement therapy is 264 per million(El-Arbagy et al., 2016) .

It has been observed that there was defective protein metabolism in patients with end-stage renal disease, especially who were treated with regular hemodialysis. The impaired protein synthesis and protein degradation may lead to generalized muscle atrophy which in turn results in significant reduction of respiratory muscle strength, its ability to generate force and consequently pulmonary functions (Rahgoshai et al., 2010), (Reboredo et al., 2007) and (Coelho et al., 2006).

Regular physical exercises in the form of intradialytic cycling ergometer may lead to improved peak oxygen consumption, maintenance of physical endurance, functional independence (Storer et al., 2005) and (Johansen, 2005), and the overall quality of life in hemodialytic patients

(Painter, 2005) and (Afshar et al., 2010).

Inspiratory muscle trainer (IMT) is a recent effective method to enhance respiratory muscles strength (Brilla and Kauffman, 2014). (Pellizzaro et al., 2013) showed that respiratory muscle training by using IMT program for 10 weeks during dialysis sessions has a significant improvement in both maximum inspiratory pressure (PImax) and maximum expiratory pressure (PEmax). (El-Deen et al.,2018), Therefore, strengthening of the respiratory muscles by using threshold inspiratory muscle trainer may enhance pulmonary functions. According to (De Medeiros et al.,2017), the percentage of type I fibers and size of type II fibers in respiratory muscles of COPD patients had increased following the application of inspiratory muscle trainer.

From the above findings, this study aims to compare the combined effect of performing both aerobic exercise training and inspiratory muscle trainer on pulmonary functions in hemodialytic patients.

MATERIALS AND METHODS

Subjects

Fifteen clinically stable hemodialysis patients from both sexes (8 males and 7 females) were enrolled into the study. They were received supervised program of aerobic training in the form of leg pedaling exercises and inspiratory muscle trainer (IMT) in addition to standard medical treatment. Their ages were from 40 to 60 years old. They had regular hemodialysis sessions at least three months with each session lasting 4 hours at a hemodialysis unit of Al-Kasr Al Aini hospital, at Faculty of Medicine, Cairo University, Egypt.

Inclusion Criteria:

Patients with an acceptable cognition level and ability to comprehend instructions were included. All of them had vascular access through an arterio-venous fistula. A specialized physician initially examined all recruited patients.

Exclusion criteria:

Patients who met the following criteria were excluded from the study such as patients with chronic cardiac, chest, neurological disease or who were currently smoking, which may interfere with exercise training. All patients, regardless of their health status were permitted to quit and withdraw from the study at any time.

A single – group interventional study design was performed according to the principles of the Declaration of Helsinki 1975, revised Hong Kong 1989 and was approved by human research ethics committee of the Faculty of Physical Therapy, Cairo University.

Evaluation Procedures:

Electronic Spirometer:

Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1 /FVC ratio, peak expiratory flow (PEF) and Maximum Voluntary Ventilation (MVV) were measured using electronic Spirometer (Model - Schiller AG, CH6304). All measurements were done according to Guidelines of Pulmonary Function Tests (Souza ,2002), (Pereira et al., 2007). MVV was calculated as approximately equal to the FEV_1 x4 (Barreiro and Perillo, 2004). Measurements for all patients were carried out once at the beginning of the study and another after conclusion of 12 weeks of training program.

Treatment Procedures:

Aerobic Training Program:

Patients were assigned to perform a supervised training program in the form of leg pedaling exercises using (grand easy exerciser 111) in a semi-supine position and during the first two hours of hemodialysis procedure to avoid dialysis hypotension episodes. Program extended over a period of 3 months, three times a week. Training sessions were done under direct supervision of a physiotherapist. Each training session consisted of three phases (El Shemy et al., 2016). Phase one– warm-up (5 minutes) – free active exercises of the lower extremities. Phase two– the conditioning phase (20 minutes) – exercise on a leg pedaling (the speed was set at one cycle per second at 0.5 km/h,). Phase three – cool-down (5 minutes) – free active exercises of the lower extremities. Training duration was gradually increased from 10 min in the first session to 30 min in the subsequent sessions (Ashfar et al., 2010), (Al Rashedi and Ghaleb, 2017) and (Bae et al., 2015).

Intensity of the prescribed exercise was based on Borg's Perceived Exertion Scale (Bae et al., 2015). According to this scale, patients assign a score to the intensity of fatigue that varies 6 to 20 points. During leg pedaling, patients were asked about the score they would assign to their fatigue every 5 minutes. The pedaling load was preserved to reach an intensity of stress enough to decide a score of fatigue between 11 and 13 points, which corresponds to an exercise of “mild” intensity to “quite hard” in this scale. If changes were observed, exercise was discontinued for 10 min. After which, if symptoms resolved, patients were allowed to carry on. If symptoms did not resolve then no more exercise was allowed for that day. Increasing the duration of a single training session and alteration of the intensity is determined by the patient's reaction to physical effort.

Termination of exercises during the training session took place in the following cases: inability to maintain the recommended rate of pedaling, occurrence of retrosternal, muscular, or articular pain, occurrence of nausea, dizziness, muscle cramps; or patient's request (malaise or fatigue) (El Shemy et al., 2016).

- Inspiratory muscle training program:

Threshold IMT (HS 730-010) manufactured for Respiratory Drug Delivery, UK, Ltd was utilized as a training program of inspiratory muscle. A dial selector used to perceive/note the resistance level in addition to containing a valve to ensure consistent resistance regardless of the airflow that trains respiratory muscles. Each patient breathes through attaching a separate mouthpiece firmly and put the nose clip and inhale deeply through the mouth piece to generate an inspiratory pressure greater than the indicated presetting threshold pressure to compress the spring and open the valve. The intensity was 30% from 10 Repetition Max with duration ranged from 20-30 minutes (Goselink et al., 2011). The Inspiratory muscle training session was started after 10 minutes of resting from aerobic training.

Statistical analysis

For descriptive statistics, mean and standard deviations were calculated for all variables. Bar graphs were used to display the means of all variables pre and post treatment. For analytical statistics, Paired t-test was used to test if there is a remarkable difference between pre and post means of the calculated variables. The Statistical program (SPSS) version 16.0 was used in statistical analysis. The significance level was set at 95% so that a test is considered significant if p-value <0.05.

RESULTS

As shown in table (1), describing the general characteristics of the subjects of training group regarding the mean values of age, weight, height, and BMI.

Table (1): The mean age, weight, height, and BMI for the training group

Variable	Study Group
	$\bar{X}$ ±SD
Age (years)	49.07 ± 6.69
Gender **Males** **Females**	 8 (53.3%) 7 (46.6%)
Weight (kg)	66.64 ± 9.35
Height (cm)	159.85 ± 8.82
BMI (kg.m-²)	25.93 ± 2

$\bar{X}$: Mean SD: Standard deviation

Table (2) shows results of the mean ± SD values of training group for all measured variables (FEV_1,FVC, FEV_1/FVC, FEF and MVV) the pretreatment mean values were 47.07 ± 16.37%, 44.85 ± 15.98%, 100 ± 17.72%, 29.78 ± 12% and 48.65 ± 18.53% respectively). While post treatment mean values were (52.57 ± 15.36%, 104.5 ± 17.54%, 38.42 ± 15.08%, 57.13 ± 19.26% respectively.

Table (2): Comparison of pre and post treatment means values of the training group.

Variables	Pre-treatment	Post treatment	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD		
FVC (%)	47.07 ± 16.37	53.14 ± 12.76	0.004	S
FEV1 (%)	44.85 ± 15.98	52.57 ± 15.36	0.002	S
FEV1/FVC (%)	100 ± 17.72	104.5 ± 17.54	0.23	NS
PEF (%)	29.78 ± 12	38.42 ± 15.08	0.004	S
MVV (%)	48.65 ± 18.53	57.13 ± 19.26	0.004	S

SD: standard deviation, P: probability, *S: significant, NS: non-significant.

Discussion

In the current study, the results showed that the inspiratory muscle trainer radically enhanced respiratory muscle strength and pulmonary functions regarding FVC, FEV1, PEF and MVV%. These results came in agreement with results concluded by (El sisi et al., 2017) who evaluated the effect of IMT versus Pranayama on pulmonary functions of hemodialysis patients, which further confirmed that IMT had more significant effect compared to other techniques (FVC, FEV_1, PEF) (p was 0.0001*).

Moreover, these results coincided with the results established by (Medeiros et al., 2018) who assessed the effects of Daily performance of IMT with good adherence in patients with chronic kidney diseases, their results demonstrated beneficial effects on pulmonary system such as increased diaphragmatic mobility and thickness, improved lung volumes and functional capacity.

Furthermore, the results of (El-Deen et al.,2018) showed significant improvement in respiratory muscle strength regarding PImax, and PE max by using pressure vacuum meter as well as improvement in pulmonary functions regarding FVC%, FEV_1%, and PEF% with application of IMT during hemodialysis sessions for 12 weeks.

(Winkelmann et al., 2009) found that exercise interventions dramatically enhanced FVC, FEV_1, PEF, in heart failure patients and cases with inspiratory muscle weakness.

Also (Enright et al., 2006) showed that this regimen of high-intensity IMT combined with aerobic training strengthened the inspiratory muscle function, as well as caused morphological changes in the diaphragm, and increased lung capacities (FVC, FEV_1, FEV_1 /FVC and peak expiratory flow) in healthy subjects.

(Dassios et al., 2013) stated that application of IMT and aerobic training for patients with cystic fibrosis provided remarkable amplification in VC, FEV_1 and arterial oxygen saturation. Also (Shendy and Farag., 2015) concluded that both IMT and aerobic training provided a significant improvement in the ventilatory functions due to heightened the respiratory muscles power, efficiency and endurance.

Also (EL Shemy et al., 2016) reported that leg pedaling for 30 to 40 mins during the 1st two hours of the dialysis session for 3 months improve musculoskeletal system, activity of daily living, circulatory, respiratory system and neurological system.

This was verified by (Carvalho ,et al., 2014) who reported that hemodialysis patients have different features that contributes to a sedentary lifestyle, such as functional and structural alterations of skeletal muscles, inflammation, uremia, reduced secretion of testosterone, malnutrition, and hyperparathyroidism. Furthermore, the procedure of dialysis itself increases catabolism, which leads to a deterioration of the physical condition, which is the direct cause of limited exercise capacity among those patients.

From the above findings, it has been determined that the limited exercise capacity and early fatigability as well as presence of muscle cramps (due to decrease the blood calcium level) are the most common causes of early termination of aerobic training session in study group. Therefore, it is recommended to conduct another study in which the aerobic training exercise can be applied intra dialytic while using inter dialytic IMT (in non- dialytic days) to avoid the occurrence of fatigue.

CONCLUSION

It was concluded that combined IMT with supervised program of aerobic training for 12 weeks have significant improvement regarding pulmonary functions in hemodialysis patients.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of the study.

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