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RESEARCH ARTICLE

DOES INSPIRATORY MUSCLE TRAINER HAVE AN EFFECT ON DIAPHRAGMATIC EXCURSION IN HEMODIALYTIC PATIENTS?

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Abstract

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Background: Hemodialysis patients suffer from severe muscular weakness and one of the most important muscle is the diaphragm – main muscle of respiration – that was experienced by dyspnea and decreased functional capacity due to a unique form of protein and energy malnutrition .**Purpose:** to determine the response of diaphragmatic excursion to inspiratory muscle trainer prior hemodialysis session. **Methods:** Thirty patients of both sexes (10 men and 20 women) were included in this study with mean age(± SD) was 35.47 (± 6.51). They were chosen from El Sahel Teaching Hospital, Nephrology department, dialysis unit, and undergoing dialysis from at least 2-3 years.Ultrasonography (U.S) was used to assess diaphragmatic excursion (D.E) during deep breathing maneuver before and at the end of the training program. All patients received the inspiratory muscle training for 12 weeks, 3 times/week. **Results:** The results of this study showed statistical significant difference between pre and post-training in diaphragmatic excursion (p <0.001) with a percentage of improvement 65.74%. The percentage of improvement in men was 65.29% corresponds that in women was 66.08% compared to the pre-data status. **Conclusion**: Inspiratory muscle training by inspiratory muscle trainer device for 12 weeks in hemodialysis patients had significantly improved the diaphragmatic excursion (DE) that ensures the improvement in their mechanics of breathing and sense of dyspnea.

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Introduction:-

Chronic kidney disease is an evolving problem in modern countries. In 2010, 520,000 patients had routine dialysis. Each year, new patients (4.1%) are added to dialysis patients. Although hemodialysis has increased life expectancy of these patients, they suffer from many complications including restricted physical activity, muscle weakness, anemia, osteoporosis and metabolic disturbances. Muscle weakness is manifested as generalized weakness and particularly respiratory muscle weakness manifested by reduced vital capacity.[1]

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Several decades of research efforts devoted to studying the patterns of chronic kidney disease-end stage renal disease (CKD-ESRD) progression as well as the impact of acute kidney injury (AKI) on this continuum of CKD-ESRD evolution but the full understanding of the process (es) of CKD-ESRD progression remains elusive[2].Significant muscle weakness and associated atrophy is seen in both dialysis patients and in patients with chronic kidney disease (CKD) stages 3–4. This is associated with increased morbidity and mortality[3,4].

Maintenance dialysis patients encounter multiple catabolic processes and experience a unique form of protein and energy malnutrition, which is characterized by muscle wasting and decreased visceral protein stores. The pathophysiology of muscle wasting in chronic kidney disease clearly is complex, multifactorial, and not fully elucidated. What is clear is that abnormalities in muscle function, exercise performance, and physical activity begin in earlier stages of chronic kidney disease and progressively worsen as ESRD ensues[5].

The diaphragm is the major respiratory muscle, contributing up to 70% to resting lung ventilation. During dialysis the diaphragm as a skeletal muscle is affected by protein breakdown leading to its weakness and limitation of its movement [6]. These muscles show decreased in muscle strength and endurance properties resulting from uremic myopathy. Some authors who have studied the involvement of uremia in the diaphragm have concluded that loss of strength occurs through severe uremia. The ventilatory deficit due to this impairment in respiratory muscles, combined with other lung tissue impairments, compromises the functioning of this system, thereby contributing towards decreased lung capacity[7].

The relationships between the lungs and the kidneys are clinically important ones in both health and disease. Chronic renal failure may affect respiratory function. Pulmonary dysfunction may be the direct consequence of circulating uremic toxins or may result indirectly from volume overload, anemia, immune suppression, extra osseous calcification, malnutrition, electrolyte disorders, and/or acid–base imbalances[8].

As the respiratory muscles are morphologically and functionally skeletal muscles and therefore respond to training, just as any muscle of the locomotor system[9]. Inspiratory muscle training (IMT) is a technique used to increase strength or endurance of the diaphragm and accessory muscles of inspiration which improve inspiratory muscle functions, lung volumes, work capacity and power output[10].

Methods:-

Participants:-

Thirty patients of both sexes (10 men &20 women) undergoing hemodialysis from at least 2-3 years selected from El Sahel teaching hospital nephrology department ,Dialysis unit with mean age (± SD) was 35.47 (± 6.51). They performed the dialysis 3 times / week. The purpose, nature and potential risk of the study were explained to all patients. All patients signed a consent form prior to participation in the study and confidentiality was assured.
The inclusion criteria in the studied group were patients with creatinine level ranged from 4.8-7.8mg/dl and didn't participate in any physical activity prior the study by at least 6months. Patients had the following criteria were excluded from the study : recent lung surgery (within 12 months), un-drained pneumothorax or large bullae on chest radiograph, marked osteoporosis(t-score >-1.5) with a spontaneous rib fracture and developing cancer or smoking patients.

Protocol:-

All enrolled patients were evaluated by M-mode Ultrasonography to assess maximum diaphragmatic excursion pre and post-training by the same (U/S) machine and examined by the same U/S skilled radiologist. Diaphragmatic excursion (DE) were measured using a real time sonographic system with a 3.8 MHz convex probe (Aloka prosound 4000,Aloka,japan ultrasound machine) at a depth of 22-24 Cm. The distance difference between the same leading edge of the diaphragm at the end expiration and end inspiration is calculated by M-mode tracing. During inspiration the diaphragm moves caudally towards the U/S probe and is represented by the upper peak on the M-mode, and during expiration the reverse occurs with the lower peak on M-mode represents the expiration. The difference between the peaks on M-mode is calculated by the machine and it represents the diaphragmatic movement (excursion) in the respiratory cycle that was ranged between 1.7- 2.5 cm.

Training Procedures:-

All patients in this study received the following instructions: Patients were instructed to wear loose, comfortable clothing especially around neck; they were rested in a sitting position. The training started by setting the maximum load in which the patient could successfully execute ten breaths at maximum resistance depending on the patients' rate of perceived exertion , the starting load equal to 30% of the patient's maximum inspiratory effort. This individualized load increase progressively as the inspiratory muscle became stronger. The recommended pressure load determined by the 30% maximum 10-repitition method by using IMTdevice[11]. The mouthpiece was attached to the device and nose clip on the patient's nose ; so that all of the breathing was done through the mouth making sure the lips were sealed around the mouthpiece and the tongue not occlude it. The patients were asked to take full breath in (maximal and deep inspiration) then longer and slow expiration through mouthpiece. Continue this breathing pattern for 10-20 breath. Repeat this pattern for 4-6), 4-6 times, or about 10-15minutes with rest in between 30 second. The session was repeated three times/week once daily for 12 weeks. The time of the session was at the morning prior to the dialysis session.

Results:-

Data obtained prior and following management including diaphragmatic excursion was statistically analyzed by SpSS. 20 computer statistical package.

Demographic data:-

Thirty patients (10 men & 20 Women) age ranged from 26 to 45 years old with mean age (± SD) was 35.47 (± 6.51) , their height ranged from 1.56 to1.8m with mean height 1.68(± 0.06),their weight ranged from 65 to 85 kg with mean weight 72.4(±5.02) and their BMI ranged from 21.95 to 27.9 kg/ m2 with mean BMI 25.63(±1.46).

Studied parameters assessment:-

Table (1):- Statistical Analysis of Diaphragmatic Excursion measured pre- and post-training for the patients.

	Range	**Mean ± SD**	**Mean difference**	**Percentage of improvement**	**t-value**	**P value**
Pre-training	1.70-2.50	2.16 ± 0.25	-1.42	↑ 65.74%	-61.856	0.001**
Post-training	3.00-4.00	3.58 ± 0.34				

**p< 0.01= highly significant.

Statistical analysis showed that increased significant improvement in diaphragmatic excursion that was shown in the mean difference (-1.42) with a percentage of improvement of 65.74% when compared to the pre- measured data that was shown in table (1) & figures (1&2).

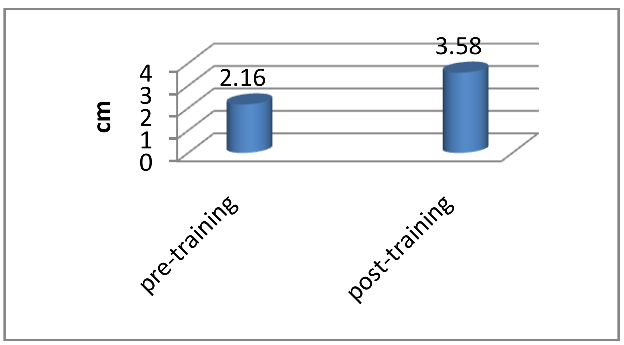

Fig.(1) :- Diaphragmatic Excursion of the Studied Group

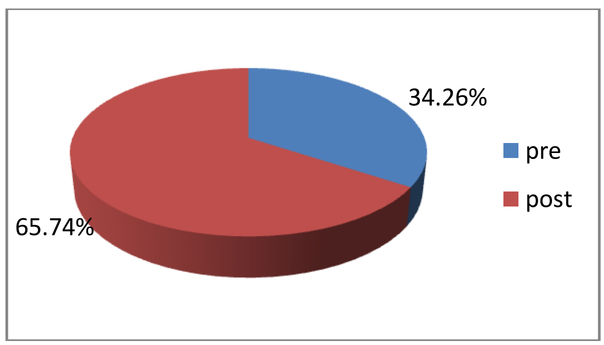

Fig.(2) :- Percent of improvement throughout the study

Table (2) :- Statistical Analysis of diaphragmatic excursion for men & women throughout the study:-

	Men (n=10)		**Women (n=20)**		MD	t-Value	P-value
	Pre	Post	Pre	Post			
Range	1.7-2.1	3-3.35	2-2.5	3.5-4			
mean ± SD	**1.93±0.16**	**3.19±0.13**	**2.27±0.22**	**3.77±0.21**			
MD	-1.26		1.50		-0.24	11.343	0.001**
% of improvement	↑65.29		↑66.08				
t-Value	-61.688		-62.761				
P-value	0.001**		0.001**				

MD: mean difference . **p< 0.01= highly significant.

As shown in table (2) & figures (3 &4) there was a significant difference between the pre and post-training results in men by 65.29% and in women by 66.08% that gives the resultant difference that women achieved a greater improvement than men did .

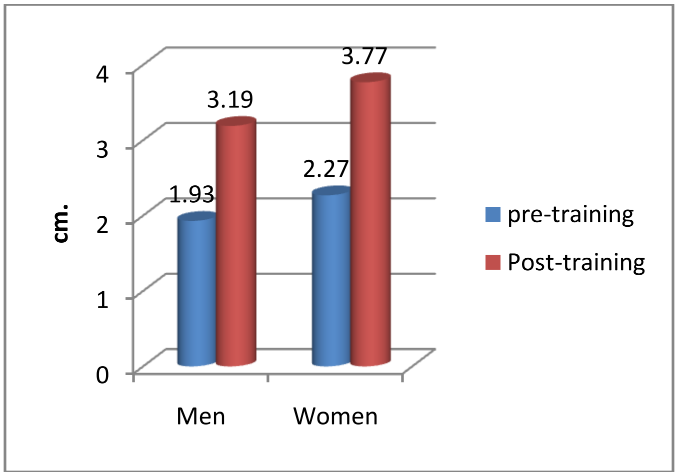

Fig.(3) : Diaphragamatic Excursion mean values pre- and post-training for men and women subgroups.

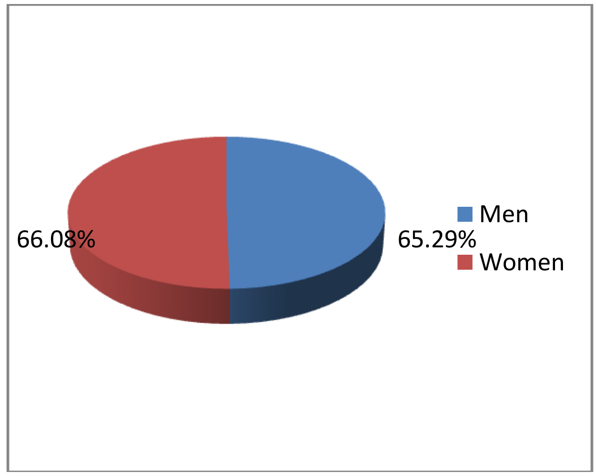

Fig.(4): The percentage of improvement represented in men and women.

Discussion:-

The analysis of the results of the current study showed that diaphragmatic excursion in hemodialysis patients that received inspiratory muscle training prior the session was significantly improved with percentage of 65.74% .This improvement in the diaphragmatic excursion may be due to improvement of diaphragm mechanics, power and inspiratory muscle strength. Studies involved the problem of strengthening of the diaphragm in hemodialysis patients is of great shortage.

The results of this study coincided with the results achieved by **Saad, 2013** [12] who **concluded** that inspiratory muscle training by IMT device for one month in post liver transplantation patients significantly improved the diaphragmatic excursion of these patients in addition to improvement of breathing mechanics for the study group.

The results of this study also agreed with the results achieved by **Saafan, 2013**[13] who concluded that the inspiratory muscle training had significantly improved the diaphragmatic strength after upper abdominal surgeries.

A study results achieved by **Hamad , 2012**[14] came in accordance with this study who concluded that inspiratory muscle training by IMT device for one month in postoperative thoracotomy patients significantly improved the diaphragmatic excursion of these patients in addition to improvement of breathing mechanics .

It was found that six weeks of post operative inspiratory muscle training using threshold IMT device significantly improved the ventilatory function and shortened the duration of postoperative hospitalization in patients gone through thoracic surgery[15]. This may be attributed to an improvement in the diaphragm strength, as evidenced by improvement in respiratory mechanics that led to better expansion of the chest which reflected as increase in the ventilatory function leading to early recovery of respiratory function impairment which consequently shortened the duration of postoperative hospitalization[16].

Also the results of this study coincided with the results achieved by **Edwards and Cooke,2008**[17] who concluded that the **i**nspiratory muscle training device had a significant effect on maximum inspiratory pressure in patients underwent pulmonary lobectomy**.**

In agreement with the results of the current study **Hart et al., 2006** [18] found that significant improvement in inspiratory muscle function and diaphragmatic excursion which were also associated with improved psychosocial status were noticed after eight weeks of high intensity IMT in patients with cystic fibrosis which suggested that increasing inspiratory muscle function may have significant long-term health implications for patients with respiratory disability.

The results of this study coincided with the results of trials with IMT. The finding revealed that IMT intervention improves exercise capacity and quality of life, particularly in patients with inspiratory muscle weakness. Some benefit from IMT may be accounted for by the attenuation of the inspiratory muscle metabolic reflex. Moreover, IMT results in improved cardiovascular responses to exercise and to those obtained with standard aerobic training[19].

In agreement with the results of the current study **Ysayama et al., 2008**[20] showed that IMT for 4 weeks before esophagectomy resulted in a significant increase of respiratory muscle strength and endurance.

In contrast **Mc Gill and Brown 2011**[21] reported a non-significant change in diaphragmatic excursion (DE) with inspiratory muscle training program for 4 weeks and might be explained by short duration of the study.

Moreover, the results of this study shows that the percentage of improvement of diaphragmatic excursion in women is better than in men as women percentage of improvement is66.08% and men percentage of improvement is 65.29% although the excursion is more stronger in men as their rhythm of respiration is abdominothoracic while the rhythm of respiration in women is thoracoabdominal that may be attributed to the fact of reduction of the inspiratory muscles strength with age in men 25_+ & women 35_+ and that must be taken into consideration the presence of weakness already with hemodialysis. With IMT women with their smaller size of the lung experienced much better benefit of the mechanics of respiration.

Conclusion:-

Inspiratory muscle training by IMT device is an effective rehabilitation method that improves diaphragmatic excursion (DE), sense of breathlessness and functional capacity in hemodialysis patients.

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