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EFFECT OF PULMONARY REHABILITATION ON MUSCLE QUALITY INDEX IN THE ELDERLY WITH SARCOPENIA

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Abstract

One of the most important changes occurring in aging is the loss of muscle mass, where muscle mass decreases about 3% to 6% per decade. Sarcopenia is a progressive and generalized skeletal muscle disorder involving the accelerated loss of muscle mass and function. The prevalence of sarcopenia between the ages of 60-70 years is between 5% to 13% and increases to between 11% to 50% at the age of 80.

Purpose: to study the effect of a 12-week pulmonary rehabilitation (PR) program on muscle quality index (MQI) in the elderly with sarcopenia.**Methods**: 65 primary sarcopenic elderly subjects participated in the present study with age (60-75 years) chosen from Dar Elshrouk nursing home. Muscle quality index were measured before and after the pulmonary rehabilitation program. Pulmonary rehabilitation program included breathing exercises (diaphragmatic breathing, costal breathing, pursed-lip breathing & exercise connected with respiration), in addition to aerobic exercise including walking exercise (moderate intensity walking, walking heel to toe, sideways walking) and strengthening exercise of upper limb and lower limb, 3sessions per week for 12 weeks. **Results**: there was 34.32% increase in MQI for all the subjectsand 25.74% decrease in Five times sit to stand for all subjects.**Conclusion**: pulmonary rehabilitation program for elderly with sarcopenia improved the sarcopenic status, exercise capacity, muscle strength, activities of daily living and health related quality of life.

Introduction

Aging is commonly used to name the progressive decay of organisms function in later life. Aging has an indistinct onset and a highly variable inter-individual progression. The rapidly changing composition of the human population will impact the incidence and the prevalence of aging-induced disorders such as sarcopenia and, henceforth, efforts to narrow the gap between healthspan and lifespan should have top priority (**Gustafsson&Ulfhake, 2021**).

Aging involves the progressive decline in all physiological processes and that, therefore, becomes an important concern because of the consequent reduced functional capacity and impaired quality of life. A natural occurrence in the aging process is sarcopenia, which involves the degenerative loss of muscle mass, strength, and function **(Sbardelotto, 2019).**

The World Health Organization (WHO) estimates the number of older men and women will be more than triple by the year 2050, dueto the increase in older adults as a percentage of the overall population plus a stable life expectancy of approximately 80 years in industrialized countries**(Rooks et al, 2019).**

Sarcopenia is a frequent, age-related muscle wasting, that results in impaired skeletal muscle performance. Its prevalence has been estimated at 9–40% among older persons.Sarcopenia has been linked to higher morbidity and mortality, increasing the need for support in the activities of daily living or institutionalization, and diminished quality of life.Sarcopenia is also responsible for high care-related burden, including burden to the family and the society. Sarcopenia is amenable to therapy, mainly rehabilitation and proper nutrition **(Piotrowicz, 2021).**

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Sarcopenia is a progressive and generalised skeletal muscle disorder involving the accelerated loss of muscle mass and function that is associated with increased adverse outcomes including falls, functional decline, frailty, and mortality. It occurs commonly as an age-related process in older people **(Cruz-Jentoft, 2019).**

Muscle quality index (MQI) has been recognized as an important surrogate for physical function and mortality in older individuals**(Silva et al, 2021)**.

The muscle quality index (MQI) hasbeen proposed as a tool to evaluate the muscle power of lower extremities through anthropometric measurements and the time needed to complete the sit-to-stand test (STS), Low levels of MQI havebeen associated with a low physical function and poor muscle strength**(Jerez-Mayorga et al, 2020).**

Five Times Sit-to-Stand Test (FTSST) is considered to be a useful, consistent and low -cost tool to assess sit-to-stand ability. The FTSST measures the time taken to stand five times from a sitting position as quickly as possible. Researchers have described its use as a measure of lower limb strength andfall risk and exercise capacity(**de Melo,2019**).

Pulmonary rehabilitation (PR) is a multidisciplinary approach that improves exercise capacity and health-related quality of life in elderly **(Vinan-Vega et al., 2021).**

The pulmonary rehabilitation model has conventionally consisted of supervised exercise training, education, self-management strategies, and support delivered to groups of subjects at least twice a week for 8 weeks or longer in either an inpatient or outpatient setting by a multidisciplinary team**(Holland et al, 2021)**

Studies have shown that aerobic exercise can improve cardiopulmonary function, muscle strength, and activities of daily living. A 24-weeks intermittent training (riding training) clinical trial on patients with muscle atrophy showed that intermittent aerobic exercise can improve muscle strength, motor function and subjective feeling of pain and fatigue of patients with muscle atrophy **(Liu et al, 2020)**

Aerobic exercise successfully suppressed muscle atrophy and activated adiponectin signalling, where the expression of adiponectin, AdipoR1, and APPL1 was found to be significantly increased by the aerobic exercise, that is why in early cachectic stages, multifarious treatments, including aerobic exercise, have been recommended in clinical settings **(Morinaga et al., 2021).**

Methods

Subjects:

This study was carried on 65 Elderly with Primary Sarcopenia, they have been selected fromDar ElshroukNursing Home, their age was between 60-75 years old.

Ethical Consideration:

Approval of Faculty Ethical Committee was achieved NO.P.T.REC/012/002441

All subjectshave signed a consent form before startingthe study with full illustration of the steps and benefits of the study.

Subjects Selection

Inclusion

Sixty Fiveelderly volunteersof both genders 35 women& 30 menparticipated in this study, the recruited elderly subjects were in good general condition with a score of 4 points on the SARC-F questionnaire, stable hemodynamic parameters, with normal blood pressure,normal heart rate of their age.All are with primary sarcopenia, all have been able to perform the pulmonary exercises and all have been able to do the five repetitions sit to stand test.

Exclusion criteria, any subject presented withpsychiatric or cognitive impairment, Progressive neuromuscular disorders, decreased level of consciousness. Unstable fracture, Secondary Sarcopenia, Pulmonary Diseases, had heart surgery, had orthopaedic problem, and sever mobility impairment.

Procedures

Evaluation Procedures

The equation of Muscle Quality Indexwhich has been developed and well tested by "**Brown et al 2016**"has be used in theassessment as following:

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MQI = [(L - 0.5) × body mass × g × 5]/$T_{sit\text{-}to\text{-}stand}$, where 0.5 (m), L (m), gravity (m/s^2), and T representstime of FTSTS, L represents leg length, acceleration of gravity (9.8 m/s^2), and time required to complete the sit-to-stand test, respectively.

The Five Times Sit to Stand (FTSTS) scoring is based on the amount of time a subject was able to transfer from a seated to a standing position and back to sitting five times. The instruction is given by asking the subject to sit on the chair by resting their back. Then the subject should be instructed to do sit-to-stand five times, as quickly as possible. SARC-F Questionnaire was used for the inclusion of the subjects, where the primary sarcopenic subjects achieved minimum score of 4 points.

SARC-F questionnaire: Reis NR et al, 2020.

Component	Question	Scoring
Strength	How much difficulty do you have in lifting and carrying 10 pounds?	None = 0 Some = 1 A lote or unable = 2
Assistance in walking	How much difficulty do you have walking across a room?	None = 0 Some = 1 A lot, use aids, or unable = 2
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot, use aids, or unable = 2
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs?	None = 0 Some = 1 A lot, use aids, or unable = 2
Falls	How many times have you fallen in the past year?	None = 0 1-3 falls = 1 4 ou more falls = 2

Rehabilitation procedures (physical procedures):

The pulmonary rehabilitation program for all elderly lasted 12 weeks and consisted of 3 sessions per week each session lasted for 120 minutes on average in the following schedule, practical and training for45-50 minutes then break of 20-25 minutes finally another 45-50 minutes for the practical.

Pulmonary Rehabilitation program included:

A) Breathing Exercise:

1- **Diaphragmatic Breathing Exercise**, used to help strengthen and train the diaphragm and other respiratory abdominal muscles, to increase tidal volume.

The position of diaphragmatic breathing techniquewas sitting&crook lying position, all subjects performed actively.

All subjects have been instructed to perform this exercise 5-10 minutes with repetition of 3-4 times per session.

2- **Costal Breathing Exercise**, it is a breathing method that uses movements of the ribs to drive both the inhale and the exhale phases of the breathing.The position of costal breathing was sitting and standing position.This exercise may also improve neck posture and posture in general or make it easier to find good posture and keep it.This exercise has been performed 5-10 minuteswith repetition of 3-4 times per session.

3- **Pursed-lip breathing Exercise,** it is a strategy that involves lightly pursing the lips together during controlled exhalation. It helps to improve ventilation and release trapped air in the lungs. Keeps the airways

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open longer and prolonged exhalation slows the breathing rate.It moves old air out of the lungs and allow new air to enter the lungs.

The subjectperformed the exercise in sitting position andhas been asked tobreathe in normally through the nose. Purse the lips as if he is going to whistle or blow out a candle, then breathe out gently through his mouth, keeping his lips pursed. The subject was instructed to repeatthis exercise 5times the same for 3-5 minutes.

4- **Exercise connected with respiration**: **a)** Trunk Rotation Breathing exercise, where we asked the subject to turn his trunk and head to the left, pause, and breathe-in then breathe-out as he turns to the right, repeat to the other side, repeat this exercise for 4 times. **b)** Elbow Back exercise, we asked the subject to sit with his arm crossed in front of him at chest level, breathe-in , breathe-out as he pull his elbows back, pause and breathe-in, breathe-out as he returns his arms to the starting position, repeat this exercise 10 times. **c)** Thigh Strengthening exercise, where we asked the subject to breathe-in, breathe-out as he straightens one leg keeping his toes pointed to the ceiling, pause and breathe-in, breathe-out, slowly as he lowers his foot to the floor, repeat with the other leg and he shouldn't let his leg drop, repeat this exercise 5 times with each leg. **d)** Leg Lifts exercise, where we asked the subject to breathe-in, breathe-out as he lifts one thigh off the chair as he breathe-out through pursed-lips, hold as he breathe-in, lower safely his leg, breathe-out, then he should do alternate leg, to repeat 5 times with each leg.

B) Aerobic Exercise:

1- Walking Exercise.

A) Moderate Intensity Walking

The Subject performed moderate intensity walking exercise with 60-70% of the maximum heart rate. The subjectperformed 5-7 minutes warming up in form of shoulder rolls, shoulder squeezes, neck stretches, leg swings, seated ankle circles, seated hamstring stretch, seated hip lifts and 5-7 minutescooling down and the exercise lasted for 15 minutes.

B) Walking Heel to Toe

The subject has been asked to hold a support and to put his right foot in front of his left foot so that the heel of the right foot touches the top of the toes of the left foot. Then, he /shewas supposed to move the left foot in front of the right, putting his weight on his heel. Then, shift his weight to his toes. Repeat the step with the left foot. The subject walked this way for 10-15 steps.

C) Sideways Walking

The subject stood with his feet together, knees slightly bent. Then has been asked to step sideways in a slow and controlled manner, moving one foot to the side first, then move the other to join it. Perform 5-10 steps each way.

2- Strengthen Exercise for Upper Limb & Lower Limb.

The subjects performed the following exercisesin sitting position

a) Arm Raise Exercise, where the subject stood straight with both arms at his side and weight of 0.75 Kghas been held in one hand then performed this exercise with l0 repetitions for each arm
b) Seated Shoulder Press Exercise, the subject performed 2-3 sets with 8-10 repetitions
c) Step ups & Step downs exercise (leg strengthening) the subject repeated 10 times each side and for sure useda chair as mean of support if needed.
d) Sit to stand (leg exercise), where the subject performed this exercise in 2-3 sets with 5-8 repetitions.
e) Hip Marches exercise, the subject performedthis exercise 5-10 times on each side with 10 repetitions

Advices for the subjects

All subjects have been advised to perform these exercise as prescribed to be as a regular daily routine to maintain the muscle capacity and improve the daily living activities, besides maintain a balanced healthy diet with vitamins and supplements. Perfectly, to perform these exercises in groups to encourage each other and preserve high morale and enjoyable social times together.

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Results

Statistical analysis

Results are expressed as minimum, maximum, median, mean and standard deviation. Test of normality, Kolmogorov-Smirnov test, was used to measure the distribution of data measured before PR exercise. Data are normally distributed, so comparison between before and after PR exercise within the same group was performed using paired t test. Analysis of covariance (ANCOVA) test was used to compare the before PR exercise values of the two groups and on the same time between the after PR exercise values on controlling the effect of pre-treatment values. Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. P value ≤ 0.05 was considered significant.

Table 1 : Descriptive statistics of different studied parameters of the studied subjects group.

	No.	Minimum	Maximum	Median	Mean	SD	SE
Age (yrs.)	65	60.00	75.00	68.00	67.63	4.89	0.61
Height (m.)	65	1.58	1.84	1.68	1.69	0.06	0.01
Weight (kg.)	65	59.00	113.00	76.00	83.23	16.19	2.01
BMI (kg/m^2)	65	22.04	39.04	27.39	29.20	5.36	0.66
Leg length (m.)	65	0.85	0.99	0.91	0.91	0.03	0.00
SBP (mm/Hg)	65	110.00	131.00	121.00	121.29	5.31	0.66
DBP (mm/Hg)	65	70.00	87.00	81.00	79.89	3.49	0.43

SD= Standard deviation; SE= Standarderror of mean; BMI=Body Mass Index; SBP= Systolic Blood Pressure; DBP=Diastolic Blood Pressure

Table2 : Descriptive statistics of FTSTS (sec) of the studied patients group measured before and after PR exercise.

	No.	Minimum	Maximum	Median	Mean	SD	SE
FTSTS before	65	15.50	22.40	18.00	18.53	1.76	0.22
FTSTS after	65	11.00	17.90	13.10	13.76	1.74	0.22

SD= Standard deviation; SE= Standarderror of mean; FTSTS=Five Times Sit-to-Stand

Comparison between mean values of FTSTS measured before and after PR exercise in the studied group

There was a statistical significant decrease in the mean value of FTSTS measured after PR exercise(13.76 ± 0.22) when compared with its corresponding value measured before PR exercise(18.53 ± 0.22)with t value = 61.950 and p value= 0.001. The percent decrease in the mean value of FTSTS was 25.74% (Table 2)

Table 3: Descriptive statistics of MQI (watts) of the studied patients group measured before and after PR exercise.

	No.	Minimum	Maximum	Median	Mean	SD	SE
MQIbefore	65	60.05	137.24	88.22	90.47	16.17	2.01
MQI after	65	81.92	190.52	120.08	121.52	20.88	2.59

SD= Standard deviation; SE= Standarderror of mean; MQI= Muscle Quality Index

Comparison between mean values of MQI measured before and after PR exercise in the studied group

There was a statistical significant increase in the mean value of MQI measured after PR exercise(121.52 ± 2.59) when compared with its corresponding value measured before PR exercise(90.47 ± 2.01)with t value = -35.907 and p value= 0.001. The percent increase in the mean value of MQI was 34.32% (Table 3)

Discussion:

This study was designed to establish the relationship between the Pulmonary Rehabilitation (PR) and the Muscle Quality Index (MQI) in Elderly subjects with Sarcopenia. Different pulmonary rehabilitation exercises for a period of 12 weeks where all the subjects (65 Elderly) briefed, supervised, and well guided on how to safely perform such PR exercises.

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As elderly population is on growth mode, so it ishighly important to introduce different physiotherapy interventions to improve their Quality of Life (QoL) especially with the increasing rates of Sarcopenia in elderly population, as Sarcopeniacan have an impact on a person's ability to perform everyday activities, such as climbing stairs, lifting objects, and walking, that has been agreed and supported by **(Fuggle, 2017),** therefore improving MQI in sarcopenic elderly is considered as an important goal and should be a priority for the community looking after the aging population.

To evaluate and assess the MQI, we have used the equation which rely on Five Times Sit-to-Stand (FTSTS), where we have recorded FTSTS before commencing PR exercise then again after the three months of PR exercises. FTSTS is often used in rehabilitation evaluation, as well as in assessing lower limb function, balance, and mobility in the elderly which has been concluded by **Chen et al 2018**.

There was a statistical significant decrease in the mean value of FTSTS measured after PR exercise (13.76 ± 0.22) when compared with its corresponding value measured before PR exercise (18.53 ± 0.22), which indicated the positive effect of PR on FTSTS.

Muscle Quality Index assessment using FTSTS-based equation was proved reliable, accurate and low cost tool which could be used in simple clinical sitting, therefore will enhance the clinical implications, appropriate and effective healthcare planning for elderly, this has beenconsistent with**Brown et al 2016,** who concluded that MQI using the FTSTS based formula is reliable and thus can help predicts QoL and other parameters for managing elderly programmes.

There was a statistical significant increase in the mean value of MQI measured after PR exercise (121.52 ± 2.59) when compared with its corresponding value measured before PR exercise (90.47 ± 2.01), which confirmed the theory of the positive effect of PR on MQI in this population group.

Five Times Sit -to-Stand Test(FTSST)is considered to be a useful. In line with many researchers have described its use as a measure of lower limb strength and exercisecapacity. Slower sit -to-stand times have been linkedto an increase risk for recurrent falls,slow gait speed and deficit in other ADL in older people, this was in parallel to **de Melo,2019**

The study shows that Pulmonary Rehabilitation“PR” exercise programs are safe, acceptable, and feasible in elderly with sarcopenia. No study-related adverse events were observed. In terms of acceptability, it has been noticed that all respondents reported that the exercise intervention was beneficial to their overall health. Most ofthe subjects planned on continuing to exercise as they have noticed the positive effect on their QoL. Pulmonary rehabilitation is supported by a strong evidence demonstrating its effectiveness in many conditions. In this studyphysical activity or exercise was an efficacious intervention to improve the MQI, that was also concluded by **Brown et al 2016**.

Different exercises has been introduced within the designed PR program for the study group, aerobic exercise was a very important element that’s been introduced, long-term aerobic exercise should also be considered a viable strategy to preserve muscle mass and function with age, as this has been proved in many studies, especially the one by**Laurin et al., 2019**agreeing and supportingthe value of PR.

In this study, after the 12 weeksPR program aerobic exercise showedimprovement in cardiopulmonary function, muscle strength, and activities of daily living. This is in parallel with a clinical trial of 24-weeks on patients with muscle atrophy showed that intermittent aerobic exercise can improve muscle strength, motor function and subjective feeling of pain and fatigue of patients with muscle atrophy, this is recently documented by **Liu et al, 2020.**

Starting aerobic exercise in early cachectic stages among other multifarious treatments,has been recommended in clinical settings by **Morinaga et al., 2021**.

Strength Training was another important exercise introduced, as it is anticipated that “Strength Training” of the lower limb is important element, it increases muscle mass, muscle strength, and motor performance. It also improves performance in a five-repetition sit-to-stand test compared to respiratory rehabilitation. In addition, after

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the exercise program, knee extensor strength, and walking distance increased in patients with sarcopenia, similar findings have been concluded and documented by **Nagano et al., 2021.**

In conclusion, 12 weeks of PR appears to be safe, acceptable, feasible, and associated with significant improvement in, physical activity, walking speed, upper and lower muscle strength, sit-to-stand test scores, and overall MQI in elderly with sarcopenia, consequently improved the sarcopenic status, exercise capacity, activities of daily living and health related quality of life.

Conflict of interest: The authors declare no conflicts of interest.

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