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Research Article

Effect Of Specific Cardio-Respiratory Endurance Training With Conventional Physiotherapy On Quality Of Life Of Parkinson's Patients

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ABSTRACT

Background

Parkinsons disease (PD) is the second most common neurodegenerative disease described as a movement disorder. As the disease progresses, motor symptoms present as resting tremors, bradykinesia or slow movements, rigidity, and / or postural instability. Cardio- respiratory endurance training is a non-drug treatment option that is a resource to complement functional rehabilitation and prevention. The purpose of the study was to determine if endurance exercise training intervention impacted functions for individuals with PD. The objective of the study is to find out the effect of cardio- respiratory endurance training with conventional physiotherapy on quality of life in Parkinsons patients.

MethodThis was an experimental study undertaken on 32 participants aged between 49 to 79 years . The participants were randomly divided into two groups (16 in each). The control group included 16 participants who received conventional physiotherapy exercises while in the experimental group the remaining 16 participants received cardiorespiratory endurance training with conventional physiotherapy exercises. The study was conducted for 6 months with sessions 4 times a week lasting for about 30 mins. Data was collected using the Fatigue Severity Scale and WHOQOL scale, and the cardiac variables like FEV1, FVC and their ratios were calculated.

Results: The forced vital capacity (FVC), the forced expiratory volume in one second (FEV1) values increased significantly in the experimental group post physiotherapy intervention as compared to the control group. The cardiorespiratory variables like heart rate, blood pressure also showed good outcomes post intervention. The main outcome measure was World health organisation quality of life – Brief (WHOQOL-BREF) which showed satisfaction with general health, pain, energy, positive feelings, personal relationship and satisfaction with home are facets affected in the early stages of PD. Mobility, body image, sexual activity and access to information are affected in progression of the disease.Secondary outcome measure which is the fatigue severity scale (FSS) showed that the participants perceived higher level of fatigue hence they faced difficulties in completing their ADLs.

Conclusion – Endurance training has shown significant benefits in improving functional mobility and quality of life (QoL) for Parkinson's disease (PD) patients. We suggest integrating cardiorespiratory endurance training with conventional physical therapy and medical treatment to optimize outcomes.A restrictive pattern of pulmonary dysfunction is present in patients with PD, The notable impact of combining endurance training with conventional therapy in PD patients underscores its potential as a rehabilitation component.

Keywords: Parkinson's disease, Balance, endurance training, Quality of Life (QOL), cardio- respiratory training.

Introduction

Parkinson's disease (PD), also known as paralysis agitans, is a prevalent neurodegenerative condition characterized by rigidity, resting tremor, bradykinesia, postural instability, and parasympathetic hyperactivity (Karlsen et al., 2000)[2]. Despite optimal therapeutic interventions, the clinical and functional status of PD patients tends to deteriorate progressively. With the aging population, the prevalence of PD is expected to rise (De Lau et al., 2005). The impact of PD extends beyond motor symptoms, encompassing non-motor manifestations such as cognitive impairment, depression, and autonomic dysfunctions[3]. These symptoms often manifest in activities of daily living (ADLs), contributing to challenges in social participation and mental well-being. Consequently, individuals with PD frequently lead sedentary lifestyles characterized by reduced motor activity.

The diversity and multifaceted effects of Parkinson's disease (PD) significantly impact resource utilization and expenditures (Pressley et al., 2003), while also undermining individuals perceived physical, social, and psychological well-being. These subjective dimensions, collectively referred to as health-related quality of life (QoL), are increasingly recognized as pivotal for comprehending the disease's impact, evaluating care efficacy, and gauging healthcare resource demand[3]. In addition to addressing motor symptoms and extending survival, enhancing QoL remains a crucial treatment goal[4]. Various aspects of PD contribute to patients' QoL. As PD progresses, non-motor alterations emerge, including cardiorespiratory compromise, which diminishes autonomy and increases fall risk, particularly due to conditions like neurogenic orthostatic hypotension[5]. Respiratory impairment in PD may result from both peripheral and central mechanisms, with motor manifestations such as rigidity, tremor, and weakness affecting upper airway and respiratory muscle function. Additionally, non-motor brainstem involvement can impact respiratory control [6].Evidence suggests that PD patients frequently experience obstructive and restrictive pulmonary dysfunction, alongside ventilatory abnormalities[7]. Recent studies have reported attenuated metabolic and cardiovascular responses during submaximal and maximal cardiopulmonary exercise testing in PD patients[10].

Physical activity is strongly recommended to prevent complications associated with a sedentary lifestyle, as it often leads to improvements in symptomatology among Parkinson's disease (PD) patients, particularly in walking and gait-related functions. Engaging in physical exercise can strengthen neuronal circuits involved in gait pacing and may even exert a neuroprotective effect. To maximize the benefits of exercise, it is generally advised to incorporate variations in training techniques such as specificity, intensity, and volume[12]. Exercise may benefit the brain through various hypothetical mechanisms. In both healthy young and older adults, exercise has been suggested to increase angiogenesis, neuroplasticity, neurogenesis, neuroprotection, anti-inflammatory effects, improve mitochondrial function and oxidative stress, enhance brain connectivity, and elevate levels of neurotrophic factors such as brain-derived neurotrophic factor (BDNF).Numerous modes of exercise have been explored in PD, including resistance exercise, balance and gait training, and endurance exercise. Recent reviews indicate that resistance exercise can be effective and valuable for individuals with mild to moderate PD, improving strength, functional outcomes like walking capacity, and potentially alleviating non-motor symptoms of the disease[14].

Endurance exercise training is characterized by activities aimed at enhancing cardiorespiratory power and cardiorespiratory endurance. Cardiorespiratory power is typically assessed through maximal oxygen uptake, known as VO2 max, which serves as the gold standard objective physiological measure of aerobic power determined during a cardiovascular endurance test. Meanwhile, cardiorespiratory endurance denotes an individual's ability to sustain an activity involving large muscle groups over a prolonged period, and it is closely correlated with VO2 max.Exercise intensity in endurance training is often gauged using absolute heart rate (HR), relative HR expressed as a percentage of maximum (%HRmax), or metabolic equivalents (METs). As there exists a linear relationship between VO2 and HR, the American College of Sports Medicine recommends that training aimed at enhancing cardiorespiratory endurance should be performed at a minimum of 55% to 65% of HRmax, with the specific range dependent on the individual's initial fitness level[14].

Due to the progressive nature of Parkinson's disease (PD), maintaining long-term exercise habits is crucial; otherwise, any gains achieved are likely to diminish rapidly. However, research indicates that within 3 months to a year, only 50% or fewer individuals with various conditions, including PD, continue to adhere to an exercise program[17]. Several barriers to exercise adherence have been identified, including poor exercise self-efficacy, a sense of lack of control over exercise behaviors, negative self-concept regarding exercise, past exercise failures, inadequate knowledge and skill, and anxiety. Among these factors, perhaps the most critical is readiness or willingness to change.

We believe that the identification of determinants of QOL in PD population could help us design effective interventions for the improvement of the distress related to the disorder. The study discussed was designed to test the hypothesis that cardiorespiratory endurance training improves responses obtained at submaximal intensities during maximal cardiopulmonary exercise testing in patients with PD. The objective of this study was to examine whether individuals with PD who participated in a cardiorespiratory endurance training program experienced significant improvements in activities of daily living, motor function, and overall quality of life.

Materials and Methods

This study is an experimental study in which 32 participants with a clinical diagnosis of PD were recruited from both in-patient and out-patient units in Krishna Hospital of Krishna Institute of Medical Sciences, Karad which is a primary hospital in the area. Data was collected from August 2023 to January 2023. All participants gave their written informed consent after their enrolment was approved. Prior to participation, each subject received an explanation of the study procedure. The project was approved by the Research Ethics Committee of the Hospital.
Subsequently, the participants had their pre and post-intervention assessments compared. The assessments were performed during the on period of medication.

The study included patients within age group 49- 79 years who are currently in stage one, two or three of the Hoehn and Yahr classification scheme.Group A (Experimental group) included 16 participants while Group B (Control group) included 16 participants in the study. Those with secondary PD, chronic heart disease, psychological disturbancesand osteoporosis were excluded based on review of medical records.Subjects completed a 4-week interval training program at a frequency of four times per week, for 30 minutes per session.
Quality of life was assessed as per WHOQOL-BREF, which was administrated on a face-to-face basis.The WHOQOL-BREF questionnaire consists of 26 items, whose mean application time is approximately 5-10 minutes. Two questions assess global QOL and the rest of the instrument approaches more specific aspects that include social, physical, psychological, and environmental domains. Higher scores indicated better quality of life.Since it is based on the WHO concept of quality of life, it emphasizes the role of the subjective perception instead of more objective approaches used in other instruments.
The Fatigue Severity Scale (FSS) was used to assess fatigue, which was validated for people with PD. FSS consists of nine items that assess the influence of fatigue in ADLs. Each question is scored from 1 to 7, and to obtain the final score it is necessary to add all the items and divide by the number of items. If the result is greater than or equal to 4, the assessed individual is fatigued. For the assessment of cardiorespiratory conditions, vital signs of HR and BP were determined in the pre and post periods. HR was obtained by palpating the radial artery and counting the beats for 1 minute (bpm). For BP measurement (mmHg), a properly calibrated stethoscope and sphygmomanometer were used. DP was obtained by SBP x HR multiplication. DP is considered the best non-invasive method to evaluate the work of the myocardium due to the correlation with oxygen consumption, where it can establish a safety range to avoid cardiac overload. The intervention was previously designed to follow an increasing sequence of complexity, aiming at a gradual increase in difficulty. The exercises progressed according to the acquired motor skills. Statistical analysis was performed using the paired t-test for FSS analysis and the repeated measures ANOVA for DP, BP and HR, using $p < 0.05$

The forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC) and FEV1/FVC were examined using a hand-held spirometer before and after four weeks. Each patient was instructed to breathe out and in as quickly and deeply as possible for 10 s, and asked to do each maneuver three times with at least 1-min rest between each test in the sitting position. The best three technically accepted tests were utilized to evaluate pulmonary function parameters. Before the beginning of the training, the subjects were instructed to perform the activities sequentially. The exercise training program consisted of walking on a treadmill with lateral bars for hand support with minimum speed of 0.1 km/h, and they were given time to become familiar with the treadmill. The training was done 30 minutes per day, four days per week for 4 weeks. Each session included a five-minute warm-up in an unloaded cycle ergometer. In the first week, each session consisted of four bouts of 4 min of walking, with 3 min rest between bouts, followed by five minutes of recovery, with decreased speed. Each week, an additional 4 min was added. The walking speed during the first training session was determined as the individual preferred speed obtained for each subject during the first evaluation. During training, the treadmill speed was gently increased and the subjects were asked to walk until the maximum comfortable speed was reached. The blood pressure was determined at the beginning and at the end of each session, and when necessary, during the session, in case the subject felt any sign of discomfort. The speed and the heart rate were recorded during the training in each session. If the submaximal value calculated for each subject was exceeded, the training session was stopped. . The walking speed of each patient was monitored across each training sessions to affirm that the patient was walking at the desired speed. During the period of training, the patients did not alter their daily activities or medication. Pursed lips pulmonary were done during the treadmill training program, while diaphragmatic pulmonary exercises were applied, after treadmill training.[7]
The training regimen for the control group exclusively comprised low-intensity exercise routines. These routines encompassed breathing and meditation techniques, resistance band exercises with minimal

resistance, and coordination movements such as tennis ball dribbling. A significant portion of the exercises were conducted while seated on a chair. Exercise intensity was modulated by amplifying movement amplitude where feasible, and by adjusting duration or speed of execution. Each exercise session lasted between 30 to 90 seconds. Participants attended two one-hour supervised sessions per week and were encouraged to engage in a third session independently at home, following instructions outlined in a provided document.

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 10.0 for Windows. Comparisons between WHOQOL-BREF scores were performed using Student's t-test for paired samples.

Results

In the Conventional Group, there were 16 participants, of which 71.0% (11 participants) were male and 29.0% (5 participants) were female. In contrast, the endurance training group also comprised of 16 participants, with a slightly different gender distribution: 61.3% (10 participants) were male and 38.7% (6 participants) were female.

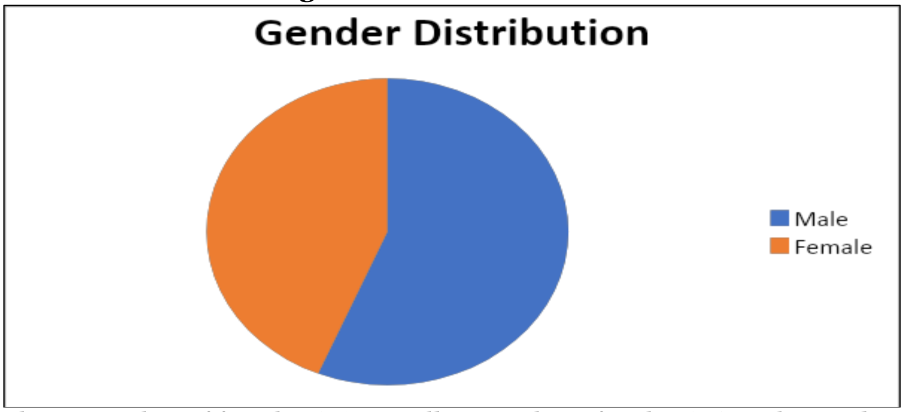
The data from both the Conventional Group and the experimental Group were analysed. The results regarding age showed that the mean and std deviation found to be 57.87+9.30 for age in conventional group and 59.52+8.95 for the endurance training group.

Both groups showed significant improvements from baseline to Week 4 in all outcome measures. The endurance training group consistently demonstrated greater improvements compared to the conventional group, with statistically significant differences observed at Week 4 for all outcome measures.

Statistical analysis for the present study was done to verify the results obtained. For this purpose, data was entered into an excel spread sheet, tabulated, and subjected to statistical analyses. Various statistical measures such as mean, standard deviation and test of significance were used.Comparison of pre intervention and post intervention was done by using Paired t- test. Probability values less than 0.05 were considered statistically significant.

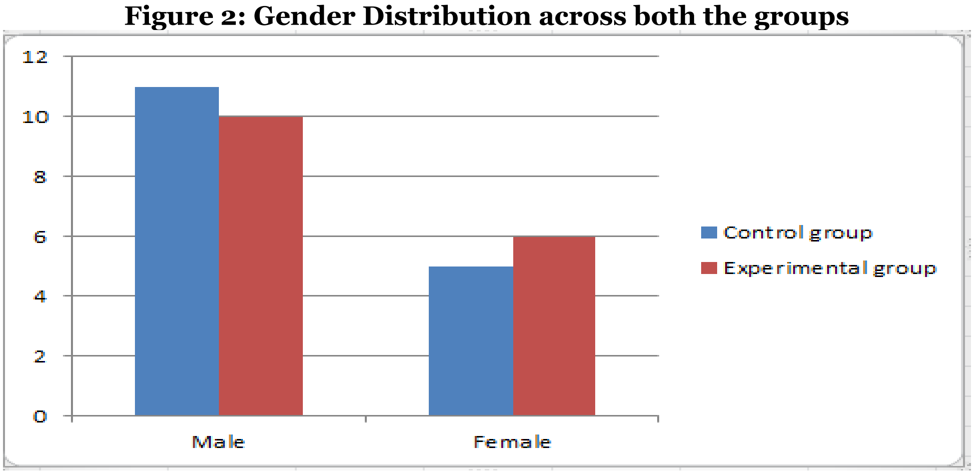
Paired t- test was used to find the significance of study parameters within the group. A total 32 participants were included in the study who received intervention for 4 weeks.

Fig 1: Gender Distribution



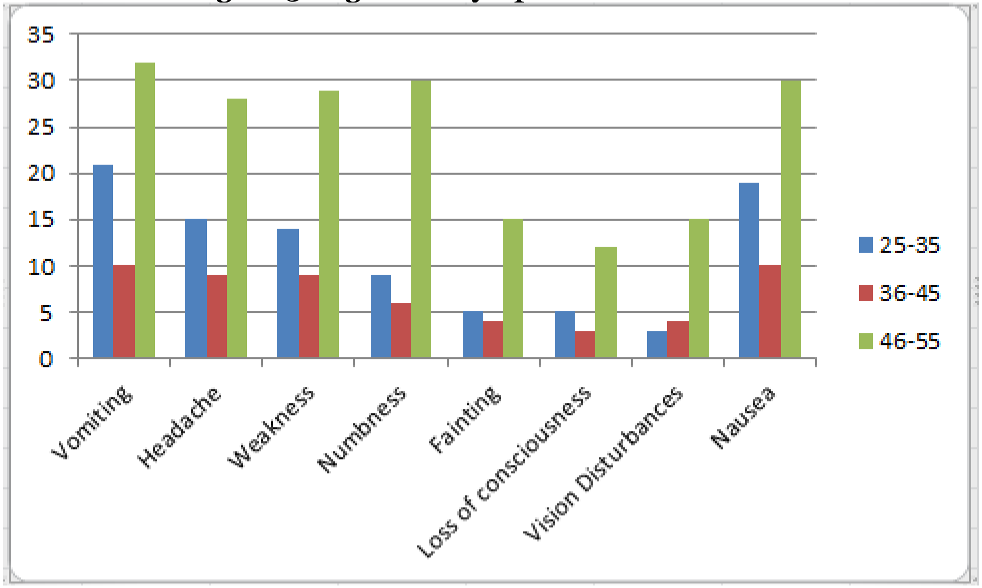
The above graph shows number of females (11) as well as number of males (21) in this study.

Figure 2: Gender Distribution across both the groups



The above mentioned graph shows 11 males and 5 females in the control group whereas 10 males and 6 females in the experimental group.

Figure 3: Signs and symptoms of the disease



The graph shows various types of signs and symptoms commonly found in Parkinson's disease patients. Out of all of them vomiting, nausea and numbness were most common.

Table Number 1: Values for age variable

Variable	Cases (n=32)	Controls (n=32)
Age (years)	54.0 ± 9.5	55.1 ± 6.5

This table summarizes the mean values and standard deviations for age variable among cases and controls, with sample sizes of 32.

Table 2 : Cardiorespiratory variables and perception of fatigue before and after physical therapy:

Variables	Before	After	Mean
HR (bpm)	76	82	79
BP (mmHg)	118 x 77	122 x 81	120 x 79
DP (SBP x HR)	9486.3 ± 595.1	9659.3 ± 455.4	-
FSS Scores	18 ± 5	23 ± 8	-

This table presents the values of heart rate (HR), blood pressure (BP), double product (DP), and Fatigue Severity Scale (FSS) before and after physical therapy, along with the mean values where applicable. The format 'Before' and 'After' represents the values before and after therapy respectively. The FSS scores reveal the higher the score, the more severe the fatigue is and the more it affects the person's activities.
The increase in FVC score for the control group at the end of the treatment was statistically significant as compared with the baseline ($P < 0.05$). The increase in the FVC score for the study group at the end of the treatment was highly statistically significant in comparison to the baseline ($P < 0.01$). There was no statistically significant difference (p- value > 0.05) between the two groups regarding FVC pre-treatment, while there was a statistically significant difference (p- value < 0.05) between the two groups regarding FVC post-treatment, as shown in Table 2. The increase in FEV_1 score for the control group at the end of the treatment was statistically significant as compared with the baseline ($P < 0.05$). The increase in the FEV_1 score for the research group at the end of the treatment was highly statistically significant in comparison to baseline ($P < 0.01$). There was no statistically significant difference (p- value >0.05) between the two groups regarding FEV_1 pre-treatment, while there was a highly statistically significant difference (pvalue < 0.01) between the two groups regarding FEV_1 posttreatment. The increase in the FEV_1/FVC score for the study group at the end of the treatment was highly statistically significant in comparison to baseline ($P < 0.01$)

Table 3 : FVC scores pre- and post-treatment for both groups:

	FVC scores before	FVC scores after	P
Control	83.6 ± 5.4	86.5 ± 5.56	.03 S
Study	80.5 ± 3.31	91.5 ± 2.07	.007

Data are presented as mean ± SD. S= significant. *P < 0.05.
This table displays the forced vital capacity (FVC) scores before and after treatment for both the control and study groups, along with the corresponding p-values.

Table 4: FEV1 scores pre- and post-treatment for both groups:

	FEV1 scores before	FEV1 scores after	P
Control	88.1 ± 2.9	86.7 ± 2.75	.013
Study	91.4 ± 4.4	94.6 ± 3.72	.001
P	.042 S	.01	

Data are presented as mean ± SD. S= significant. P < 0.05.
This table presents the forced expiratory volume in one second (FEV1) scores before and after treatment for both the control and study groups, along with the corresponding p-values.

Table 5: FEV1/FVC scores pre- and post-treatment for both groups:

	FEV1/FVC scores before	FEV1/FVC scores after	P
Control	88.5 ± 4.77	87.8 ± 5.07	.042 S
Study	88.9 ± 3.7	92.6 ± 3.17	.006
P	.036 S	.021*	

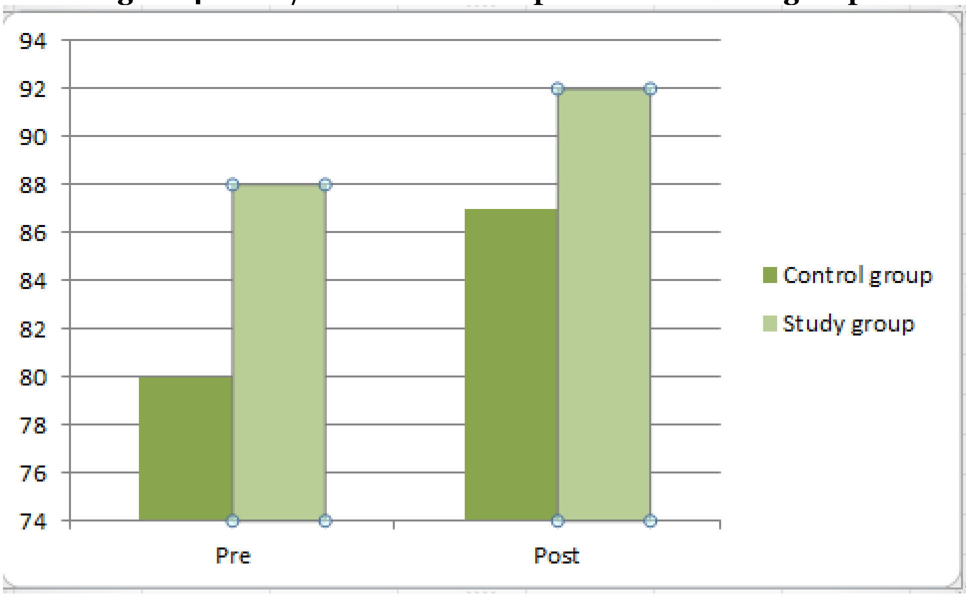
Data are presented as mean ± SD. NS= non-significant. *P < 0.05.
This table displays the ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC) scores before and after treatment for both the control and study groups, along with the corresponding p-values.

Table Number 6: Comparison of mean scores of four domains of WHOQOL-BREF, according to the severity of Parkinson's Disease (PD):

Question number	Domain/facet	CC
1	Overall Qol	-0.48
2	General Health	-0.30
3	Pain	-0.40
4	Medication	-0.16
5	Positive feelings	-0.38
6	Personal Beliefs	-0.12
7	Concentration	-0.18
8	Safety and security	-0.26
9	Environment	-0.04
10	Energy	-0.31
11	Body image	-0.34
12	Financial Resources	-0.17
13	Information	-0.36
14	Lesiure	-0.06
15	Mobility	-0.45
16	Sleep	-0.04
17	ADL	-0.43
18	Working Capacity	-0.51
19	Self Esteem	-0.43
20	Personal relationships	-0.31
22	Social support	-0.30
23	Home	-0.19
24	Healthcare	-0.27
25	Transport	-0.21
26	Negative feelings	-0.17

Results indicate that physical capacity was the most deteriorated domain. An association between severity of PD and perception of QoL was found in the study. Satisfaction with general health, pain, energy, positive feelings, personal relationship and satisfaction with home are facets affected in the early stages of PD. Mobility, body image, sexual activity and access to information are affected in progression of the disease.

Figure 4: FEV1/FVC ratio in comparison with both groups



The graph shows 80 and 88 were the pre values in control and study group respectively while the post value were 88 and 92 respectively.

Discussion

Most of the Parkinson's disease (PD) patients experience significant musculoskeletal and nervous system involvement, leading to compromised community ambulation and cardiovascular fitness. Despite being asymptomatic during pulmonary status assessments, PD patients often exhibit a notable reduction in pulmonary function parameters, which may go unnoticed as the disease progresses. This is partly due to physical disability in PD, which often results in a sedentary lifestyle and limits activities where respiratory problems may become evident[1-2].

Studies have revealed abnormalities in pulmonary function among PD patients, characterized by reductions in lung volumes, capacities, flow rates, and respiratory muscle strength [2]. As the disease progresses, various facets of quality of life (QoL) are affected, with the psychological domain being of particular importance [3]. Depressive symptoms, which are more prevalent in PD patients than in the general population, significantly impact psychological domain scores [4].

Fatigue is another common symptom in PD, often underestimated clinically due to its subjective nature and lack of exploration. Nonetheless, fatigue can directly affect activities of daily living (ADLs) and QoL[5]. While the relationship between fatigue and motor aspects in PD remains controversial, studies suggest associations with non-motor aspects such as depression, apathy, sleep disorders, and autonomic dysfunctions. This association may be attributed to fatigue being a primary manifestation of PD, possibly linked to neuroinflammatory markers such as IL-6[6].

Moreover, the reduction in walking capacity in PD patients significantly contributes to a negative perception of QoL[7]. Physiotherapy interventions have been recommended to improve functioning and physical competence in PD patients, with evidence suggesting improvements may occur within four weeks for functioning and at least eight weeks for physical competence.[8,11]

The specific treadmill training (TT) programs demonstrated superiority over non-specific exercise programs in improving health-related quality of life (QoL) among patients with mild to moderate Parkinson's disease (PD). Previous studies have consistently shown that most patients with mild to moderate PD experience QoL improvements after TT. This may be attributed to the titration period, allowing participants to reach 100% of their preferred walking speed.[10,12]

Previous studies also indicate that TT sessions, lasting 25 minutes and conducted three times a week at an intensity of up to 75% of the estimated maximum heart rate, are sufficiently specific to yield mobility gains for PD patients after 12 weeks. While gait parameters remained unchanged at the end of the study, even with the addition of TT after the 20th week, there was a significant improvement in distance travelled after the first 20 weeks, with a trend towards further improvements after 40 weeks.[12]It's worth noting that treadmill training without body weight support is a highly efficient and cost-effective approach. Treadmills are relatively inexpensive fitness equipment that can be easily installed at home or used in gym or recreational facilities. However, it's possible that fatigue induced by the intensive mixed TT program may have limited its potential benefits. Longer-term training protocols may offer additional advantages from both perceptual and physical perspectives.[12]

The findings of the present study align with Margaret Schenkman et al. (2008), who demonstrated the potential benefits of endurance exercise programs for individuals with mild to moderate Parkinson's disease (PD)[13]. Endurance exercise training has been shown to enhance cardiovascular fitness, which can be particularly advantageous for PD patients, especially those with comorbid complications.[14] Additionally, endurance exercise training has the potential to improve walking economy and reduce fatigue during daily activities, thus facilitating the completion of day-to-day tasks for individuals with PD.

Studies by Shulman et al. have indicated significant improvements in the 6-minute walk test (6MWT) for lower intensity treadmill and stretching and resistance groups, highlighting the effectiveness of lower intensity treadmill exercise in improving gait and fitness. However, the superiority of one exercise intervention over another remains inconclusive, and the underlying mechanisms for exercise-induced changes in each program are not fully understood.[14]

Given the variable and progressive nature of PD, it is possible that only certain patients may benefit from specific exercise regimens based on factors such as disease severity, clinical presentation, lifestyle, or genetics. Therefore, well-designed controlled clinical trials comparing and/or combining different modes of exercise are needed to determine the most effective exercise intervention for PD patients.[14]One strength of the training program is the implementation of strategies from the outset to assist patients in developing exercise habits. This may play a crucial role in enabling individuals to maintain gains and continue improving over the course of the exercise program.[15]

Furthermore, studies suggest that combining treadmill and resistance training may offer synergistic benefits, targeting cardiovascular fitness and muscle strengthening, respectively.[16]

Hence clinicians should strive to support patients with PD in establishing and maintaining long-term exercise habits, providing appropriate exercise programs, regular re-evaluation, and ongoing support.[17]

Limitations

We emphasize the necessity for further research aimed at investigating the effects of cardiorespiratory endurance training in Parkinson's disease (PD) using larger population samples. Given the compromised physical abilities of individuals with PD, longer rehabilitation durations may be required. Therefore, it is suggested that future studies consider increasing the duration of their protocols to potentially elicit more profound responses from Parkinsonism patients to this unique intervention.

The generalizability of findings from this study is limited due to the absence of a more rigorous randomized design. However, the statistically significant changes observed in the primary outcome variables suggest a robust effect of the treatment employed in this study. It's noteworthy that the selected patients were at stages 1 to 3 of theHoehn&Yahr scale, and thus, the findings may not be applicable to patients in other stages of PD.

The variability in treatment durations, and the limited data on follow-up effects may have contributed to the diverse conclusions drawn from the study.

Conclusion

Endurance training has demonstrated significant improvements in functional mobility and quality of life (QoL) among Parkinson's disease (PD) patients. Building upon the findings of the present study, we recommend combining cardiorespiratory endurance training with conventional physical therapy and medical treatment to maximize outcomes, particularly in terms of QoL enhancement. Althoughconventional modalities show promise in improving QoL and function,cardiorespiratory endurance training offers distinct advantages worth noting.

Continued research is imperative to identify optimal physical therapy strategies for PD patients, but current insights underline the value of cardiorespiratory endurance training. The significant effect of endurance training combined with conventional therapy on balance in Parkinsonian patients suggests its potential as a rehabilitation program component. Further studies are warranted to comprehensively explore the effects of PD on various health and well-being aspects, including the intricate interplay between motor and non-motor symptoms and their influence on QoL. By delving deeper into these relationships, we can better tailor interventions to address the multifaceted needs of individuals living with PD.

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