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Original Article

Effect of Aerobic Exercise with and without Strengthening Exercises on Neuropathic Symptoms in People with Diabetic Peripheral Neuropathy

Hifza Naseer[1]*, Muhammad Umair Javaid[2], Moeen Ahmad Khan[3], Rubab Nadeem[3]

[1]Gujranwala Institute of Rehabilitation Sciences, Gujranwala
[2]Fatima memorial hospital, Lahore
[3]UMT, Lahore
Corresponding Author: Hifza Naseer, Assistant professor; Email: hifza.naseerulhaq@gmail.com

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ABSTRACT

Background: The incidence of peripheral neuropathy among chronic diabetic patients is escalating, with a notable rise observed in Pakistan. This trend has been partly attributed to the predominant reliance on pharmacotherapy, while the role of physical exercise in management remains underutilized. Aerobic exercise is widely recommended in clinical guidelines for the treatment and prevention of diabetic complications, and it is hypothesized that the addition of strength training could yield even more benefits.

Objective: This study aimed to evaluate the effects of combined aerobic and strength training exercises on neuropathic symptoms in patients with diabetic peripheral neuropathy.

Methods: In this randomized clinical trial, 40 patients with diabetic peripheral neuropathy were equally divided into two groups: Group A underwent a combined regimen of aerobic and strength training exercises, whereas Group B engaged in aerobic exercises alone. The effectiveness of these interventions was assessed using the Michigan Neuropathy Screening Instrument (MNSI), Numeric Pain Rating Scale (NPRS), and Clinical Global Impression of Change (CGIC). Data were analyzed using SPSS version 20.0, employing independent t-tests, repeated measures ANOVA, and descriptive statistics for in-depth analysis.

Results: Group A demonstrated a significant reduction in MNSI scores with a mean difference of 1.700 and a p-value < 0.001, indicating a substantial improvement in neuropathic symptoms compared to Group B. While both groups showed significant improvements in NPRS and CGIC scores, the differences were not statistically significant, with p-values of 0.599 and 0.330, respectively, and mean differences of 0.1500 and 0.2500 for NPRS and CGIC. The overall statistical analysis revealed a high significance level ($p < 0.001$) within both groups in all measured outcomes, suggesting considerable improvements post-intervention.

Conclusion: The addition of strength training to aerobic exercises significantly enhances the reduction of neuropathic symptoms in diabetic patients. However, for pain relief and overall clinical improvement, both treatment approaches—combined aerobic and strength training or aerobic exercise alone—were equally effective.

Keywords: Diabetic Peripheral Neuropathy, Aerobic Exercise, Strength Training, Randomized Clinical Trial, Pain Management.

INTRODUCTION

The escalating prevalence of diabetes worldwide has become a significant public health concern in the 21st century. Data from the Centers for Disease Control and Prevention indicate that nearly 10% of the population is affected by diabetes, with this number increasing annually by approximately 5% (1). A common and debilitating complication of diabetes, particularly type 2, is diabetic peripheral neuropathy (DPN) (2). This condition, affecting roughly one-third of diabetic individuals over 40, is characterized by pain and sensory loss in the lower limbs due to the gradual deterioration of peripheral nerves (3, 4). The most frequent form of DPN involves symmetrical distal nerve degeneration with impaired nerve regeneration .

DPN often leads to sensory deficits, including reduced tactile sensitivity, impaired vibration sense, and diminished proprioception in the joints of the lower limbs (5, 6). These sensory impairments can lead to a higher risk of falls, lower extremity injuries, and in

severe cases, amputation (7, 8). Moreover, individuals with DPN tend to lead more sedentary lifestyles and experience decreased daily walking distances.

Diabetic neuropathy (DN) is a broad term encompassing various clinical and subclinical conditions that affect the peripheral nervous system (PNS) as a complication of diabetes mellitus (DM) (9, 10). The pathophysiological mechanisms underlying DN can vary, contributing to its diverse clinical presentations and progression rates (11).

In the realm of physical activity, aerobic exercises, which range from low to high intensity, primarily utilize the aerobic energy-generating process (12, 13). Engaging in aerobic exercise can gradually reduce body weight, although significant weight loss usually requires concurrent calorie restriction (14). This is particularly relevant in addressing obesity, a common comorbidity in diabetic patients (15).

Interestingly, previous research has suggested that both strength training and aerobic exercises may offer symptomatic relief for chemotherapy-induced peripheral neuropathy (CIPN) (16, 17). For instance, Kludging and colleagues found that a combined regimen of aerobic and strength training effectively reduced pain and symptoms associated with diabetic peripheral neuropathy (18).

When assessing CIPN, several methods are in use, including nerve conduction tests, the Michigan Neuropathy Screening Instrument, and the Semmes Weinstein monofilament tests (SWMT) (19, 20). While no gold standard exists for CIPN assessment, SWMT has been highlighted as a particularly useful tool for longitudinal evaluation through a composite score. However, there is a notable gap in research regarding the effects of combined aerobic and strength training interventions on CIPN (21).

This research article aims to explore the impact of aerobic exercise, both with and without strength training, on neuropathic symptoms in individuals with diabetic peripheral neuropathy. By examining the effectiveness of these exercise modalities, this study seeks to contribute valuable insights into the management and mitigation of DPN symptoms, ultimately improving the quality of life for those affected by this condition.

MATERIAL AND METHODS

This study was designed as a Randomized Clinical Trial, conducted over a period of six months following the approval of the research synopsis. Data collection took place at GENERAL Hospital in Lahore and THQ in Bhalwal. A sample of 40 patients was selected using consecutive sampling techniques. The study focused on participants aged between 40 to 70 years, who were diagnosed with type 2 diabetes and associated neuropathies but were otherwise medically stable.

Patients were excluded from the study if they exhibited neurological symptoms requiring surgery, had severe cardiac pathologies, musculoskeletal issues that limited exercise capacity, or open wounds on the weight-bearing surfaces of their feet. Following these inclusion and exclusion criteria, eligible participants were approached and provided with detailed information about the study. Written informed consent was obtained from each participant, ensuring their voluntary participation and confidentiality of personal data.

Participants were then randomly assigned to one of two groups through a draw. They were asked to pick either number one or two from a container, with number one assigning them to Group A, and number two to Group B. The study utilized a single-blind approach where patients remained unaware of the treatment modalities of the alternate group. However, due to the distinct nature of the interventions, blinding of clinicians and assessors was not possible.

Both groups initially underwent a baseline treatment of aerobic exercise. In addition to this, Group A received strengthening exercises, while Group B continued with solely aerobic exercises. All treatment sessions were conducted under the supervision of the researcher.

The initial visit involved a comprehensive case history, physical examination, and regional assessment by the researcher. Participants' subjective symptoms were measured using the Numeric Pain Rating Scale (NPRS) and the Michigan Neuropathy Screening Instrument (MNSI), alongside the Clinical Global Rating of Change. Treatment was then administered according to the assigned group.

Follow-up visits included reassessments, where participants completed the NPRS and MNSI for subjective evaluation. Objective assessments were also conducted during treatment sessions at both the first and second follow-ups. Over a period of 10 weeks, each participant received a total of 20 sessions, equating to two sessions per week. The analysis of the data was conducted utilizing SPSS, version 20, with a predetermined statistical significance level of p=0.05. summary presentations of group measurements over time were illustrated using pie charts, bar charts, and frequency tables. Changes between groups on successive visits were analyzed by repeated measure ANOVA. The data was normative and homogenous without much skewness. There were a total of three levels, baseline, after treatment, and follow-up visit. To assess the difference between groups, an independent sample t-test was employed. This non-parametric test was utilized to compare variables between groups across various levels of assessment.

Prior to the commencement of the study, ethical clearance was obtained from the ethical committee of Riphah International University, Lahore. This ensured adherence to ethical standards in research involving human subjects. Permissions were also acquired from the respective medical facilities involved in the study.

RESULTS

The study's demographic profile revealed a nearly balanced gender distribution with Group A comprising 12 males and 8 females, and Group B containing 10 males and 8 females, indicating a slight male predominance in Group A. In terms of smoking habits, a slight difference was observed; Group A had 4 smokers, while Group B had 3, with non-smokers accounting for 16 and 17 individuals in Groups A and B, respectively. Hypertension prevalence was evenly distributed across both groups, with 10 individuals diagnosed with hypertension and 10 without in each group, ensuring uniformity in the selection criteria regarding this comorbidity.

Examining the continuous demographic data, both groups presented a median age in the mid-50s. Group A exhibited a broader age range, as indicated by a more extensive interquartile range and the presence of at least one significantly younger outlier. The duration of diabetes was comparable between the groups, with a median of around 10 years, suggesting participants had managed their condition for a similar period. Body Mass Index (BMI) assessments showed a marginally higher median BMI for Group A compared to Group B; however, the interquartile ranges were nearly identical, indicating a close similarity in bodyweight distribution. HbA1c levels, a marker of long-term glycemic control, revealed a median slightly above 7% for Group A and just at or below 7% for Group B, with Group A displaying both a wider range of values and an outlier indicating a notably lower HbA1c level than the group's average.

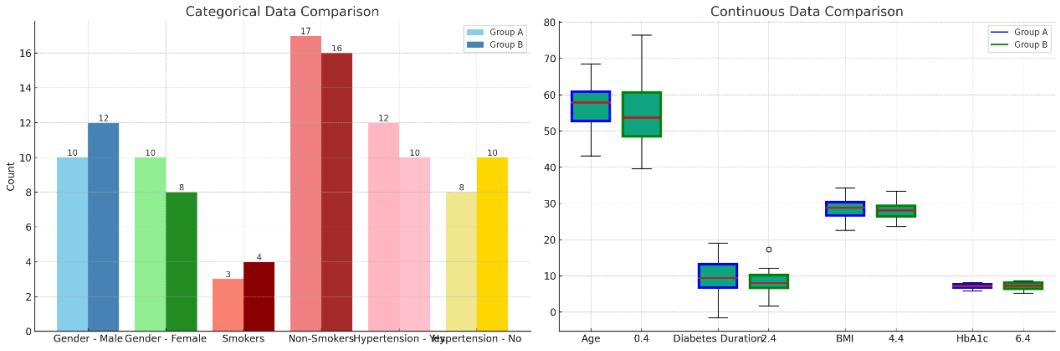

Figure 1 Comparative Study Demographics

In terms of clinical outcomes, both groups experienced significant improvements following the intervention. Group A's MNSI scores decreased from a mean of 8.100 ± 0.553 before treatment to 5.600 ± 0.681 after treatment, further declining to 3.350 ± 0.489 at follow-up. The mean difference calculated through RM ANOVA was significant at 4.750 (p-value = 0.000). Group B also saw a reduction in MNSI scores but with a less pronounced mean difference of 2.650 (p-value = 0.000), decreasing from an initial mean of 7.700 ± 0.923 to 6.600 ± 0.940 post-treatment, and then to 5.050 ± 0.945 at follow-up.

For NPRS scores, Group A reduced from a mean of 5.400 ± 1.231 pre-treatment to 3.150 ± 0.988 post-treatment, and further down to 1.150 ± 0.671 at follow-up. Group B followed a similar trend, with scores falling from an initial mean of 5.200 ± 1.152 to 2.900 ± 0.852 after treatment, and reaching 1.000 ± 0.918 at follow-up. The mean differences for NPRS were 4.250 for Group A and 4.200 for Group B, both statistically significant with p-values of 0.000.

The CGIS provided only baseline measures of severity, with Group A recording a mean score of 6.150 ± 0.813 and Group B a mean of 5.900 ± 0.788. The absence of follow-up data for this parameter precludes any post-treatment comparison.

Table 1 Ciinical Outcomes

Variable	Group	Mean ± SD (Before Treatment)	Mean ± SD (After Treatment)	Mean ± SD (Follow-Up)	Mean Difference (RM ANOVA)	P-value (RM ANOVA)
Michigan Neuropathy Screening Instrument (MNSI)	A	8.100 ± 0.553	5.600 ± 0.681	3.350 ± 0.489	4.750*	0.000
	B	7.700 ± 0.923	6.600 ± 0.940	5.050 ± 0.945	2.650*	0.000

Variable	Group	Mean ± SD (Before Treatment)	Mean ± SD (After Treatment)	Mean ± SD (Follow-Up)	Mean Difference (RM ANOVA)	P-value (RM ANOVA)
Numeric Pain Rating Scale (NPRS)	A	5.400 ± 1.231	3.150 ± 0.988	1.150 ± 0.671	4.250*	0.000
	B	5.200 ± 1.152	2.900 ± 0.852	1.000 ± 0.918	4.200*	0.000
Clinical Global Impressions of Severity	A	6.150 ± 0.813	-	-	-	0.33
	B	5.900 ± 0.788	-	-	-	-

Overall, the interventions were effective in both groups, as evidenced by the significant reductions in MNSI and NPRS scores. Notably, Group A's results suggest a potentially higher efficacy of their treatment modality in managing neuropathic symptoms and pain. The statistically significant p-values reinforce the robustness of these findings, with the demographic data underscoring a well-matched participant profile that supports the validity of the clinical outcomes.

DISCUSSION

The current study's exploration into the effects of aerobic exercise, both with and without resistive training, on peripheral neuropathy has yielded significant insights (22). The inclusion of resistance training in aerobic regimens has demonstrated a marked improvement in the reduction of peripheral neuropathy symptoms, as evidenced by the post-treatment measurements using the Michigan Neuropathy Screening Instrument (MNSI) (23, 24). Specifically, Group A (aerobic plus resistance training) showed a mean MNSI score of 3.350 ± 0.489 at follow-up, while Group B (aerobic only) had a mean score of 5.050 ± 0.944 (25). The significant mean difference and a p-value of 0.000 indicate a marked improvement in Group A over Group B.

Pain, as measured by the Numeric Pain Rating Scale (NPRS), presented less differentiation between the groups at follow-up, with Group A reporting a mean pain score of 1.150 ± 0.670 and Group B reporting a mean of 1.00 ± 0.917 (26). This outcome, evidenced by a non-significant p-value of 0.559, suggests that both aerobic exercises with and without resistance training are comparably effective in pain management. The Clinical Global Impressions of Severity scale, which did not show a significant difference between groups at the terminal end (p-value = 0.330), supports this conclusion.

These findings align with the broader body of research emphasizing the benefits of physical activity for individuals with type 2 diabetes. Studies have consistently shown that physical activity improves carbohydrate metabolism and insulin sensitivity, with benefits lasting up to five years. These effects are most pronounced in those with mild type 2 diabetes or higher levels of insulin resistance, with typical HbA1c improvements ranging from 10% to 20% from baseline. However, it must be noted that many of these studies have limitations in terms of randomization and control and are often confounded by concomitant lifestyle changes.

In comparison with prior research, the current study adds to the evidence supporting the efficacy of structured exercise programs in managing diabetes-related complications. It concurs with the literature suggesting that resistance exercise can be beneficial, though data on resistance training, particularly in type 2 diabetes, remain sparse.

The study design, which allowed for a direct comparison of aerobic exercise with and without resistance training, is a strength that contributes to its clinical relevance. However, several limitations warrant consideration. Recruiting participants who met the strict inclusion criteria posed a challenge, and reluctance to exercise was noted among the patients with diabetes at the study's outset. This reluctance underscores the need for educational interventions that highlight the therapeutic benefits of exercise in managing diabetes and its complications.

To address these limitations and suggestions from the study, it is recommended that light resistance exercises be incorporated into the treatment regimens for neuropathic patients. For those who find resistance exercises daunting, aerobic exercise alone should still be promoted as a beneficial intervention. To increase the reach and impact of these findings, publication and dissemination of the study's results are essential for raising awareness about the importance of incorporating aerobic exercises, with or without resistance training, in managing peripheral neuropathy.

Future studies should aim to include larger and more diverse populations, with randomized controlled trial designs to enhance the generalizability of the results. Furthermore, long-term follow-up is needed to assess the sustainability of the benefits observed and to evaluate the long-term adherence to exercise interventions. The study's findings highlight the potential for exercise to play a critical role in the management of diabetic peripheral neuropathy, offering a non-pharmacological avenue that can substantially improve patient outcomes.

CONCLUSION

The study provides compelling evidence that the integration of resistance training with aerobic exercises significantly enhances the reduction of peripheral neuropathy symptoms in patients with diabetes. These results highlight the therapeutic advantage of a combined exercise regimen, potentially offering a more effective approach for addressing neuropathic symptoms than aerobic exercise alone. Despite this, when considering the management of pain and the overall change in condition, the addition of resistance training to aerobic exercise does not demonstrate superiority. Both methods—whether combined or aerobic exercise in isolation—prove to be significantly effective, indicating that patients can achieve notable pain relief and overall condition improvement with either approach.

The study's findings advocate for the integration of combined aerobic and resistance training in clinical practice to alleviate symptoms of peripheral neuropathy in diabetic patients. This approach provides flexibility in treatment planning, accommodating patient preferences and capabilities, and potentially leading to better adherence and outcomes. Furthermore, the evidence for the effectiveness of exercise in managing diabetic complications reinforces the need for its inclusion in comprehensive diabetes care strategies. Future research should focus on understanding the underlying mechanisms that differentiate the impact of combined exercises from aerobic-only interventions on neuropathy symptoms.

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26. STRENGTH OQ. Dr Abdul Hannan PT1, Dr Madiha Younas PT2, Dr. Sabahat Ali sheikh PT3, Dr. Akhtar Rasul PT4, Dr Sania Anwar PT5, Dr. Misdaq Batool PT6 1Student Riphah international university Lahore, Pakistan 2Senior lecturer Riphah international university Lahore, Pakistan 3, 5Lecturer University of Lahore, Sargodha campus, Pakistan.