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From Recovery to Resurgence: Cardiac Rehabilitation's Impact on Cardiovascular Outcomes

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Abstract

Background: The paper underscores the growing importance of cardiac rehabilitation in contemporary healthcare due to the persistent burden of cardiovascular diseases (CVDs) on public health. Cardiovascular diseases have wide-ranging consequences, and managing them requires a comprehensive approach involving both short-term recovery and long-term prevention. Cardiac rehabilitation is highlighted as a crucial component, offering a holistic approach to enhance recovery post-cardiac events and reduce the risk of future occurrences.

Methods: A randomized controlled trial was conducted to assess the impact of two distinct rehabilitation approaches among stroke patients. Participants aged 45–70 years diagnosed with ischemic stroke in the subacute stage were recruited and randomly assigned to two groups. Group x received a stroke-specific rehabilitation protocol, while Group y received a combined intervention of individualized cardiac rehabilitation in addition to stroke rehabilitation. The study utilized computerized random sampling for participant selection, emphasizing a systematic and unbiased approach. Various outcome measures, including cardiac autonomic function, balance, mobility, cardiovascular fitness, respiratory parameters, and exercise efficiency, were assessed through baseline and post-intervention measurements.

Results: The study involved 38 participants in Group x and 37 participants in Group y. Demographic and medical factors were assessed, including age, stroke type distribution, smoking habits, hypertension, diabetes, and heart failure. Significant improvements were observed in Group y compared to Group x in post-Mean NN and post-RMSSD, indicating enhanced heart rate variability and parasympathetic nervous system activity. Group y also demonstrated improved respiratory performance, exercise efficiency, and endurance compared to Group x.

Conclusions: The study concludes that individualized cardiac rehabilitation programs for stroke patients can offer significant benefits, including improvements in balance, mobility, exercise efficiency, and autonomic regulation. The findings underscore the importance of tailored rehabilitation approaches in optimizing recovery, enhancing cardiovascular health, and improving overall well-being in stroke survivors.

Keywords: Cardiac Rehabilitation, cardiovascular, recovery, exercise factor, fitness, Postoperative Recovery

Introduction

Heart rehabilitation is essential in today's medical environment. Cardiovascular diseases (CVDs) continue to be a substantial public health burden due to their long-term implications, which go beyond a person's symptoms [1]. To manage these illnesses effectively, a comprehensive strategy addressing both immediate rehabilitation and long-term prevention is required. An essential part of this system is cardiac rehabilitation, which offers a thorough strategy to improve patients' recovery from cardiac events and lower their risk of recurrence [2]. This study highlights the expanding significance of cardiac rehabilitation in modern healthcare.

This study also aims to provide readers with a thorough understanding of how cardiac rehabilitation fits into the larger goals of modern medicine by shedding light on the most recent developments, current problems, and promising career paths in this area. In the current healthcare system, heart rehabilitation is now considered an essential component of the complete care given to patients suffering from cardiovascular disorders rather than merely an optional one [3]. Altogether, these conditions—which include a wide range of disorders like coronary artery disease, arrhythmias, and heart failure—make up the leading cause of death worldwide. CVDs not only directly impair patients' quality of life but also impose a heavy financial cost on society, healthcare systems, and individuals. Preventive care, patient-centred therapy, and prudent resource allocation are becoming more and more important as healthcare paradigms change [4].

Within this framework, cardiac rehabilitation has become a vital tactic to accomplish these goals. A major paradigm shift in the treatment of cardiovascular diseases has been brought about by the concept of cardiac rehabilitation [5]. After a stroke, patients can engage in a variety of fitness activities, such as cardiac rehabilitation and traditional exercise [6]. Specialist rehabilitation programmes for stroke patients may involve range-of-motion

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exercises, breathing exercises, neuromuscular re-education, gait training, balance and coordination training, functional mobility training, and strength training on the paralysed side [7]. Enhancing muscular tone, strength, coordination, and balance are the goals of these exercises. When performed under the supervision of a physical therapist, they are typically safe and beneficial for stroke patients; nevertheless, those with significant impairment may not benefit from them [8]. Programmes for cardio rehabilitation are typically more rigorous than those for stroke recovery. Ongoing therapy or significant deficits may make stroke victims more effective candidates for them.

Many studies have examined the benefits of physical activity and exercise for stroke survivors [9, 10]. The American Heart Association recommends that stroke survivors exercise three days a week for at least twenty to thirty minutes of moderate-to-intense cardiovascular exercise or twenty to thirty minutes of vigorous-intensity aerobic activity. It is recommended to perform strength training twice or three times a week in addition to daily flexibility exercises. These suggestions are supported by research showing that exercise and physical activity can enhance cardiovascular health, lower the risk of stroke in the future, and improve physical function in stroke survivors [11]. Analysing heart rate variability (HRV) during the chronic phase of the disease can yield important information on stroke mortality, recurrence, and likely underlying causes. The course provides a comprehensive strategy that addresses the various needs of those who have experienced cardiac events, going beyond the scope of traditional medical therapy. Apart from the medical aspects, this therapy provides a comprehensive rehabilitation strategy by incorporating social support, lifestyle adjustments, mental health, and risk factor control [12].

Therefore, heart rehabilitation acts as a link between the initial stage of medical intervention and ongoing heart disease management and relief [13]. This specific situation highlights the importance of cardiac rehabilitation even more. Its preceding sentence suggests a change in emphasis in favour of all-encompassing, preventive, and empowered care [14]. Acknowledging the intricacy of cardiac rehabilitation is crucial, considering the obstacles confronting healthcare systems with the rising prevalence of chronic illnesses [15]. The purpose of this study is to assess and contrast the efficacy of two different rehabilitation regimens: activities for stroke recovery and individualised cardiac rehabilitation. Numerous outcome markers, such as cardiovascular fitness, respiratory parameters, mobility, balance, cardiac autonomic function, and exercise efficiency, were investigated in this study. The main goal of this study is to assess how these therapies affect stroke patient's improved cardiac recovery during rehabilitation.

Materials and Methods

A randomised controlled trial was conducted to examine the rehabilitation programmes offered to two distinct stroke victims. The study involved two groups: Group X received rehabilitation tailored only for stroke, whereas Group Y additionally received specialised cardiac rehabilitation. The nature of the interventions meant that single blinding was utilised whenever practicable. Because of the variety of rehabilitation treatments involved, it is impossible to totally blind patients, therapists, and assessors; however, steps were taken to lessen the likelihood of bias. To avoid selection bias, the group assignment was kept a secret until baseline evaluations were finished. Assessors responsible for collecting outcome data were blind to the groups they belonged to to minimise measurement bias.

Study design

The study employed computerised random selection to identify participants. In this way, the participants were divided into two groups, Group X and Group Y, and computer software was used to produce random sequences of numbers. The use of computerised random sampling increases the study's scientific rigour and decreases the danger of group assignment bias by providing a logical and objective process for participant selection.

Sample size

Patients with strokes, ranging in age from 45 to 70, were selected from medical centres or rehabilitation centres. They were randomly allocated to either Group X or Group Y. Group X participated in a structured stroke rehabilitation plan for fifteen weeks, attending daily sessions three days a week. Group Y, on the other hand, received a combination strategy consisting of specialist cardiac rehabilitation in addition to stroke treatment. This intervention comprised two days of whole-body weight training exercises and four days of moderate-intensity aerobic exercise lasting forty to fifty minutes each per week. The entire duration of the intervention was fifteen weeks. Every participant was measured for respiratory parameters, exercise efficiency, mobility, balance, cardiovascular fitness, and cardiac autonomic function during baseline assessments at 0 days and a post-intervention evaluation

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at 15 weeks. Enhancing endurance, respiratory parameters, cardiovascular fitness, and autonomic function were the program's goals.

Inclusion Criteria

Participants had to meet certain requirements to be eligible: they had to be in the subacute stage of the disease, be between the ages of 45 and 70, have a verified diagnosis of ischemic stroke, be medically stable, and have received the all-clear from a physician to resume physical activity. The study primarily focused on male participants to enhance its generalizability, considering the increased incidence of ischemic stroke in this population. Moreover, patients must have a Chedoke–McMaster Stroke Assessment leg impairment score of three or above.

Exclusion criteria

Patients with significant neurological impairments, severe comorbidities, severe cognitive impairments, uncontrolled medical problems that preclude maximal exercise testing, conditions that safely limit exertion, incapacity to give informed consent, or noncompliance with research procedures were excluded.

Statistical analysis

Statistical analysis was done with SPSS Version 22. We evaluated the normalcy assumption using the Shapiro-Wilk test before doing parametric testing. After the exercise-based cardiac rehabilitation course ended, or after a comparable period for the control group, further tests were conducted. An independent t-test was used to examine the data between the two groups, and a paired t-test was used for within-group analysis. A significance threshold of $p<0.05$ and a 95% confidence range were applied. Both Group x and Group y's participant means and standard deviations were computed and reported using descriptive statistics.

Ethical approval

The research protocol has received approval from the hospital's Ethical Committee, ensuring adherence to ethical standards and safeguarding the well-being and rights of the participants.

Results

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This study included a comprehensive assessment of the medical and demographic features of stroke patients allocated to two groups: Group x [n=38; male=32 (84%) and female=06 (15%)] and Group y [n=37; male=33 (89.19%) and female=4 (10.81%)]. Groups x and y had similar mean ages (57.50±2.61 and 58.50±2.50 years), respectively. 86.7% of Group x and 73.3% of Group y had ischemic strokes, according to an examination of the distribution of stroke types; nevertheless, there were no significant variations in their incidence (χ 2=0.83, p=0.36). Similarly, no significant differences were seen with respect to the side of the stroke (80.0% in Group x and 73.3% left-sided strokes in Group x; χ 2=0.19, p=0.67). With 68.80% of smokers in Group x and 94% in Group y (χ 2=3.33, p=0.17), there was a noteworthy, albeit non-significant, difference in smoking tendencies. Group y had rates of 72.80% (χ 2=0.17, p=0.71) compared to 68.5% for Group x, suggesting no appreciable difference in hypertension. Furthermore, at 94.80% and 79.0%, respectively, there was no statistically significant difference in the prevalence of diabetes between Groups X and Y (χ2=1.15, p=0.28). In terms of heart failure prevalence, which was observed in 79.0% of Group x and 68.80% of Group y, there was no appreciable difference between the two groups. These findings provide valuable insights into the study population's baseline characteristics Table 1 and Fig. 1.

Table 1. Demographic data of participants

Variable	Group x	Group y
Age	57.50±2.61	58.50±2.50
BMI	31.70±2.80	31.72±5.18
Weight	62.85±8.80	61.70±11.34
Height	1.44±0.46	1.41±0.45

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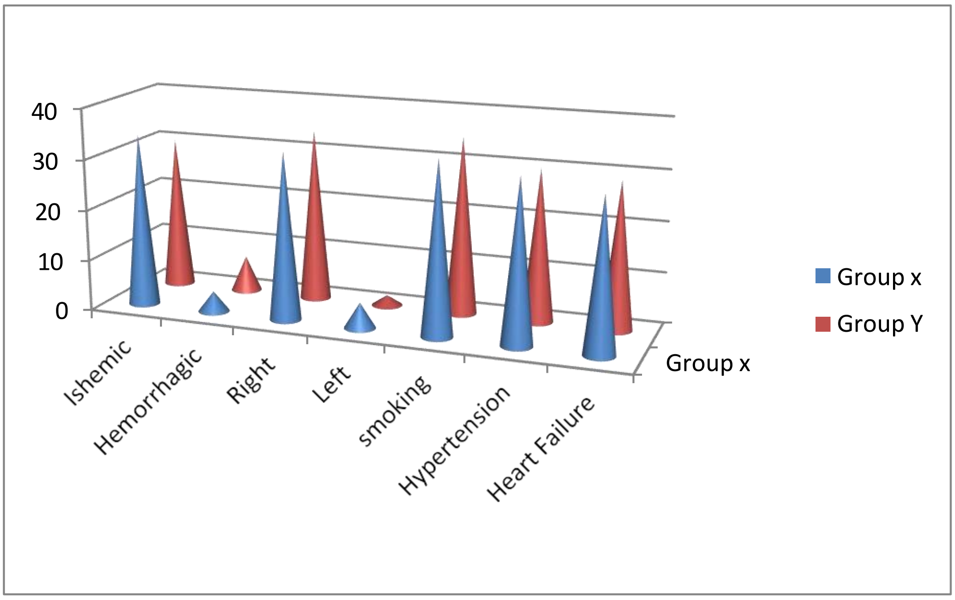

Fig. 1 Different types of cardiovascular attacks

The outcomes of an independent t-test contrasting the benefits of customised cardio rehab in Group y with stroke-specific rehab in Group x is shown in Table 2. When comparing Group y to Group x, there was a substantial improvement in Post-Mean NN (p=0.01) and Post-RMSSD (p=0.01), suggesting that the intervention increased heart rate variability and parasympathetic nervous system activity. The groups' Pre Mean NN and Post nLF did not, however, differ significantly (p>0.05).

Table 2 Evaluation of variations in autonomic nervous system and cardiovascular parameters by group analysis

Variable	**Group X**	**Group Y**	**p value**
Mean Hr	901.61±42.29	912.72±61.50	0.51
Resting Hr	82.54±8.35	92.41±7.21	0.39
RMSSD	51.09±12.61	55.88±9.70	0.1
pNN50	48.33±8.77	46.66±7.55	0.75
SDNN	161.82±59.47	160.52±58.37	0.79
LF/HF	1.39±0.47	1.07±1.01	0.21
nHF	41.1±10.50	39.11±19.14	0.17
nLF	44.20±18.06	47.01±17.70	0.77

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The cardiovascular fitness markers, SBP, DBP, HR Rest, and HR Peak, did not substantially differ in the Pre or Post assessments between Groups x and y ($p>0.05$), indicating that their baseline characteristics and reactions to the interventions were same. Figure 3 presents these findings. With significant differences ($p<0.05$) seen between the groups' post-intervention VE Peak, RR Peak, PET CO2 Peak, VE/CO2 Slope, and VE/O2 Slope, Group y outperformed Group x in terms of respiratory parameters. Furthermore, after the intervention, Group y performed significantly better than Group x in terms of exercise time and RER ($p<0.05$), demonstrating increased exercise endurance and efficiency.

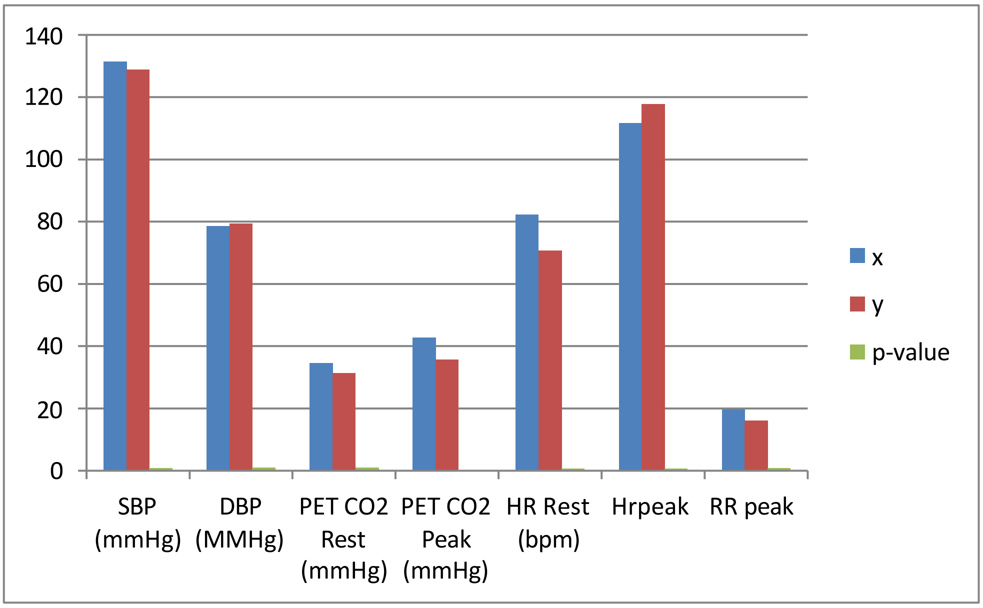

Fig. 3 Analysis to assess variations in exercise intensity, duration, and subjective effort

Discussion

A growing range of cardiovascular exercise choices, including sports, treadmill training, above-the-ground walking, and technology-based programmes, are offered for post-stroke rehabilitation [16]. Electromechanically assisted gait training, which may incorporate body weight support, may be helpful for stroke patients who are unable to walk alone [17]. Research on the effectiveness of mental practice in accelerating stroke patients' recovery has produced conflicting results [18]. This research attempts to address the crucial question of whether patients with strokes benefit more from cardiac rehabilitation programmes that are specially tailored to their needs or from stroke-specific rehab, which concentrates on the major functional limitations a patient has following a stroke. In this study, balance and mobility—two crucial aspects of post-stroke rehabilitation and general well-being—were significantly

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improved in stroke patients who underwent individualised cardio rehab. The four primary areas of recovery for stroke survivors are proprioception, cardiovascular health, spatial awareness, and muscular strength, which are the focus of these exercises. Studies have demonstrated the value of the SPPB and Berg Balance Scale (BBS) in assessing the balance and mobility of stroke patients [19].

A thorough study [20] found that exercise programmes can help stroke patients with strength, physical function, and daily tasks. This illustrates how important it is to adjust workout plans based on the stage that follows a stroke. The American Heart Association also suggests that stroke survivors exercise regularly, including aerobic, strength, and balance training, to enhance overall health and physical function. Autonomic anomalies are commonly seen after a stroke, although they are often poorly understood and understudied [20]. The autonomic nervous system's (ANS) intricate architecture could be a contributing factor to the lack of comprehensive studies in this field. The ANS is a complicated structure with multiple regulatory sites and complex linkages, making it challenging to determine the exact effects of individual pathways [21]. Due to the high cost and limited availability of most currently available diagnostics, assessing the ANS in a clinical context is more challenging.

Numerous aggravating factors, including concomitant medical disorders, medication use, degree of hydration, and persistent severe impairment, can change test results. Following individualised cardiac rehabilitation programmes, the stroke patients in this study demonstrated notable improvements in several critical spectral domain measures, including heart rate variability (HRV). These improvements made the root reasons for these changes more apparent. The previous study did not find a meaningful association between a higher resting heart rate (RHR) and the overall risk of stroke. Men, on the other hand, are particularly attached to this [22]. In a different prospective study, a sizable cohort of Chinese people aged 40 and above showed an increased risk of total and hemorrhagic strokes but not ischemic strokes [23].

This comprehensive meta-analysis found that for every ten beats per minute rise in RHR, there was a 6% increased risk of stroke. Moreover, individuals with an RHR>80 bpm had a 47% higher risk of hemorrhagic stroke, a 38% higher risk of ischemic stroke, and a 68% higher risk of unclassified stroke in comparison to those whose RHR was less than 65 bpm. This study's findings show that a decrease in resting heart rate (HR Rest) is indicative of increased cardiac efficiency, which is linked to improved cardiovascular fitness in general [24, 25]. Improved autonomic control and the heart's reaction to stress are indicated by increased root mean square of successive differences (RMSSD) and NN intervals (SDNN) in stroke patients receiving customised radiotherapy. One of the most important markers of cardiac adaptability is heart rate recovery or the amount of time it takes for the heart rate to return to normal following exercise. Higher SDNN and RMSSD during cardiac rehabilitation indicate that regular exercise can aid in heart rate recovery [26].

Patients can gradually acclimatise to higher levels of physical activity with the help of a customised rehabilitation plan that includes a progressive progression of activities. Both HRV levels and the cardiovascular system's flexibility may increase because of this controlled approach [27]. It has been demonstrated that exercise training enhances autonomic function and speeds up the heart rate's recovery following exertion [28]. Individual responses to cardiac rehabilitation can vary, even while increased SDNN and RMSSD generally strongly reflect greater autonomic control and cardiac adaptability. Consequently, the reasons behind each patient's experience of these benefits may vary [29].

Improved thermoregulation and maybe reduced renin-angiotensin-aldosterone system activity could result from increased very low-frequency power (VLF), which could be advantageous for blood pressure regulation and cardiovascular health in general. Moreover, the VLF band exhibits a stronger correlation with the prognosis of metabolic syndromes, cardiovascular illness, and all-cause mortality following traumatic brain injury compared to the other HRV components [30, 31].

The degree to which the participants thought the exercise was difficult was indicated by a decline in their rating of perceived exertion (RPE). A more all-encompassing approach to stroke patients' recovery may be provided by carefully designed rehabilitation programmes, which seem to enhance stroke patients' capacity to tolerate exercise in both the physiological and subjective dimensions because of the excellent association between RPE measurement during sub-maximum exercise conditions and other established physical fitness markers that have been observed in both trained and untrained men, RER can be used as a measure of exercise efficiency in persons with reduced exercise tolerance [15].

Enhanced substrate utilisation during exercise has been associated with a decrease in RER shown in longitudinal research following training at the same absolute workload but not at the same relative intensity. The effects of low peak RER on cardiac rehabilitation are not well studied. It may not be possible for a patient with a lower RER peak to surpass the peak exercise tolerance threshold during cardiac rehabilitation for coronary artery disease [28]. A

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third study found that oxygen consumption and cardiorespiratory burden were low during robot-assisted gait after a stroke, indicating a decrease in RPE [29].

Conclusion

The results of the study demonstrate the potential advantages of cardiac rehabilitation programmes created especially for stroke victims. By addressing the specific requirements of stroke survivors, these tailored routines have significantly improved balance, mobility, autonomic regulation, and exercise efficiency. This has been emphasized by lowered respiratory exchange ratios (RER), decreased ratings of perceived effort (RPE), increased heart rate variability (HRV), and increased ventilatory efficiency. These results underline how important tailored rehabilitation programmes are for speeding up the healing process, strengthening cardiovascular health, and raising stroke victims' overall quality of life.

The prospect of technology-aided rehabilitation, including electromechanically assisted gait training and virtual reality training, is exciting to contemplate, particularly for persons with severe mobility difficulties. By carrying out more studies on the use of biomarkers as indications of stroke recovery and treatment response, we can get more insight into the fundamental mechanisms of personalised cardiac rehabilitation. Investigating possible drug interactions with underlying medical conditions may be part of creating customised exercise regimens and medication schedules for a variety of patient profiles.

Limitations

This inquiry may be subject to numerous limitations. First off, even if the sample size can account for an expected dropout rate, it is still quite small, which may limit statistical power and generalizability.

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