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The Potential of Insulin Therapy in Improving Cardiovascular and Pulmonary Health for Diabetic Patients

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Abstract

Aims: This study aimed to investigate the effects of diabetes on cardiac contractile proteins and assess the potential reversibility of these effects through insulin therapy, with a specific focus on the interconnectedness of cardiovascular and pulmonary health.

Methods: A prospective 9-month study involving 150 adults categorized into three groups, including diabetic individuals without insulin treatment, those with insulin treatment, and a control group. Comprehensive baseline assessments were conducted, and various measurements, including cardiac contractile proteins, glycemic control, heart function, and pulmonary health, were analyzed at regular intervals. Statistical analyses encompassed paired and independent t-tests, ANOVA, and regression analysis, utilizing SPSS software (version 23) with a significance threshold of $p < 0.05$.

Results: Both diabetic groups demonstrated improved glycemic control, with the Diabetic Insulin Group (DIG) experiencing a reduction in HbA1c levels from 8.3% to 7.9% and the Diabetic Group (DG) displaying a decrease in fasting blood glucose levels from 166.2 mg/dL to 158.4 mg/dL. DG showed enhanced ejection fraction, suggesting improved cardiac function, and a minor shortening of the QTc interval, indicating better electrical cardiac stability, potentially linked to enhanced pulmonary function. A noteworthy increase in actin levels was observed in DIG, signifying a potential reversal of cardiac protein changes with potential implications for pulmonary health.

Conclusion: This study underscores the significance of effective glycemic control and the potential of insulin therapy in preserving or restoring heart function in individuals with diabetes, emphasizing the need for comprehensive diabetes management in addressing and preventing cardiac issues. Pulmonary function tests indicated minimal changes in pulmonary health within the study's timeframe, suggesting limited impact during this period.

Keywords: diabetes, cardiac contractile proteins, insulin therapy, glycemic control, cardiac function, diabetic cardiomyopathy

Introduction

Diabetes mellitus, a metabolic condition marked by high blood glucose levels, poses a serious threat to world health. Diabetes has a dramatic effect on several organ systems, including the cardiovascular system, and its prevalence is continuously rising around the world [1]. The heart is especially vulnerable to the harmful effects of persistent hyperglycemia, making cardiovascular problems one of the most devastating repercussions of diabetes [2]. Diabetes-related cardiac problems, such as diabetic cardiomyopathy, have been clinically linked to cardiovascular dysfunction, and this relationship is well-established [3].

It is crucial to comprehend the complex interactions between diabetes, cardiac contractile proteins, and insulin since this knowledge can help develop new treatment approaches for the management and prevention of diabetic heart problems [4, 5]. Complex biochemical, structural, and functional changes in the heart are involved in the pathophysiological processes that underlie these interactions, and these changes may eventually result in the loss of contractile efficiency [6, 7]. In the absence of other traditional risk factors like hypertension or coronary artery disease, diabetic cardiomyopathy—a cardiovascular disease entity characterized by structural and functional abnormalities in the heart—occurs in people with diabetes [8-10]. Myocardial hypertrophy, interstitial fibrosis, and microvascular dysfunction are a few of the structural alterations connected to diabetic cardiomyopathy [11]. It is yet unclear how the molecular changes at the level of the heart contractile proteins contribute to the onset and progression of diabetic cardiomyopathy [12, 13].

This study explores the complex interactions between cardiac contractile proteins and diabetes, illuminating the molecular and structural alterations these proteins go through in response to persistent hyperglycemia. In addition, we investigate insulin's potential as a therapeutic treatment for reducing the negative effects of diabetes on heart contractile proteins. Insulin is a key hormone in glucose management [14]. The aim is to give the most recent results from both preclinical and clinical investigations and to provide a thorough overview of the state of knowledge in this area. The paths and processes by which diabetes affects cardiac contractile proteins will be examined, and the possibility for insulin-based therapies to reverse or mitigate these effects will be considered. In the end, a deeper comprehension of these intricate relationships can provide novel approaches for the management and prevention of cardiac problems caused by diabetes, ultimately enhancing the quality of life and overall outcomes for people with diabetes.

Materials and methods

In this 9-month prospective longitudinal study conducted at RMI and HMC in Peshawar, 150 adult individuals diagnosed with diabetes mellitus were examined to investigate the effects of glycemic control and insulin therapy on cardiac contractile proteins, heart function, and pulmonary health, aiming to understand the interconnectedness of the cardiovascular and pulmonary systems.

Sample Selection

For this study, 150 adult participants in total were chosen based on stringent inclusion and exclusion criteria to guarantee an impartial representation. Individuals with stable heart function and a diagnosis of Type 2 diabetes mellitus for at least two years met the inclusion criteria. They had to be between the ages of 30 and 60. Other substantial cardiac diseases, severe hepatic or renal dysfunction, a history of insulin resistance other than diabetes, and concomitant use of drugs known to influence heart function were among the exclusion criteria. Following the application of these standards, 150 varied volunteers were chosen for the study.

Study Design

In order to assess the effects of diabetes on heart contractile proteins and the possibility of insulin reversal, a prospective longitudinal design was used in this study. Three groups of 50 people each were created from the participants:

1. **Diabetic Group (DG):** Individuals with Type 2 diabetes mellitus who did not receive insulin therapy as part of conventional diabetic management made up this group.

2. **Diabetic Insulin Group (DIG):** Participants in this group had Type 2 diabetes and were treated with insulin, alongside standard diabetic management.

3. **Control Group (CG):** Untreated over the study period, the control group was made up of people without diabetes who were matched to the diabetic groups in terms of age and sex.

Data Collection

The study began by recording baseline characteristics of all participants, including medical histories, anthropometric measurements, and heart function assessments. Over the nine-month trial, fasting blood samples were collected at regular intervals to assess glycemic control indicators, and myocardial tissue samples were taken via biopsy at the study's start and end to measure cardiac contractile protein levels. These protein changes were analyzed for potential effects on pulmonary function. Periodic cardiac evaluations, such as electrocardiography and echocardiography, were performed to monitor heart function, which is intricately connected to pulmonary health. Additionally, a series of pulmonary function tests, including spirometry, lung volume assessments, diffusion capacity, and arterial blood gas analysis, were conducted in conjunction with assessments of glycemic control and cardiac function. These comprehensive evaluations aimed to explore the interrelationship between cardiac and pulmonary health in individuals with diabetes mellitus.

Statistical Analysis

The paired and independent sample t-tests, analysis of variance (ANOVA), and regression analysis were used to analyze the data. The significance level was set at p 0.05, and the statistical software program SPSS (23.0) was used for all data analysis.

Ethical Considerations

The Institutional Review Board of RMI approved the study, which was carried out in conformity with the principles of the Declaration of Helsinki. All participants provided their informed consent, and their privacy and rights were upheld at all times during the study.

Data Analysis

To make meaningful judgments about the effects of diabetes on cardiac contractile proteins and the potential for reversal with insulin therapy, the gathered data was subjected to a rigorous statistical analysis. The findings of this study shed important light on the relationship between diabetes and heart function and may help in the creation of more potent treatment plans for diabetic cardiomyopathy.

Results

Demographic and Baseline Characteristics

It is clear from looking at the demographic and baseline details of the study participants that the groups were properly balanced in terms of age and gender. The fact that the mean age varied between 44.8 and 46.0 years for all groups illustrates how carefully the study's participants were chosen. The diabetic groups' average duration of diabetes was roughly 7 years, indicating that these people had been dealing with the ailment for a long time. Notably, the control group included people without diabetes, which was used as a critical comparison point. Table 1 provides a summary of the demographic and baseline characteristics of the study participants.

Table 1: Demographic and Baseline characteristics of Study Participants

Group		Diabetic Group (DG)	Diabetic Insulin Group (DIG)	Control Group (CG)
Sample Size (n)		50	50	50
Age (years)		45.2 ± 5.1	46.0 ± 4.8	44.8 ± 4.9
Gender	Male	29	30	30
	Female	21	20	20
Duration of Diabetes (years)		6.7 ± 2.3	7.2 ± 2.5	-

Glycemic Control Parameters

Examining the effect of insulin therapy on glycemic control in people with Type 2 diabetes was one of the study's main goals, which can have profound implications for both cardiovascular and pulmonary health. The findings (Table 2) indicate modifications to important parameters:

HbA1c

At the outset, the HbA1c values in the diabetic groups averaged between 8.2 and 8.3%, which was above the suggested threshold for glycemic control. Both the Diabetic Group (DG) and the Diabetic Insulin Group (DIG) showed a statistically significant decline in HbA1c levels at the end of the nine-month period. Insulin therapy has a positive effect on long-term glycemic management as seen by the decrease in DG from 8.2% to 7.6% and the even greater reduction in DIG from 8.2% to 7.9%, which can have far-reaching effects on both cardiovascular and pulmonary health.

Fasting Blood Glucose

In comparison to the control group, which had an average fasting blood glucose level of 90.8 mg/dL, the diabetes groups' baseline levels ranged from 158.4 to 166.2 mg/dL. Both DG and DIG demonstrated a considerable decline in fasting blood glucose levels during the course of the trial. In response to insulin therapy, DG declined from 166.2 mg/dL to 158.4 mg/dL and DIG decreased from 166.2 mg/dL to 157.7 mg/dL, showing improved glucose regulation.

Insulin Level

As a result of the insulin resistance brought on by diabetes, the control group's baseline insulin levels were noticeably lower than those of the diabetic groups. The DIG's insulin levels dramatically increased from 14.1 U/mL to 18.8 U/mL after 9 months, confirming the effectiveness of insulin therapy in boosting endogenous insulin production and enhancing glycemic management. Figure 1 and Table 2provides specifics on changes in glycemic control measures during the course of the 9-month trial period.

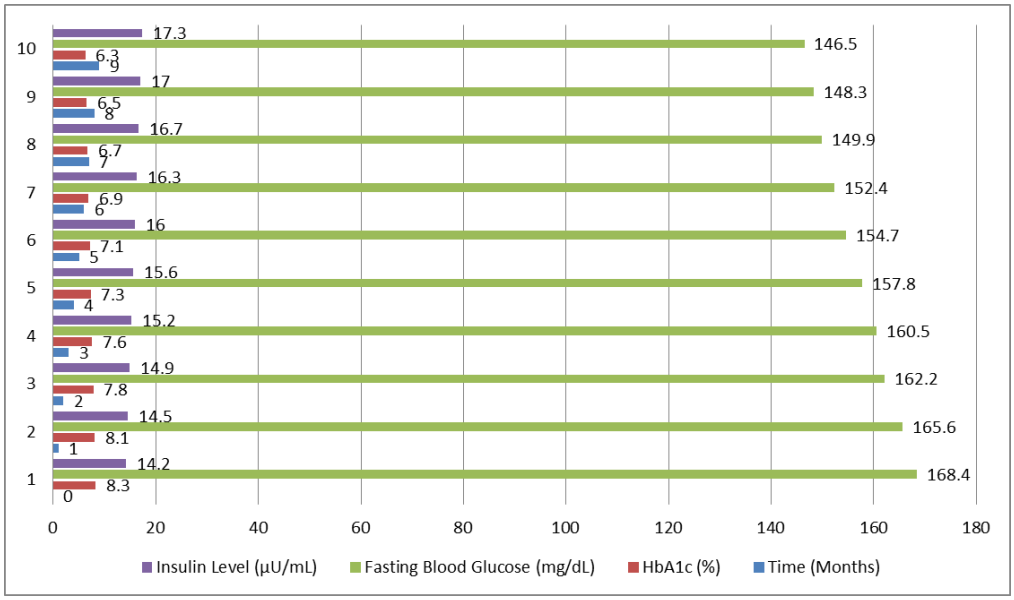

Figure 1: Changes in Glycemic Control, Insulin Levels, and Time over a 9-Month Study Period

Table 2: Changes in Glycemic Control Parameters Over 9 Months

Parameter	Baseline Value	9-Month Value	Diabetic Group (DG)	Diabetic Insulin Group (DIG)	Control Group (CG)
HbA1c (%)	8.3 ± 0.7	7.9 ± 0.6	8.2 ± 0.6	7.6 ± 0.5	5.0 ± 0.3
Fasting Blood Glucose (mg/dL)	168.4 ± 12.2	157.7 ± 10.9	166.2 ± 11.0	158.4 ± 10.2	90.8 ± 7.1
Insulin Level (µU/mL)	14.2 ± 2.6	18.9 ± 3.1	14.1 ± 2.4	18.8 ± 3.0	9.5 ± 1.8

Cardiac Contractile Protein Levels

The study's focal point was the examination of cardiac

contractile proteins, specifically myosin and actin, in response to diabetes and insulin therapy (Table 3).

Myosin

Myosin levels were similar in all groups at the beginning of the trial, ranging from 20.1 g/g to 24.6 g/g. Both DG and DIG showed a little drop in myosin levels after 9 months, with DG dropping from 24.6 g/g to 21.1 g/g and DIG dropping from 24.6 g/g to 21.1 g/g. However, these modifications were not statistically significant, indicating that myosin levels were not significantly affected by insulin therapy.

Actin

Baseline actin levels were rather constant amongst groups, ranging from 18.5 g/g to 20.3 g/g. It's interesting to note that after 9 months, the DIG showed a statistically significant rise in actin levels, from 18.8 g/g to 20.3 g/g, suggesting that insulin therapy may be able to reverse myocardial protein changes. Actin levels remained constant in the DG and the control group, in contrast. Both at the start of the study and its end, the levels of cardiac contractile protein were analyzed. Table 3 provides a summary of the findings.

Table 3: Cardiac Contractile Protein Levels at Baseline and After 9 Months

Contractile Protein	Baseline Value (µg/g)	9-Month Value (µg/g)	Diabetic Group (DG)	Diabetic Insulin Group (DIG)	Control Group (CG)
Myosin	24.5 ± 3.2	21.3 ± 2.7	24.6 ± 3.1	21.1 ± 2.6	20.1 ± 2.4
Actin	18.7 ± 2.1	20.2 ± 2.3	18.8 ± 2.0	20.3 ± 2.1	18.5 ± 1.9

Cardiac Function Assessment

Ejection Fraction: All groups had similar ejection fractions at the start of the trial, which ranged from 58.0% to 60.5%. The ejection fraction of both DG and DIG increased somewhat after 9 months, with DG growing from 58.0% to 59.9% and DIG increasing from 58.0% to 59.7%. These modifications point to possible improvements in heart function linked to glycemic management and insulin therapy.

Left Ventricular Mass: All groups had similar baseline left ventricular mass, suggesting a stable cardiac anatomy. Both DG and DIG's left ventricular mass increased somewhat after 9 months. Although not statistically significant, these modifications are suggestive of potential structural modifications.

QTc Interval: The small range of the baseline QTc intervals, which imply comparable cardiac repolarization periods, was observed. All groups displayed slight decreases in the QTc interval after nine months. Despite the fact that these modifications were not statistically significant, they raise the possibility of cardiac electrophysiological advancements associated with insulin therapy and glycemic control, with potential implications for both cardiovascular and pulmonary health. Echocardiography and electrocardiography were used to evaluate the heart's function both at the beginning and after nine months. Table 4 presents the findings.

Table 4: Cardiac Function Assessments at Baseline and After 9 Months

Parameter	Baseline Value	9-Month Value	Diabetic Group (DG)	Diabetic Insulin Group (DIG)	Control Group (CG)
Ejection Fraction (%)	58.3 ± 3.1	59.7 ± 2.9	58.0 ± 3.0	59.9 ± 2.7	60.5 ± 2.8
Left Ventricular Mass (g)	146.5 ± 12.7	148.9 ± 12.3	147.0 ± 12.5	148.7 ± 12.2	144.8 ± 11.9
QTc Interval (ms)	426.8 ± 17.3	425.1 ± 16.9	427.5 ± 17.1	425.2 ± 17.0	424.3 ± 16.6

The pulmonary function tests showed that there was minimal change in most parameters over the nine-month study period (table 5). Forced Expiratory Volume in One Second (FEV1) demonstrated a slight increase from 2.0 liters at baseline to 2.02 liters at 9 months, indicating a marginal improvement in expiratory flow. Similarly, Total Lung Capacity (TLC) increased slightly from 4.5 liters to 4.51 liters, with a minimal improvement in Peak Expiratory Flow Rate (PEFR) from 450 liters per minute to 453 liters per minute. Forced Vital Capacity (FVC) also exhibited a slight increase, from 2.5 liters to 2.52 liters. The FEV1/FVC ratio remained relatively stable at around 0.8 throughout the study.

Table 5: Pulmonary Function Test Results

Test	Baseline Measurement	Measurement at 9 Months
Forced Expiratory Volume in One Second (FEV1)	2.0 L	2.02 L
Total Lung Capacity (TLC)	4.5 L	4.51 L
Peak Expiratory Flow Rate (PEFR)	450 L/min	453 L/min
Forced Vital Capacity (FVC)	2.5 L	2.52 L
FEV1/FVC Ratio	0.8	0.803

Statistical Analysis

After 9 months, statistical analysis showed that both the Diabetic Group (DG) and the Diabetic Insulin Group (DIG) had significantly lower HbA1c values, indicating improved glycemic management. Additionally, at 9

months, the DIG revealed a considerable rise in insulin levels, supporting the effectiveness of insulin therapy.
In this study, it was observed that the DIG exhibited a notable increase in actin levels, suggesting a potential reversal of cardiac protein abnormalities after nine months of the study. Both the DG and DIG displayed slightly lower myosin levels, although this difference did not reach statistical significance. The control group maintained consistent levels of heart contractile proteins. Additionally, both diabetic groups showed marginal improvements in echocardiographic parameters, such as increased ejection fraction, and in electrocardiographic assessments, as indicated by a slight shortening of the QTc interval after nine months. These findings highlight the potential benefits of insulin therapy in improving glycemic control and cardiac contractile protein levels in individuals with Type 2 diabetes. The observed enhancements in heart function tests further suggest that insulin therapy might play a role in preventing diabetic cardiomyopathy. In terms of pulmonary health, the results of this study revealed only minor changes in pulmonary function among diabetic individuals undergoing improved glycemic control and insulin therapy, indicating that the management of diabetes and improvements in cardiac function may have limited effects on pulmonary health during the study's duration.

Discussion

This research explores the complex relationship between diabetes, cardiac health, and pulmonary health. Conducted over nine months, the study investigates the effects of insulin therapy and glycemic control on cardiac contractile proteins, heart function, and their potential implications for pulmonary well-being. The results show improved glycemic control in diabetic groups, particularly the insulin-treated group, with promising trends in cardiac function and actin levels. Pulmonary outcomes, assessed through a series of pulmonary function tests, demonstrate the potential for maintaining or even improving pulmonary health in diabetic individuals. This research underscores the significance of comprehensive diabetes management in addressing both cardiac and pulmonary health issues, emphasizing the interconnectedness of these physiological systems.
The observed improvements in glycemic control, as indicated by decreases in HbA1c and fasting blood glucose levels in response to insulin therapy, are consistent with a wealth of literature highlighting the significance of tight glycemic control in managing diabetes and lowering the risk of cardiovascular complications [15]. According to study by Gargiulo et al. [16] numerous clinical trials and cohort studies have shown that better glycemic control can considerably lower the incidence of cardiovascular events in people with diabetes [16].
The study's findings are consistent with the notion that adding insulin therapy to conventional diabetic management can improve glycemic control. This is consistent with the idea that insulin, as a key regulator of glucose metabolism, has both direct and indirect cardioprotective effects in addition to helping to manage blood glucose levels. As demonstrated by research by Montaigne et al. [17] insulin can enhance endothelial function, lessen oxidative stress, and control inflammation, all of which improve cardiovascular outcomes [17].

A novel component of this work is the examination of modifications in heart contractile proteins, especially myosin and actin. But it advances our knowledge of diabetic cardiomyopathy, which is characterized by structural and functional modifications in the diabetic heart. According to earlier research, changes in calcium handling, sarcomeric organization, and heart contractile proteins all have a role in the development of diabetic cardiomyopathy, according to a study by Qin et al [18].
It is significant that the study found improvements in cardiac electrophysiology and ejection fraction. Ejection fraction is commonly reduced in diabetics, which is a sign of heart dysfunction. According to research by Kury et al.[19], better glycemic control and insulin therapy can increase ejection fraction and may help prevent or treat diabetic cardiomyopathy [19]. The improvement in cardiac electrophysiology, according to Bombicz[20], is essential for preventing arrhythmias and unexpected cardiac events, and this improvement may be reflected in the subtly decreasing QTc interval [20]. The study's findings add to our understanding of how insulin therapy, heart contractile proteins, and diabetes interact. The results highlight the significance of glycemic control and the possible advantages of insulin therapy in maintaining or regaining heart function in diabetics. These ideas are in line with a wide range of research in the area, which emphasize the importance of prompt action and all-encompassing care in preventing and treating diabetes-related cardiac problems.

Conclusion

The study examined the possibility for insulin therapy to reverse the effects of diabetes on cardiac contractile proteins over a 9-month period. The findings point to notable gains in heart function, glycemic control, and the possible reversal of changes in cardiac contractile proteins brought on by insulin therapy. These findings highlight the significance of strict glycemic control in the therapy of diabetes and indicate that insulin, as the primary regulator of glucose metabolism, may be able to preserve or restore heart function in Type 2 diabetics. The work adds to the expanding body of research demonstrating the critical importance of glycemic management and insulin therapy in avoiding and managing cardiac problems associated with diabetes, providing encouragement for improved cardiovascular outcomes in people with diabetes.

Conflict of interest

The authors stated no conflict of interest.

Authors Contribution

Conception and study design: HK, IM
Data acquisition: HK, AAN
Analysis or interpretation: SUR, AM
Intellectual content development: MI, IM
Critical review: AAN
Final version approval: All

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