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Original Research

Evaluation of the Effectiveness of Lifestyle Interventions in Managing Pre-Diabetes in Rural vs. Urban Populations

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ABSTRACT

Background: Pre-diabetes is a critical stage in the progression to type 2 diabetes mellitus, making timely intervention essential. Lifestyle changes, including diet modification and physical activity, have shown promise in preventing or delaying diabetes onset. This study evaluates the effectiveness of lifestyle interventions in managing pre-diabetes among rural and urban populations.

Materials and Methods: A prospective interventional study was conducted over six months, involving 300 pre-diabetic participants (150 each from rural and urban areas). Participants were enrolled based on fasting blood glucose (100–125 mg/dL) and HbA1c levels (5.7–6.4%). Lifestyle interventions included personalized diet plans, physical activity regimens, and regular health counselling sessions. Blood glucose and HbA1c levels were assessed at baseline, 3 months, and 6 months. Statistical analysis was performed using paired t-tests and ANOVA to compare outcomes between the two groups.

Results: At the end of six months, participants in the urban group showed a mean reduction in fasting blood glucose levels from 118.2 ± 4.5 mg/dL to 101.6 ± 3.8 mg/dL, while the rural group showed a reduction from 120.1 ± 5.2 mg/dL to 104.8 ± 4.0 mg/dL. HbA1c levels decreased by 0.9% in urban participants compared to 0.7% in rural participants. Physical activity adherence was significantly higher in the urban group (80%) compared to the rural group (65%). However, dietary compliance was higher in the rural group (75%) compared to the urban group (60%). Both groups demonstrated significant improvements in glycemic parameters, but urban participants exhibited slightly better outcomes.

Conclusion: Lifestyle interventions are effective in managing pre-diabetes in both rural and urban populations. Urban participants showed marginally better glycemic control, possibly due to greater adherence to physical activity. Tailored strategies are required to address the specific needs of rural populations to enhance intervention effectiveness.

Keywords: Pre-diabetes, lifestyle interventions, rural population, urban population, glycemic control, diet, physical activity.

INTRODUCTION

Pre-diabetes is a reversible metabolic condition characterized by impaired fasting glucose (IFG), impaired glucose tolerance (IGT), or elevated glycated hemoglobin (HbA1c) levels, placing individuals at high risk for developing type 2 diabetes mellitus (T2DM) [1,2]. The global prevalence of pre-diabetes is on the rise, with projections suggesting that nearly 470 million individuals may be affected by 2030, highlighting the urgency for effective preventive strategies [3]. Lifestyle interventions, including dietary modifications, regular physical activity, and behaviorcounselling, have been demonstrated to delay or prevent the progression of pre-diabetes to T2DM in various populations [4,5].

The effectiveness of these interventions, however, may differ between rural and urban populations due to disparities in socioeconomic status, access to healthcare facilities, and cultural attitudes toward health behaviors [6]. Urban populations often benefit from better healthcare access and infrastructure, whereas rural populations face barriers such as limited healthcare resources, lower health literacy, and geographical challenges [7]. These differences necessitate targeted strategies to optimize intervention outcomes across diverse populations.

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Despite existing evidence supporting lifestyle interventions, limited data is available comparing their effectiveness in rural versus urban settings, particularly in developing countries where healthcare delivery systems and lifestyle patterns vary widely [8,9]. Understanding these differences is crucial for designing population-specific strategies to manage pre-diabetes effectively.

This study aims to evaluate and compare the effectiveness of lifestyle interventions in managing pre-diabetes among rural and urban populations. By addressing this gap, the findings will contribute to developing targeted preventive measures to curb the growing burden of diabetes globally.

MATERIALS AND METHODS

Study Design and Participants: This was a prospective interventional study conducted over six months to evaluate the effectiveness of lifestyle interventions in managing pre-diabetes among rural and urban populations. A total of 300 participants were recruited, with 150 from rural areas and 150 from urban areas. Participants were selected based on fasting blood glucose (100–125 mg/dL) and HbA1c levels (5.7–6.4%), following the diagnostic criteria for pre-diabetes.

Inclusion and Exclusion Criteria: Inclusion criteria included adults aged 18–65 years diagnosed with pre-diabetes who provided informed consent. Exclusion criteria included individuals with a history of type 1 or type 2 diabetes, significant comorbidities, pregnancy, or those on medications that could alter glucose metabolism.

Intervention: Participants were enrolled in a structured lifestyle intervention program consisting of personalized dietary recommendations, physical activity guidelines, and regular counselling sessions. Diet plans were developed by qualified nutritionists, focusing on reducing calorie intake, balanced macronutrient distribution, and increased fibre consumption. Physical activity recommendations included at least 150 minutes of moderate-intensity aerobic exercise per week, such as brisk walking or cycling. Counselling sessions were conducted monthly to address adherence, motivation, and any challenges faced by participants.

Data Collection and Monitoring: Baseline data, including fasting blood glucose, HbA1c, and body mass index (BMI), were recorded. Follow-up assessments were conducted at 3 months and 6 months. Adherence to diet and physical activity recommendations was monitored through self-reported diaries and periodic phone interviews.

Outcome Measures: The primary outcome measures were changes in fasting blood glucose and HbA1c levels from baseline to 6 months. Secondary outcomes included BMI reduction and adherence rates to the intervention program.

Statistical Analysis: Data were analyzed using SPSS version 26.0. Paired t-tests were used to compare pre- and post-intervention values within each group, and independent t-tests were used to compare outcomes between rural and urban groups. A p-value of <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics: The study included 300 participants, equally distributed between rural (n=150) and urban (n=150) populations. At baseline, there was no significant difference in fasting blood glucose, HbA1c levels, or BMI between the groups (Table 1).

Table 1. Baseline characteristics of participants

Variable	Rural (n=150)	Urban (n=150)	p-value
Age (years)	45.2 ± 6.3	44.8 ± 6.1	0.61
Gender (M/F)	82/68	79/71	0.58
Fasting Blood Glucose (mg/dL)	120.1 ± 5.2	118.2 ± 4.5	0.07
HbA1c (%)	6.1 ± 0.2	6.0 ± 0.3	0.09
BMI (kg/m²)	27.5 ± 2.1	27.3 ± 2.0	0.45

Changes in Glycemic Parameters: At the end of six months, both groups showed significant improvements in fasting blood glucose and HbA1c levels. The urban group demonstrated a greater reduction in fasting blood glucose (101.6 ± 3.8 mg/dL) compared to the rural group (104.8 ± 4.0 mg/dL, $p = 0.02$). Similarly, HbA1c levels decreased more in the urban group (5.2 ± 0.2%) than in the rural group (5.4 ± 0.2%, $p = 0.03$; Table 2).

Table 2. Changes in fasting blood glucose and HbA1c levels over six months

Time Point	Rural	Urban	p-value
Fasting Blood Glucose (mg/dL)	Baseline: 120.1 ± 5.2	Baseline: 118.2 ± 4.5	0.07
	6 months: 104.8 ± 4.0	6 months: 101.6 ± 3.8	0.02
HbA1c (%)	Baseline: 6.1 ± 0.2	Baseline: 6.0 ± 0.3	0.09
	6 months: 5.4 ± 0.2	6 months: 5.2 ± 0.2	0.03

Adherence to Lifestyle Interventions: Adherence rates to physical activity and dietary recommendations were assessed. Urban participants demonstrated better adherence to physical activity guidelines (80%) compared to rural participants (65%, $p = 0.01$). However, dietary

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compliance was higher in the rural group (75%) than in the urban group (60%, $p = 0.02$; Table 3).

Table 3. Adherence rates to lifestyle interventions

Adherence Parameter	Rural (%)	Urban (%)	p-value
Physical Activity	65	80	0.01
Dietary Compliance	75	60	0.02

Secondary Outcomes: The mean BMI decreased in both groups, with rural participants showing a reduction from 27.5 ± 2.1 to 26.8 ± 2.0 kg/m², and urban participants showing a reduction from 27.3 ± 2.0 to 26.5 ± 1.9 kg/m². However, the difference between groups was not statistically significant ($p = 0.12$).

Overall, these findings indicate that lifestyle interventions significantly improved glycemic parameters in both rural and urban populations, with slightly better outcomes observed in the urban group.

DISCUSSION

The results of this study demonstrate that lifestyle interventions, including personalized dietary plans and physical activity regimens, effectively manage pre-diabetes in both rural and urban populations, with marginally better outcomes observed in urban participants. These findings align with previous studies that have emphasized the importance of lifestyle modification in preventing the progression of pre-diabetes to type 2 diabetes mellitus [1,2].

Urban participants exhibited greater reductions in fasting blood glucose and HbA1c levels compared to their rural counterparts, potentially due to higher adherence to physical activity recommendations. This observation is consistent with studies that suggest urban populations may have better access to fitness facilities and more opportunities for structured exercise programs [3,4]. However, rural participants demonstrated better adherence to dietary recommendations, which may be attributed to traditional dietary habits and reliance on locally sourced, unprocessed foods [5,6].

One of the significant challenges in rural areas is the limited access to healthcare infrastructure and professional guidance, which can impact the effectiveness of lifestyle interventions [7]. Health literacy and cultural differences also play a role in the acceptance and adherence to intervention programs [8]. These disparities underline the need for tailored strategies to address the unique challenges of rural populations, such as mobile health units and community-based educational programs [9,10].

Although both groups achieved significant improvements in glycemic parameters, urban participants showed slightly better outcomes, possibly due to better socioeconomic conditions and healthcare access. Similar trends have been reported in studies conducted in other developing countries, highlighting the urban-rural divide in healthcare delivery and intervention outcomes [11,12]. However, the dietary compliance observed in rural participants emphasizes the potential for leveraging traditional lifestyles to achieve better health outcomes [13].

The study's findings also highlight the importance of addressing behavioral and psychosocial factors to improve adherence to lifestyle interventions. Regular counselling sessions, which were an integral part of this study, likely contributed to the observed improvements by providing motivation and addressing barriers to adherence. This approach aligns with evidence suggesting that behavioral support significantly enhances the effectiveness of lifestyle modification programs [14,15].

Despite its strengths, including a well-defined study design and robust data collection, this study has some limitations. The reliance on self-reported adherence rates may introduce bias, and the study's relatively short duration may not capture long-term outcomes. Future studies should consider longer follow-up periods and incorporate objective measures of adherence, such as wearable activity trackers, to enhance data accuracy.

CONCLUSION

In conclusion, lifestyle interventions are effective in managing pre-diabetes in both rural and urban populations. The marginally better outcomes in urban participants highlight the need for customized strategies to bridge the urban-rural divide and improve intervention outcomes in rural areas. This study provides a foundation for future research and policy development aimed at reducing the global burden of diabetes through targeted preventive measures.

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