

Investigation and Research on Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation among Young and Middle-Aged Patients with Type 2 Diabetes

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Abstract

Objective: This study aims to investigate the current status of knowledge, attitudes, and practices regarding insulin injection site rotation among young and middle-aged patients with type 2 diabetes, providing evidence for the development of targeted nursing interventions. **Methods:** This research is designed as a cross-sectional study. By using the convenience sampling method, 240 patients diagnosed with type 2 diabetes in a hospital in Baise City, Guangxi Zhuang Autonomous Region, China, from January 1, 2024, to December 31, 2024, were selected as the research subjects. A questionnaire survey on the knowledge, attitude, and practice of insulin injection site rotation in diabetic patients was adopted to conduct a questionnaire survey among the research subjects, and data were collected through a combination of face-to-face, WeChat, and phone calls. The data were analyzed using SPSS 25.0 software. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean \pm standard deviation. Descriptive statistics were performed, and health education was provided to participants to promote improved self-management and quality of life. **Results:** The overall mean score for knowledge, attitudes, and practices regarding insulin injection site rotation was 40.38 ± 5.71 (59.57% of the maximum possible score), indicating

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a low level of performance. The mean scores for the knowledge, attitude, and practice dimensions were 8.54 ± 2.15 (53.41%), 11.85 ± 2.94 (59.27%), and 19.99 ± 3.03 (62.47%), respectively. These corresponded to low, low, and moderate levels, respectively. **Conclusion:** Knowledge, attitudes, and practices concerning insulin injection site rotation among young and middle-aged patients with type 2 diabetes are suboptimal. There is a need to strengthen patient education in this domain to enhance understanding and adherence, thereby improving insulin therapy outcomes, self-management capabilities, and overall quality of life.

Keywords

Middle-Aged and Young Adults, Diabetes Mellitus, Insulin Therapy, Knowledge, Attitudes, and Practices, Injection Site Rotation

1. Introduction

Insulin injection is a cornerstone of diabetes management, and standardized rotation of injection sites plays a critical role in maintaining stable glycemic control. For patients with newly diagnosed type 2 diabetes, short-term intensive insulin therapy—typically lasting from 2 weeks to 3 months—is commonly recommended. However, in the presence of multiple complications, extension of the treatment duration may be necessary to achieve optimal glycemic targets. Evidence indicates that individuals with diabetes who self-administer insulin exhibit suboptimal knowledge, attitudes, and practices concerning injection site rotation [1]. Furthermore, studies have demonstrated poor adherence to recommended site rotation protocols among these patients [2].

Existing research shows that prolonged improper rotation of insulin injection sites can lead to localized adverse tissue reactions, including erythema, edema, lipohypertrophy, fibrosis, and even infection. These complications may impair insulin absorption and compromise glycemic control [3]. Although clinical guidelines emphasize the importance of healthcare providers, particularly diabetes educators, in educating patients about proper site rotation, practical challenges in clinical settings—such as heavy workloads and time constraints—often hinder consistent follow-up and patient monitoring. Combined with limited patient adherence, this makes it difficult to ensure standardized injection practices when patients administer insulin at home. Therefore, enhancing education and interventions targeting patients' knowledge, attitudes, and behaviors regarding insulin injection site rotation is both necessary and urgent.

In China, the population is commonly categorized into young and middle-aged groups based on the following age ranges: individuals aged 18 to 44 are classified as young adults, while those aged 45 to 59 are considered middle-aged. This study adopted these nationally recognized age classifications and focused on diabetic patients within these age groups as the research population. The

study aims to assess the current status of knowledge, attitudes, and practices related to insulin injection site rotation among these individuals, identify existing gaps and deficiencies in their understanding, beliefs, and behaviors, and provide evidence to inform the development of targeted health education interventions in the future.

2. Materials and Methods

2.1. Study Population

A total of 240 patients diagnosed with type 2 diabetes were recruited from a hospital in Baise City, Guangxi Zhuang Autonomous Region, China, between January 1, 2024, and December 31, 2024, for inclusion in this study. The study was conducted in accordance with ethical guidelines and received formal approval from the relevant institutional review board in China (approval number: YYFY-LL-2023-012). Inclusion criteria were as follows: 1) patients meeting the diagnostic criteria for type 2 diabetes as defined in the Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 Edition) [4] [5]; 2) aged between 18 and 59 years; 3) hospitalized in the Department of Endocrinology and receiving insulin therapy for the first time, with insulin pens prescribed as the injection device after discharge; 4) individuals who provided written informed consent and voluntarily participated in the study; and 5) patients who were conscious, capable of verbal communication, and able to independently complete study questionnaires. Exclusion criteria included: 1) presence of severe psychiatric or psychological disorders; 2) diagnosis of a critical comorbid illness; 3) history of malignant tumors; and 4) diagnosis of gestational diabetes.

2.2. Research Design

This study adopts a cross-sectional research design.

2.3. Sample Size Determination

According to Medical Statistics (Third Edition), edited by Professors Lu Shouzheng and Chen Feng [6], the required sample size for a multivariate analysis should be at least 5 to 10 times the number of independent variables, with a recommended multiplier of 9 used in this study. There are a total of 22 variables included in this study. The study includes 12 variables related to general and disease-specific information, 7 items from the health education status questionnaire, and 3 dimensions from the Insulin Injection Site Rotation—Knowledge, Attitude, and Practice Scale. To account for potential questionnaire attrition and invalid responses, an additional 15% of the sample size was incorporated. The final sample size was subsequently determined using the following formula:

$$n = \text{Total number of variables} \times 9 \times (1 + 15\%) = 22 \times 9 \times 1.15 = 228.$$

After rounding up to ensure adequate power, the final sample size was set at 240 participants.

2.4. Research Tools

2.4.1. General Information and Disease Information Questionnaire

A self-developed questionnaire on general and disease-related information was utilized, comprising 12 items: gender, age, educational background, marital status, occupational status, monthly household income, current residential status, method of medical expense payment, presence of complications, daily frequency of insulin injections, body mass index (BMI), and duration of diabetes.

2.4.2. Health Education Status Questionnaire

A self-developed questionnaire on health education status was utilized, comprising 7 items, including the frequency of participation in diabetes-related health education activities per month during insulin therapy.

2.4.3. Questionnaire on Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation among Diabetic Patients

The questionnaire on insulin injection site rotation for diabetic patients developed by Scholar Song Jinxiao [1] was utilized in this study. It comprises three domains—knowledge, attitude, and practice—with a total of 23 items. The knowledge domain includes multiple-choice questions: single-answer items are scored as 1 point for each correct response, while multiple-answer items accumulate 1 point per correctly selected option; no points are awarded for incorrect or ambiguous responses. The attitude domain employs a 5-point Likert scale, ranging from 5 (“strongly agree”) to 1 (“strongly disagree”), with intermediate values representing “agree,” “neutral,” and “disagree.” The behavior domain uses a 4-point scoring system, where scores range from 4 (“always”) to 1 (“never”); notably, item P8 is reverse-scored. The overall Cronbach’s α coefficient of the questionnaire is 0.901, with domain-specific coefficients ranging from 0.851 to 0.898, indicating high internal consistency. According to the scoring criteria established in [1], higher scores in each domain and in the total questionnaire reflect better knowledge, more favorable attitudes, and improved practices regarding insulin injection site rotation. Classification by performance level is based on the percentage of the maximum possible score: scores below 60% are classified as low level, 60% - 80% as moderate level, and above 80% as high level.

The full version of the questionnaire assessing knowledge, attitude, and practice regarding insulin injection site rotation in diabetic patients is presented in **Figure 1**.

2.5. Statistical Analysis

The questionnaire data regarding insulin injection site rotation, encompassing knowledge, attitudes, and practices, were analyzed using SPSS 25.0 software. The primary objective of this study was to assess the scoring rate among research participants. By calculating the scoring rate, the levels of knowledge, attitudes, and practices related to insulin injection in young and middle-aged patients with type 2 diabetes could be evaluated without requiring intergroup comparisons. Therefore, only descriptive statistics were performed on the questionnaire data. Cate-

gorical data are presented as frequencies and percentages, while continuous data are reported as means ± standard deviation.

The questionnaire regarding the rotation of insulin injection sites for diabetic patients includes the following content:

Questionnaire on Knowledge, Attitude, and Practice Regarding Insulin Injection Site Rotation Among Diabetic Patients

Part One: Knowledge of Insulin Injection Site Rotation

1. Which of the following sites do you consider appropriate for insulin injection? (Multiple choices allowed)

- Abdomen
- Upper arm
- Thigh
- Buttocks
- Unclear

2. In your opinion, which site allows the fastest absorption of insulin after injection?

- Abdomen
- Upper arms
- Thighs
- Buttocks
- All are the same
- Unclear

3. In your opinion, which site has the highest insulin absorption rate after injection?

- Abdomen
- Upper arms
- Thighs
- Buttocks
- All are the same
- Unclear

4. Within the abdominal area, where do you believe insulin can be safely injected?

- The entire abdomen
- Both sides around the umbilicus
- Above and below the umbilicus
- Bilateral areas beyond 2.5 cm from the umbilicus
- Approximately 1 cm below the costal margin and 1 cm above the pubic symphysis
- Unclear

5. In the upper arm, which area do you consider suitable for insulin injection?

- The entire upper arm
- Deltoid muscle region
- Inner side of the upper arm
- Middle one-third of the outer side of the upper arm
- Unclear

6. In the thigh, which area do you consider appropriate for insulin injection?

- The entire thigh
- Inner anterior portion
- Upper one-third of the outer anterior portion
- Outer posterior portion
- Unclear

7. In the buttocks, which area do you consider suitable for insulin injection?

- The entire buttocks
- Outer upper quadrant
- Center of the buttocks
- Unclear

8. What do you believe is the minimum recommended distance between two consecutive insulin injection sites?

- 1 cm
- 2 cm
- No interval required
- Unclear

9. What adverse effects do you associate with repeated insulin injections at the same site? (Multiple choices allowed)

- Bleeding
- Subcutaneous induration
- Lipohypertrophy (subcutaneous fat hyperplasia)
- Lipoatrophy (subcutaneous atrophy)
- Unclear

10. What do you consider to be the minimum time interval before reusing the same injection site?

- No interval required
- One week
- One month
- Unclear

Part Two: Attitudes Toward Insulin Injection Site Rotation

1. To what extent do you agree that regularly rotating insulin injection sites contributes to better blood glucose control?

- Completely agree
- Somewhat agree
- Uncertain
- Somewhat disagree
- Completely disagree

2. To what extent do you agree that technical guidance on insulin injection helps you rotate injection sites appropriately?

- Completely agree
- Somewhat agree
- Uncertain
- Somewhat disagree
- Completely disagree

3. To what extent do you agree that you possess sufficient knowledge about proper insulin injection site rotation?

- Completely agree
- Somewhat agree
- Uncertain
- Somewhat disagree
- Completely disagree

4. To what extent do you agree that you would like to learn more about insulin injection site rotation?

- Completely agree
- Somewhat agree
- Uncertain
- Somewhat disagree
- Completely disagree

Part Three: Practices Related to Insulin Injection Site Rotation

1. Do you assess the skin condition at the intended injection site before each insulin injection?

- Always
- Often
- Occasionally
- Never

2. Do you consciously rotate the injection site each time you administer insulin?

- Always
- Often
- Occasionally
- Never

3. Do you consistently inject insulin (e.g., pre-breakfast dose) in the same anatomical area every day?

- Always
- Often
- Occasionally
- Never

4. Do you alternate injection sites between the left and right sides of the body?

- Always
- Often
- Occasionally
- Never

5. Do you rotate injection sites among different body regions (e.g., abdomen, upper arm, thigh, buttocks)?

- Always
- Often
- Occasionally
- Never

6. When injecting in the same anatomical area (e.g., abdomen), do you rotate the specific injection points within that area?

- Always
- Often
- Occasionally
- Never

7. Is the distance between consecutive injection sites always at least 1 cm?

- Always
- Often
- Occasionally
- Never

8. Do you ever inject insulin into raised, hardened lumps or areas with bruising (ecchymosis)?

- Always
- Often
- Occasionally
- Never

9. Do you use any structured site rotation tools or methods (e.g., rotation charts, body maps) when administering insulin?

- Always
- Often
- Occasionally
- Never

Page 1 Page 2

Figure 1. Screenshot of the questionnaire on knowledge, attitudes, and practices regarding insulin injection site rotation among diabetic patients.

2.6. Data Collection Methods

Following the acquisition of informed consent from patients, trained researchers systematically collected data using a combination of face-to-face interviews, telephone calls, and WeChat communications. The completion of the questionnaire required approximately 10 minutes per participant.

3. Results

3.1. General Information Survey Results

A total of 240 questionnaires were distributed in this study, all of which were successfully retrieved and deemed valid, resulting in a 100% valid response rate. Regarding the demographic characteristics of the participants, males accounted for

54.58%, while females constituted 45.41%. In terms of age distribution, individuals aged 45 to 59 years represented the majority (52.5%), followed by those aged 18 to 44 years (47.5%). With respect to educational attainment, 78.75% of the participants had attained at least a high school or technical secondary school education. Concerning marital status, 90% of the participants were married. The majority (64.58%) were currently employed, and more than half (56.25%) reported a monthly household income between 5000 and 10,000 yuan. Nearly all participants had medical insurance coverage. A significant proportion (82.9%) lived with their spouse, children, or parents. Additionally, 80.83% of the participants reported experiencing diabetes-related complications to varying degrees. Most participants (85.42%) administered insulin three to four times daily. Over half (53.33%) had a body mass index outside the normal range. Furthermore, 77.5% of the participants had been diagnosed with diabetes for five years or less. Detailed information is shown in **Table 1**.

Table 1. General information of the study subjects (N = 240).

Project	Classification	Number of Individuals	Percentage (%)
Gender	Male	131	54.58
	Female	109	45.41
Age Group	Individuals aged 18 to 44	114	47.5
	Individuals aged 45 to 59 years	126	52.5
Academic Qualifications	Junior high school or lower educational attainment	51	21.25
	High school, technical secondary school, or higher education	189	78.75
Marital Status	Single or divorced	24	10
	Married or widowed	216	90
Occupational Status	Employed	155	64.58
	Not applicable or currently not employed	16	6.66
	Retirement or departure due to old age	69	28.75
Monthly Household Income	<5000 RMB	98	40.83
	5000 - 10,000 RMB	135	56.25
	>10,000 RMB	7	2.92
Methods of Payment for Medical Expenses	At my own expense	2	0.83
	Health insurance	238	99.17
Living Conditions	Living independently	2	0.83
	Living with a spouse, children, or parents	199	82.9
	Others	39	16.25
Whether Diabetes Complications Are Present	Is	194	80.83
	None	46	19.17
The Frequency of Daily Insulin Injections	No more than twice	35	14.58
	Three to four times	205	85.42
Body Mass Index (BMI)	≤ 23.9 Kg/m ²	112	46.67
	> 24 Kg/m ²	128	53.33
How Long Have You Been Living with Diabetes?	0 to 5 years	186	77.5
	Six to ten years	39	16.25
	Over a decade	15	6.25

3.2. Survey Results on Health Education

Among the participants in this study, during insulin therapy, the vast majority (93.75%) attended health education sessions no more than once per month. Similarly, 92.08% of participants reported receiving technical guidance on insulin injection no more than once a month. The majority of the research participants

Table 2: Current status of health education.

Questionnaire Item	Number of Individuals	Composition Ratio (%)
1. During insulin therapy, the frequency of monthly participation in diabetes health education programs was recorded (n = 240):		
No more than once	225	93.75
>Once	15	6.25
2. During insulin therapy, the frequency of monthly technical guidance sessions for insulin injection administration was recorded (n = 240):		
No more than once	221	92.08
>Once	19	7.92
3. Have you ever received guidance on insulin injection site rotation (n = 240)?		
Is	236	98.33
None	4	1.67
4. Was the skin at the injection site examined (n = 240) during your follow-up visit?		
Is	198	82.5
None	42	17.5
5. Are you familiar with the method or tool used for rotating insulin injection sites? (n = 240)		
I have heard of it	165	68.75
I have never heard of it	75	31.25
6. Have you ever utilized the insulin injection site rotation technique? This is a single-choice question with skip logic enabled. Selecting the “unused” option will automatically bypass question 7.		
Utilized	117	48.75
Not previously utilized	103	42.92
I previously used it, but I no longer use it	20	8.33
7. Which insulin injection site rotation method or tool have you specifically used? (Multiple-choice question) Note: Based on skip logic in Question 6, only respondents who selected “used” or “previously used but no longer using” proceeded to this question. A total of 137 individuals provided responses, forming the denominator for this item (n = 137). Those who selected “not used” were automatically skipped.		
Card-type positioning card	79	57.66
Palm and finger joint positioning method	106	77.37
Utilizing wearable positioning devices	65	27.08
Various alternative tools and methodologies	56	40.88

received guidance on insulin injection site rotation, representing 98.33% of the total sample. During follow-up visits, 82.5% of participants reported undergoing a skin examination at the injection site, whereas 17.5% indicated that such an examination had not been conducted. Regarding awareness of site rotation methods or tools, 68.75% of participants stated they had heard of them; however, among this group, 42.92% reported never having used any such tools. Among those who have ever used or are currently using rotation tools, the palm and finger joint positioning method was the most commonly adopted approach, accounting for 77.37%. Detailed information is shown in **Table 2**.

3.3. Questionnaire on Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation among Patients with Type 2 Diabetes

The overall mean score for knowledge, attitude, and practice of insulin injection site rotation among young and middle-aged patients with type 2 diabetes was (40.38 ± 5.71), corresponding to a total score rate of 59.57%, indicating a relatively low level of understanding and adherence. The mean scores for the knowledge, attitude, and practice dimensions were (8.54 ± 2.15), (11.85 ± 2.94), and (19.99 ± 3.03), respectively, with corresponding score rates of 53.41%, 59.27%, and 62.47%. These results suggest that knowledge and attitude levels were low, while practice reached a moderate level. Detailed data are presented in **Table 3**.

Table 3. Questionnaire on knowledge, attitudes, and practices regarding insulin injection site rotation among diabetic patients ($n = 240$, $\bar{x} \pm s$).

Project	Actual Score	Average Scoring Rate	The Average Score
Knowledge of insulin injection site rotation	1 - 16	53.41%	8.54 ± 2.15
Alternative approaches to insulin injection site management	4 - 20	59.27%	11.85 ± 2.94
The practice of rotating insulin injection sites	12 - 32	62.47%	19.99 ± 3.03
Total questionnaire score	16 - 68	59.57%	40.38 ± 5.71

4. Discussion

4.1. General Characteristics of the Study Population

According to **Table 1**, the demographic characteristics of the research subjects indicate that males account for 54.58% and females 45.41%, with a slightly higher proportion of males. With regard to age distribution, 47.5% of participants belong to the young adult group (aged 18 - 44 years), while 52.5% fall into the middle-aged group (45 - 59 years). In terms of educational attainment, individuals with a high school or technical secondary school education and above constitute the majority (78.75%), which aligns closely with the current educational structure of residents in southern provinces and cities of China. Regarding marital status, 90% of

the participants are married. A majority of the research subjects (64.58%) are currently employed, a finding likely attributable to the fact that all participants are adults within the middle-aged and young adult range. Concerning monthly household income, over half (56.25%) report an income between 5000 and 10,000 yuan, consistent with the average income levels observed in ethnic minority regions along the western border of Guangxi, China.

Nearly all participants have medical insurance coverage (99.17%), reflecting a strong emphasis on healthcare investment among urban residents. A substantial proportion (82.9%) live with their spouse, children, or parents, which may be associated with the high marriage rate within the sample. Additionally, 80.83% of the participants have been diagnosed with diabetes-related complications to varying degrees, a figure broadly consistent with epidemiological data from the “Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes Mellitus (2024 Edition)” [7].

The majority (85.42%) administer insulin injections three to four times daily, reflecting standard clinical management practices. More than half (53.33%) exhibit a body mass index outside the normal range, a pattern commonly observed in clinical populations with type 2 diabetes. Furthermore, 77.5% of the subjects have had diabetes for 0 to 5 years, indicating a concentration of recent disease onset, which corresponds to the current trend of earlier onset of type 2 diabetes in China.

4.2. Characteristics of Health Education Received by the Research Subjects

As shown in **Table 2**, the majority of research subjects (93.75%) participated in health education sessions no more than once per month, indicating a lack of regular engagement in health education during the treatment period. This may be attributed to the fact that all participants were between 18 and 59 years of age and primarily engaged in academic or occupational activities. These findings underscore the importance for diabetes educators to actively encourage patients to participate regularly in diabetes-related health education programs, which can be delivered through in-person sessions, online lectures, or individualized communication via platforms such as WeChat. The research findings of Ke Ming [8] *et al.* indicate that diabetes knowledge awareness and insulin-related cognitive levels are independent factors influencing insulin injection adherence among patients with type 2 diabetes. The majority of study participants (92.08%) received insulin injection technique guidance no more than once per month. This may be attributed to the fact that most patients self-administered insulin at home, typically administering at least two doses over a two-week period, while visiting healthcare facilities for medication refills no more than twice monthly—thereby limiting their contact with medical professionals. These findings underscore the importance for diabetes educators to maintain regular communication with patients through follow-up mechanisms such as telephone calls or WeChat, and to increase the fre-

quency of technical support regarding proper injection techniques.

The majority of research participants received guidance on insulin injection site rotation, accounting for 98.33% of the total sample. Additionally, 82.5% indicated that skin assessments at injection sites were conducted during outpatient follow-up visits, while 17.5% reported no such examinations. This suggests that outpatient healthcare providers should place greater emphasis on routinely evaluating skin conditions at injection sites and improving the coverage of such assessments.

Furthermore, 68.75% of participants reported being aware of insulin injection site rotation methods or tools; however, among these individuals, 42.92% had never used such tools. This indicates a need for enhanced dissemination and practical training regarding available rotation aids. Among those who have used or currently use rotation tools, the palm and finger joint positioning method was the most commonly adopted (77.37%). This result suggests that the current entity rotation tool remains underutilized in clinical practice. This issue warrants careful attention from diabetes educators.

4.3. Current Status of Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation among Study Participants

As shown in **Table 3**, the overall score for knowledge, attitude, and practice related to insulin injection site rotation among young and middle-aged patients with type 2 diabetes was (40.38 ± 5.71), with a total scoring rate of 59.57%, indicating a relatively low level of performance. The scores for the three dimensions—knowledge, attitude, and practice—were (8.54 ± 2.15), (11.85 ± 2.94), and (19.99 ± 3.03), respectively, with corresponding scoring rates of 53.41%, 59.27%, and 62.47%. These correspond to low, low, and moderate levels, respectively. This finding is consistent with domestic studies conducted by Song Jinxiao *et al.* [1], suggesting that knowledge, attitudes, and practices regarding insulin injection site rotation among the study population remain suboptimal and require improvement. Therefore, enhanced health education and follow-up interventions for this group are warranted.

The study by Ke Ming *et al.* in China indicates that diabetic patients with better insulin treatment adherence tend to be younger compared to those with poor adherence. Factors such as age, educational level, knowledge of diabetes, understanding of insulin therapy, and income status were identified as independent predictors influencing insulin injection compliance among patients with type 2 diabetes [8]. This may be attributed to the natural decline in memory and learning capacity with advancing age. Although the current study focuses on middle-aged and young individuals, this demographic often faces time constraints due to work or academic commitments, limiting their participation in comprehensive insulin injection training programs. These findings suggest the need for targeted interventions in diabetes education to enhance treatment adherence. Furthermore, Wu Meng *et al.* demonstrated positive outcomes by applying individualized rotation techniques to insulin injection sites in diabetic patients [9].

5. Conclusion

Based on the survey data, it can be concluded that the overall level of insulin-related knowledge, attitude, and practice among young and middle-aged patients with type 2 diabetes in the study population is suboptimal. Specifically, the three domains—knowledge, attitude, and practice—were found to be at low, low, and moderate levels, respectively. Diabetes educators should prioritize health education and implement targeted follow-up interventions to improve insulin-related knowledge, attitudes, and self-management behaviors in this patient group. Particular emphasis should be placed on enhancing adherence to insulin injection site rotation, thereby optimizing glycemic control and improving therapeutic outcomes.

6. Recommendations

Diabetes and its associated complications significantly affect patients' quality of life [10]. It is recommended that diabetes educators, when providing education on insulin injection site rotation, incorporate dedicated educational tools to enhance the delivery of technical guidance. Such tools can make instruction more intuitive, specific, and easier for patients to retain key procedural points. Educators are also encouraged to consult existing literature and draw upon best practices from peer experiences. For example, Yang Ying [11] *et al.* demonstrated favorable outcomes using the palm positioning method for insulin injection site rotation in diabetic patients. Similarly, Xu Haiqun [12] *et al.* reported positive results with a self-developed medical abdominal injection projection flashlight in guiding injection site rotation. Additionally, Li Lianyun [13] *et al.* successfully implemented umbilical patch graphic positioning cards in patient education for abdominal insulin injection site rotation among individuals with type 2 diabetes, achieving excellent adherence and accuracy.

Furthermore, healthcare managers may consider strategies to reduce the daily frequency of insulin injections. Research by Song Jinxiao [1] indicates that patient compliance with insulin therapy is inversely related to the number of daily injections. Therefore, minimizing injection frequency could improve treatment adherence, particularly among young and middle-aged patients with type 2 diabetes. Lastly, given the widespread integration of artificial intelligence across various sectors, diabetes educators have the opportunity to develop AI-based software [14] as an auxiliary teaching tool. Such technology can not only enhance patient education but also reduce the human resource burden associated with traditional educational approaches.

7. The Limitations of the Study

This study is limited by its single-center design and small sample size, which may restrict the generalizability of the findings. Therefore, the conclusions should be interpreted with caution. Future research should include multicenter studies with larger sample sizes to provide more robust evidence for clinical application.

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Authors' Contributions

Yijuan Li, Yan Chen, Yun Liu: proposed research ideas and designed research schemes; Yijuan Li, Yun Liu: Conducting experiments and investigations; Qingsong Zhang, Shuangqi Li, Mengyi Li: Data collection, data sorting, and statistical analysis; Yijuan Li, Yan Chen, Qingsong Zhang, Yun Liu, Ting Meng, Yanzhen Lu, Meiyuan Ou, Shuangqi Li, Mengyi Li: Paper writing; Yijuan Li: Overall check and review papers.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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