Scientific Research Publishing

Open Journal of Applied Sciences, 2025, 15(12), 4145-4157
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Investigation and Analysis of Knowledge, Attitudes, and Practices regarding Insulin Injection Site Rotation among Adolescent Patients with Diabetes

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How to cite this paper: Wang, S.X., Huang, Z., Li, Y.J., Li, S.Q., Meng, T., Lu, Y.Z. and Ou, M.Y. (2025) Investigation and Analysis of Knowledge, Attitudes, and Practices regarding Insulin Injection Site Rotation among Adolescent Patients with Diabetes. *Open Journal of Applied Sciences*, **15**, 4145-4157.
https://doi.org/10.4236/ojapps.2025.1512268

Received: December 8, 2025
Accepted: December 21, 2025
Published: December 24, 2025

Abstract

Objective: To investigate the knowledge, attitudes, and practices of adolescent diabetic patients regarding three-dimensional insulin injection site rotation and to identify the factors influencing their knowledge, beliefs, and behaviors in this regard. **Methods:** This study was designed as a cross-sectional survey. From November 2024 to October 2025, a total of 116 adolescent patients with diabetes who had prior experience with insulin therapy were recruited from a tertiary hospital in Baise City, Guangxi Zhuang Autonomous Region, China. Data were collected using structured questionnaires, including those on general and disease-related characteristics, health education status, and insulin injection site rotation practices. A convenience sampling method was employed, and data analysis was performed using SPSS 25.0 software. **Results:** The overall mean score for knowledge, attitude, and practice (KAP) of insulin injection site rotation among the 116 participants was 43.28 ± 7.688, corresponding to a scoring rate of 60.1%, indicating a moderate level of KAP. Specifically, the knowledge subscale yielded a mean score of 6.12 ± 2.625 (scoring rate: 40.8%), reflecting a low level of knowledge. The attitude subscale score was 13.98 ± 3.318 (scoring rate: 69.9%), indicating a moderate level, while the practice subscale score was 23.17 ± 4.142 (scoring rate: 64.4%), also at a moderate level. The

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scores in all three dimensions, as well as the total KAP score, were significantly higher in the juvenile subgroup compared to the young adolescent subgroup, with statistically significant differences ($P < 0.05$). **Conclusion:** Healthcare providers and relevant institutions should pay greater attention to the knowledge, attitudes, and practices of adolescent diabetic patients concerning insulin injection site rotation, particularly among younger adolescents. Enhanced health education and systematic follow-up interventions are recommended to improve patient understanding and adherence, thereby optimizing insulin therapy outcomes, glycemic control, and overall quality of life.

Keywords

Diabetes, Insulin, Injection Site Rotation, Knowledge, Attitudes, and Practices, Adolescents

1. Introduction

With the rapid development of the social economy and significant shifts in lifestyle patterns, adolescents are increasingly confronted with the growing threat of diabetes [1]. Rising academic pressures have contributed to prolonged sedentary behavior among teenagers, while the widespread use of electronic devices has further diminished opportunities for physical activity. Concurrently, the prevalence of fast food culture has led to a sustained increase in the consumption of unhealthy dietary items, such as sugar-sweetened beverages and fried foods. These factors collectively contribute to the deteriorating metabolic health of adolescents, significantly impairing their quality of life [2].

In recent years, the prevalence of overweight and obesity among Chinese adolescents has risen sharply, directly accelerating the trend of earlier onset of diabetes [3]. Insulin therapy, although a cornerstone in diabetes management, may lead to clinical complications when improperly administered—particularly related to injection techniques—which can adversely affect glycemic control [4]. Therefore, this study aims to investigate the current status of knowledge, attitudes, and practices regarding insulin injection site rotation among adolescent diabetic patients across three dimensions. Furthermore, it seeks to identify the key influencing factors affecting these knowledge, attitude, and practice levels. The findings will assist healthcare professionals, particularly nurses, in delivering targeted and evidence-based health education, thereby enhancing self-management capabilities among adolescent patients.

2. Operational Definitions Related to This Study

1) Adolescents: The term "adolescents" is interpreted differently across cultural and regional contexts. According to the World Health Organization's 2013 age classification, individuals aged 19 to 44 are categorized as young adults, while those aged 13 to 18 fall within the adolescent age range [5] [6]. In alignment with China's na-

tional age classification standards [7], this study defines "adolescents" as encompassing both the youth and juvenile populations. Therefore, adolescent diabetic patients in this study are defined as individuals between the ages of 13 and 44.

2) Insulin Injection Site Rotation: This refers to the systematic and strategic alternation of anatomical injection sites during long-term insulin therapy, aimed at optimizing insulin absorption and minimizing complications such as lipohypertrophy, thereby enhancing overall treatment efficacy [8].

3) Knowledge, Attitudes, and Practice Regarding Insulin Injection Site Rotation: The "Knowledge, Attitudes, and Practice" (KAP) model is a widely used framework representing cognitive awareness, personal attitudes, and behavioral adherence [9]. In this study, KAP pertains specifically to diabetic patients' understanding, perceptions, and actual practices related to insulin injection site rotation. "Knowledge" denotes the extent of patients' awareness and understanding of proper site rotation techniques. "Attitudes" reflects patients' attitudes and the perceived importance of adhering to rotation protocols. "Practice" refers to the consistent and standardized implementation of injection site rotation by patients during self-administered insulin therapy [10].

3. Objects and Methods

3.1. Study Population

This study was granted ethical approval by the Ethics Committee of the Affiliated Hospital of Youjiang Medical University for Nationalities, China (Ethical Approval No. YYFY-LL-2023-012). This study was designed as a cross-sectional investigation. A total of 116 adolescent patients with type 1 or type 2 diabetes who had experience with insulin therapy were recruited through convenience sampling from a tertiary hospital in Baise City, Guangxi, between November 2024 and October 2025. Inclusion criteria were as follows: 1) adolescents aged 13 to 18 years diagnosed with diabetes; 2) individuals meeting the diagnostic criteria for diabetes as defined in the Chinese Guidelines for the Prevention and Control of Diabetes (2024 Edition) [11] and currently receiving insulin injection therapy; 3) willingness to voluntarily participate in the study and provision of informed consent; and 4) ability to independently perform insulin injections. Exclusion criteria included: 1) presence of psychiatric disorders or cognitive/behavioral impairments affecting comprehension; 2) withdrawal from participation during the study; and 3) severe medical conditions that prevented completion of the questionnaire.1.2 Sample Size Estimation.

3.2. Sample Size Estimation

According to the third edition of Medical Statistics [12], the required sample size for a multivariate analysis should be at least 5 to 10 times the number of independent variables, with a minimum multiplier of 5 recommended for this study. The present study includes a total of 21 variables: 12 related to demographic and clinical characteristics, 6 derived from the Health Education Questionnaire, and 3 dimensions from the Insulin Injection Site Rotation Knowledge-Attitude-Practice

Scale. To account for potential questionnaire attrition and data incompleteness, an additional 10% was incorporated into the sample size calculation. Based on the following formula:

$$n = \text{Total number of variables} \times 5 \times (1 + 10\%) = 21 \times 5 \times 1.10 = 116$$

So, we set the target sample size at 116. Ultimately, 116 eligible participants were included in the study, exceeding the minimum requirement.

3.3. Investigation Tools

3.3.1. General Information and Disease History Questionnaire

A self-developed questionnaire on general and disease-related information was administered, comprising a demographic section and 12 items assessing disease-specific data.

3.3.2. Health Education Status Survey Questionnaire

A self-designed health education status questionnaire was developed, comprising six items, including the frequency of receiving health education.

3.3.3. 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 [10] 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; for single-answer items, one point is awarded for each correct response, while in multiple-answer items, one point is assigned for each correctly selected option. No points are given for incorrect or ambiguous responses. The attitude domain employs a Likert-type 5-point scale, ranging from 5 ("strongly agree") to 1 ("strongly disagree"), with intermediate options including "agree," "uncertain," and "disagree." The practice domain uses a 4-point frequency scale, where scores range from 4 ("always") to 1 ("never"), with item P8 reverse-scored. The overall Cronbach's α coefficient of the questionnaire is 0.901, and the Cronbach's α coefficients for the three domains range from 0.851 to 0.898, indicating high internal consistency. According to the scoring criteria outlined in [10], higher scores in each domain and in the total questionnaire reflect better levels of knowledge, attitude, and practice regarding insulin injection site rotation. Classification within each domain 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 content of the questionnaire on the rotation of insulin injection sites for diabetic patients is detailed in **Figure 1**.

3.4. Questionnaire Collection Method

Trained investigators collected questionnaire data from research participants who met the inclusion criteria using a combination of face-to-face interviews, telephone calls, and WeChat communication. After obtaining informed consent from the participants and securing signed documentation, researchers distributed the

questionnaires and provided standardized instructions. Participants were required to complete the questionnaires independently. In cases where participants were unable to do so, investigators assisted by reading questions aloud using a standardized script, ensuring consistency and minimizing bias. Questionnaires were completed and collected on-site, and each was immediately reviewed for completeness. The entire process, from initiation to completion of the questionnaire, took approximately 10 minutes. Participation was anonymous and voluntary.

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
Page 1
□ 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
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Figure 1. Screenshot of the questionnaire on knowledge, attitude, and practice of insulin injection site rotation in diabetic patients.

3.5. Data Processing

Data processing was performed using SPSS 25.0 software. Descriptive statistics were employed to summarize general information. Count data are presented as rates and composition ratios, while measurement data are expressed as mean ± standard deviation. The scores of the Insulin Injection Site Rotation Knowledge, Attitude, and Practice Scale were analyzed using frequency and percentage distributions. The dimension scores and total scores for both the youth group and the junior group were found to conform to a normal distribution. Independent sam-

ples t-tests were conducted to compare the differences in the three-dimensional scores and total scores between the two groups.

4. Results

4.1. General Information on the Study Subjects

The demographic and baseline characteristics of the research subjects included in this study are presented in Table 1.

Table 1. General information (n = 116).

Project	Classification	Number of Cases	Composition Ratio (%)
Gender	Male	57	49.1
	Female	59	50.9
Age Group	Ages 13 to 18 (junior group)	21	18.1
	Individuals aged 19 to 44 (youth cohort)	95	81.9
Educational Attainment	Below the level of junior college	84	72.4
	A bachelor's degree or higher	32	27.6
Marriage	Single	46	39.7
	Married	58	50
	Divorce and other matters	12	10.3
Current Work Status	Employed	61	52.6
	No occupation listed	43	37.1
	Retirement from employment	12	10.3
Living Status	Living alone	24	20.7
	Residing with children and/or spouse	55	47.4
	Others	37	31.9
Household Income (CNY/month)	<5000	80	69.0
	5000 - 10,000	21	18.1
	>10,000	15	12.9
Types of Diabetes	Type I	37	31.9
	Type II	74	63.8
	Other categories	5	4.3
Disease Progression	Five years or less	57	49.1
	Six to ten years	45	38.8
	Over a decade	14	12.1
Duration of Insulin Therapy	Five years or younger	17	55.2
	Six to ten years	47	40.5
	A decade	5	4.3
Glycated Hemoglobin	<7%	12	10.3
	≥7%	104	89.7
Daily Injection Frequency	Less than two times	38	32.8
	Three to four times	78	67.2

4.2. Health Education Status of the Study Participants

The health education status of the study participants is presented in detail in Table 2.

Table 2. Health education received by adolescent patients with diabetes (n = 116).

Project	Classification	Number of Cases	Composition Ratio (%)
1. How frequently do you engage in health education activities during your insulin therapy?	Uncertain	61	52.6
	Annually	22	19.0
	On a Monthly Basis	17	14.7
	On a Weekly Basis	16	13.8
2. The frequency of receiving technical guidance regarding insulin injection?	Uncertain	57	49.1
	Annually	31	26.7
	On a Monthly Basis	22	19.0
	On a Weekly Basis	6	5.2
3. Have you ever received guidance regarding the rotation of insulin injection sites?	Is	71	61.2
	None	45	38.8
4. A skin examination at the injection site will be	Is	43	37.1
	None	73	62.9
5. Have you ever heard of the insulin injection site rotation tool? (This question includes a conditional skip logic. Selecting "No" will result in skipping question 6).	Is	32	27.6
	None	84	72.4
6. Have you ever used the insulin injection site rotation tool? (For question 5, since the response "Yes, there are" was selected by 32 participants, the sample size for this question is n = 32).	I previously used it, but I no longer use it	1	3.1
	Is	17	53.1
	None	14	43.7

4.3. Scores of the Questionnaire on Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation among Adolescent Diabetic Patients

1) Overall Situation

The research data indicate that the overall mean score on the questionnaire assessing knowledge, attitude, and practice regarding insulin injection site rotation among adolescent diabetic patients was (43.28 ± 7.688), corresponding to a scoring rate of 60.10%. This suggests a moderate level of overall performance. Specifically, the mean scores for the knowledge, attitude, and practice dimensions were (6.12 ± 2.625), (13.98 ± 3.318), and (23.17 ± 4.142), respectively. These results reflect a low level of knowledge and moderate levels in both attitude and practice. Detailed information is shown in Table 3:

Table 3. Presents the questionnaire scores regarding knowledge, attitude, and practice of insulin injection site rotation among adolescent diabetic patients in non-hospital settings.

Project	Score (Points)	Scoring Rate (%)	Mean Score (Points)	Level One Is Located at
Overall score	19 - 68	60.1	43.28 ± 7.688	At a moderate level
Knowledge dimension	1 - 15	40.8	6.12 ± 2.625	At a basic level
Belief dimension	4 - 20	69.9	13.98 ± 3.318	At a moderate level
Behavioral dimension	12 - 36	64.4	23.17 ± 4.142	At a moderate level

2) Comparative Analysis of the Total Scores and Dimensional Scores of Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation between Young Adult and Juvenile Patient Groups with Diabetes

The scores of the youth group and the juvenile group were compared using an independent samples t-test. The results indicated statistically significant differences between the two groups in both the overall scores and the subscores across all dimensions related to knowledge, attitude, and practice regarding insulin injection site rotation ($P < 0.05$). Detailed results are presented in Table 4.

Table 4. Comparative analysis of scores on insulin injection site rotation between young and adolescent diabetic patients.

Project	Number of Cases	Mean	t-value	P-value
Knowledge Dimension Score			4.170	<0.05
Adolescents Aged 13 to 18 Years	21	8.14 ± 2.851		
Individuals Aged 19 to 44 Years	95	5.67 ± 2.363		
Belief Dimension Score			2.557	<0.05
Adolescents Aged 13 to 18 Years	21	15.61 ± 3.024		
Individuals Aged 19 to 44 Years	95	13.62 ± 3.284		
Behavioral Dimension Score			3.636	<0.05
Adolescents Aged 13 to 18 Years	21	26.00 ± 4.438		
Individuals Aged 19 to 44 Years	95	22.55 ± 3.823		
Overall Score			4.637	<0.05
Adolescents Aged 13 to 18 Years	21	49.76 ± 8.729		
Individuals Aged 19 to 44 Years	95	41.84 ± 6.680		

5. Discussion

5.1. General Demographic Characteristics and Disease Conditions of the Research Subjects

As shown in Table 1, the gender distribution in this study is approximately balanced, with nearly equal proportions of male and female participants. Age groups

were categorized into adolescents (13 - 18 years) and young adults (19 - 44 years). The adolescent group constitutes 18.1% of the sample, while the young adult group accounts for 81.7%. A majority of participants (72.5%) have an educational level below junior college, whereas only 27.6% have attained a junior college degree or higher. This distribution may be attributed to the fact that a significant proportion of the participants are adolescents who have not yet reached college age.

Regarding marital status, married individuals represent the largest group (50.0%), followed by unmarried participants (39.7%). In terms of employment, 52.6% of the patients are currently employed, while 47.4% are unemployed or retired. With respect to household income, 69.0% of families report a monthly income below 5000 yuan. This may reflect the limited economic independence of adolescent patients, who are typically dependent on their families.

In terms of living arrangements, 69.1% of participants reside with their spouse, children, or both, while 31.9% fall into other categories. This pattern aligns with the sociodemographic characteristics commonly observed in underdeveloped regions of Guangxi, China.

With regard to diabetes type, 63.8% of patients have type 2 diabetes, 32.9% have type 1 diabetes, and 9.5% are diagnosed with other types. This distribution is consistent with current epidemiological trends in diabetes prevalence. The largest proportion of patients (55.2%) has a disease duration of 1 to 5 years, which corresponds to the younger age profile of the study population and is comparable to findings reported by domestic scholar Wu Na [13]. Additionally, 89.7% of patients exhibit glycated hemoglobin (HbA1c) levels ≥ 7%, indicating suboptimal glycemic control in the majority of cases. Furthermore, 67.2% of patients require insulin injections three to four times daily, highlighting the intensive treatment regimens necessary for blood glucose management among adolescent and young adult diabetic patients.

5.2. Current Status of Health Education Received by Study Participants

According to **Table 2**, during insulin therapy, more than half (52.6%) of respondents reported irregular participation in health education sessions, while nearly half (49.1%) received technical guidance on insulin injection at inconsistent intervals. These findings suggest that many patients have not established a routine for regular engagement in diabetes self-management education. Notably, although 61.2% of participants received guidance on injection site rotation during treatment, 38.8% did not—an outcome that warrants serious attention from diabetes educators to ensure equitable and comprehensive patient education.

A substantial proportion of patients (62.9%) did not receive skin examinations at the injection site during follow-up visits, highlighting a critical gap in clinical monitoring that warrants enhanced vigilance and supervision by healthcare professionals. It is imperative for both physicians and nurses to strengthen routine

assessments and encourage patients to perform regular self-examinations. Furthermore, 72.4% of the study participants were unaware of the insulin injection site rotation education tool, indicating a significant deficit in patient education. Diabetes educators must prioritize the dissemination and implementation of such tools, as only 27.6% of participants had prior knowledge of them. Among those who were aware, 96.9% reported having used the tool, underscoring its potential effectiveness once introduced. Therefore, it is recommended that diabetes education programs actively involve both patients and their family members to promote shared responsibility and sustained self-management. Additionally, during follow-up consultations, healthcare providers should routinely inquire about any local discomfort at injection sites to address misconceptions—such as the belief that site rotation is unnecessary in the absence of pain—and reinforce proper injection practices.

Adolescents represent a developmental stage characterized by heightened receptivity to new knowledge and optimal learning capacity. Leveraging online software and multimedia platforms offers an effective approach to delivering health education on insulin injection site rotation for adolescent diabetic patients. Such initiatives significantly enhance the dissemination of critical health information. For instance, scholars have introduced a "standardized guidance" model accompanied by a dedicated diabetes health information website [14]. Additionally, QR codes promoting standardized insulin injection practices have been widely distributed, while educational videos have been produced and disseminated through popular short-video platforms. These strategies enable patients not only to access essential knowledge about injection site rotation in their daily lives but also to learn during leisure time, thereby facilitating consistent and standardized injection site management.

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

As shown in **Table 3**, with respect to the knowledge dimension of insulin injection site rotation among adolescent diabetic patients, the scores ranged from 1 to 15, yielding a mean score of (6.12 ± 2.625) and a correct response rate of 37.33%, indicating a generally low level of knowledge. Only 34.5% of participants were aware that the abdominal area exhibits the highest insulin absorption rate, a proportion lower than that reported by Song Jinxiao [10]. These findings suggest a significant gap in knowledge regarding proper injection site rotation, highlighting the urgent need for enhanced health education interventions tailored to this population [15].

Effective education on insulin injection site rotation is essential for helping diabetic patients achieve optimal glycemic control. Healthcare providers, including physicians and nurses, should deliver standardized, evidence-based instruction during the initial insulin administration counseling session [15] [16]. They should also communicate, in a clear and empathetic manner, the clinical manifestations

of potential complications associated with improper injection practices. Furthermore, it should be emphasized that consistent and correct rotation of injection sites plays a critical role in preventing localized complications such as lipohypertrophy and can contribute to improved long-term diabetes management outcomes.

5.4. The Scores for Knowledge, Attitude, and Practice regarding Insulin Injection Site Rotation in the Adolescent Group Were Higher than Those in the Young Adult Group

As shown in Table 4, the total scores regarding knowledge, attitude, and practice of insulin injection site rotation, as well as the scores across all three dimensions, were higher among diabetic patients in the adolescent group compared to those in the young adult group. This finding is consistent with the results reported by Ke Ming [17] *et al.* The observed difference may be attributed to age-related variations in cognitive function and lifestyle factors. Although the study focuses on adolescent populations, it is noteworthy that most individuals in the young adult group are occupied with work or academic responsibilities, leaving limited time for participation in diabetes self-management education, including training on proper insulin injection techniques. In contrast, adolescents are primarily school-enrolled students who generally possess better memory retention and greater access to structured health education programs, which may enhance their understanding and adoption of recommended practices related to insulin injection site rotation. These findings underscore the importance of developing targeted and individualized intervention strategies tailored to the specific needs and circumstances of different patient groups. Personalized diabetes education is essential to improve health outcomes.

6. Summary and Outlook

With a total score rate of 60.1%, the findings indicate suboptimal levels of knowledge, attitude, and practice regarding insulin injection site rotation among adolescent diabetic patients. Notably, the knowledge dimension scored only 40.8%, reflecting a particularly low level of understanding in this area. This highlights the urgent need for improved education on proper injection site rotation among adolescents with diabetes. Given that lifelong insulin therapy is an inevitable reality for individuals with type 1 diabetes, effective glycemic control is essential to delay the onset of diabetes-related complications [10]. Standardized insulin injection practices represent a key component of successful glucose management [16].

To date, various tools and methods designed to assist patients in rotating injection sites have been developed by researchers [18], and broader dissemination and implementation of these resources are recommended. Future interventions targeting insulin injection site rotation should be structured around three critical time points: before, during, and after insulin administration. For example, the abdominal insulin injection site rotation guidance device developed by Sun Li and Lu

Chunjie has demonstrated promising results [19]. Additional strategies may include equipping insulin pens with audio reminders, providing pre-injection prompts from family members, and implementing regular telephone follow-ups to reinforce adherence.

Authors' Contributions

Shuxian Wang, Yijuan Li: proposed research ideas and designed research schemes; Yijuan Li, Zhen Huang: Conducting experiments and investigations; Shuangqi Li, Meng Ting, Yanzheng Lu, Meiyan Ou: Data collection, data sorting, and statistical analysis; Shuxian Wang, Zhen Huang, Yijuan Li, Shuangqi Li: Paper writing; Shuxian Wang: Overall check and review papers.

Funding

This study was supported as a self-funded project by the Health Commission of the Guangxi Zhuang Autonomous Region, China [2023] (Project No. Z-L20230883).

Acknowledgements

We gratefully acknowledge the participation and contributions of all individuals involved in this study.

Conflicts of Interest

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

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