 Research Article

# Instructional program to enhance adolescents' knowledge of insulin self-administration

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**Abstract**

Type 1 diabetes mellitus is a chronic autoimmune disorder characterized by destruction of pancreatic $\beta$-cells and the need for lifelong insulin replacement. Safe insulin self-administration requires adolescents to understand dose preparation, injection technique, insulin storage, and routine monitoring. **Aim:** To assess adolescents' knowledge of insulin self-administration and determine whether a structured instructional program improves knowledge over time. **Methods:** A quasi-experimental, two-group study was conducted at the Diabetic and Endocrine Center in Al-Hilla City. A total of 120 adolescents were assessed using a structured questionnaire at baseline (pre-test), post-test I, and post-test II between May 17, 2025 and October 4, 2025. **Results:** The intervention group demonstrated a marked increase in mean knowledge scores from pre-test to post-test I, with a slight decline at post-test II, whereas the control group showed minimal change over the same period. Repeated-measures analysis showed significant effects of Time, Group, and Time × Group, with large effect sizes. **Conclusion:** A structured instructional program significantly improved adolescents' knowledge of insulin self-administration and showed evidence of knowledge retention over follow-up.

**Keywords:** instructional program, adolescent knowledge, insulin self-administration

# 1 Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia caused by impaired insulin secretion, impaired insulin action, or both. Pancreatic $\beta$-cells produce insulin, a hormone that is essential for glucose regulation and metabolic balance. Although diabetes can be managed, it remains a lifelong condition that requires continuous medical care and consistent self-management, particularly in insulin-dependent disease [10].

The term diabetes originates from the Greek expression meaning "to pass through," a reference to the excessive urination historically associated with the disease. Diabetes mellitus includes a group of metabolic disorders linked to abnormal glucose regulation, impaired insulin secretion, insulin resistance, or a combination of these mechanisms, all of which increase the risk of serious complications. Historically, diabetes was recognized clinically before its pathophysiological mechanisms were fully defined [3].

Insulin facilitates the uptake of glucose into muscle, liver, and adipose tissue, allowing cells to use glucose as their principal energy source. Under normal physiological conditions, insulin helps match glucose use to metabolic demand. In diabetes, reduced insulin production or ineffective insulin action disrupts this process, leading to chronic hyperglycemia, impaired cellular metabolism, and progressive multisystem complications [17].

The three principal types of diabetes mellitus are gestational diabetes, type 1 diabetes, and type 2 diabetes. In type 1 diabetes, autoimmune destruction of pancreatic $\beta$-cells causes absolute insulin deficiency. Type 2 diabetes is primarily associated with insulin resistance, whereas gestational diabetes develops during pregnancy because of altered glucose regulation and often resolves after delivery [19].

Type 1 diabetes mellitus is one of the most common endocrine disorders affecting children and adolescents. In this autoimmune disease, immune-mediated destruction of insulin-producing $\beta$-cells leads to little or no endogenous insulin production. Because there is no curative therapy, lifelong insulin treatment is required to maintain glucose control and reduce acute and chronic complications [5, 15].

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Received: 17/10/2025 – Approved: 08/12/2025 – Published 11/03/2026

Globally, the prevalence and incidence of type 1 diabetes have increased over recent decades, particularly among children younger than fifteen years. Epidemiological evidence indicates that most affected patients require intensive insulin therapy because of major loss of $\beta$-cell function. This growing burden highlights the importance of effective disease management and targeted patient education [2].

Studies have shown that the prevalence of type 1 diabetes among adolescents in Iraq is increasing. Reports from Baghdad and other regions indicate a growing public health burden that is comparable to, or higher than, that of nearby countries. These findings emphasize the need for stronger diabetes care plans and context-specific educational initiatives [8].

Accurate insulin administration, regular blood glucose monitoring, adherence to dietary guidance, and appropriate physical activity are all essential components of type 1 diabetes management. Although insulin therapy aims to mimic physiological insulin secretion as closely as possible, correct handling, dosing, and administration remain critical to safe and effective treatment.

Insulin self-administration is usually performed at home and requires adequate knowledge, practical skill, and confidence. Proper insulin storage, accurate dose preparation, correct injection-site selection, and adherence to hygienic technique are essential for safety and effectiveness. Clinical reports indicate that fear of injections, limited confidence, and insufficient instruction remain important barriers to correct insulin self-administration, especially among adolescents [7, 11].

Insulin therapy involves subcutaneous administration of insulin, usually in the arms, abdomen, thighs, or buttocks. Dose preparation, measurement, storage of insulin and equipment, and the administration procedure all require careful attention. Because this treatment is frequently performed at home by patients or their families, adolescents must be adequately prepared to avoid errors and preventable complications [7].

### *1.1 Instructional program*

Education is a core component of diabetes self-management. Teaching an adolescent how to administer insulin independently can strengthen confidence, improve adherence, and support safer daily care. Nurses play a central role in this process by promoting self-care, prevention, and health maintenance. Once insulin therapy is prescribed, teaching should begin promptly and should include the adolescent and, when appropriate, family members through verbal instruction, written guidance, and demonstration [14].

### *1.2 Adolescents' knowledge of insulin self-administration*

Previous studies indicate that adolescents with type 1 diabetes may struggle with insulin injection, glucose monitoring, meal planning, and exercise-related self-management. Psychological factors are also important, because anxiety, depression, family conflict, school stress, and peer perceptions can reduce consistent self-care behaviors and weaken diabetes management among adolescents with type 1 diabetes [16].

Patients who receive insulin need both adequate knowledge and a positive attitude toward self-injection in order to overcome common barriers, use insulin correctly, and support better glycemic control. Improving knowledge of insulin administration may therefore contribute to safer care, fewer avoidable errors, and better long-term treatment outcomes [18].

## 2 Methodology

1) A quasi-experimental, non-randomized study was conducted among 120 adolescents attending the Al-Hilla City Diabetes and Endocrinology Center. The sample was divided equally into a study group (n=60) and a control group (n=60) to permit comparison over time.

2) The researchers used a structured evaluation instrument with two parts. The first part contained seven items covering the sociodemographic characteristics of adolescents with type I diabetes mellitus, and

the second part contained eighteen items assessing knowledge of insulin self-injection. Correct responses were scored as two and incorrect responses were scored as one, so higher total scores reflected better knowledge.

3) Data collection was carried out with adolescents with type I diabetes mellitus between May 17, 2025, and October 4, 2025. Knowledge was assessed at baseline (pre-test), at the first post-intervention assessment (post-test I), and at a follow-up assessment (post-test II) in both groups.

4) Questionnaire reliability was evaluated using Cronbach's alpha, and the overall internal consistency coefficient was (0.720), indicating acceptable reliability for group-level analysis.

5) Data were entered, checked, and analyzed using Microsoft Excel 2010 and the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics, normality testing, chi-square testing, and repeated-measures analyses were used to evaluate changes in knowledge and between-group differences.

## 3 Results

Study sample distribution according to sociodemographic variables (SDVs) is given in Table 1. Most participants in both groups were 15-18 years old (70.0% in the study group and 66.7% in the control group), whereas 30.0% and 33.3%, respectively, were 10-14 years old. Males accounted for 46.7% of the study group and 43.3% of the control group, while females accounted for 53.3% and 56.7%. In both groups, all participants had basic literacy; 25.0% of the study group and 28.3% of the control group had completed primary school, and the remainder had completed secondary school. Most participants lived in urban areas (60.0% in the study group and 55.0% in the control group). In addition, 63.3% of the study group and 66.7% of the control group had lived with diabetes for five years or less. Nearly half of each group reported previous self-insulin injection training, and insulin-use patterns were also similar between groups. Chi-square testing showed no statistically significant between-group differences across the measured sociodemographic variables (all $p > 0.05$), indicating that the groups were comparable at baseline on the variables assessed.

Table 1: Study Sample Distribution according to Sociodemographic Variables (SDVs)

| Variable | Category | Study Group (n=60) | Control Group (n=60) | Chi-square | p-value |
|---|---|---|---|---|---|
| Age (years) | 10–14 | 18 (30.0%) | 20 (33.3%) | 0.267 | 0.967 |
| | 15–18 | 42 (70.0%) | 40 (66.7%) | | |
| | Mean ± SD | 16.4 ± 2.1 | 16.1 ± 2.3 | | |
| Sex | Males | 28 (46.7%) | 26 (43.3%) | 0.133 | 0.715 |
| | Females | 32 (53.3%) | 34 (56.7%) | | |
| Educational level | Read & write only | 60 (100%) | 60 (100%) | 0.267 | 0.964 |
| | Primary school | 15 (25.0%) | 17 (28.3%) | | |
| | Secondary school | 45 (75.0%) | 43 (71.7%) | | |
| Residence | Urban | 36 (60.0%) | 33 (55.0%) | 0.300 | 0.584 |
| | Rural | 24 (40.0%) | 27 (45.0%) | | |
| Type one Diabetes Duration | ≤ 5 years | 38 (63.3%) | 40 (66.7%) | 0.133 | 0.715 |
| | > 5 years | 22 (36.7%) | 20 (33.3%) | | |
| Training on Self-Insulin Injection | Yes | 28 (46.7%) | 30 (50.0%) | 0.133 | 0.715 |
| | No | 32 (53.3%) | 30 (50.0%) | | |
| Type of Insulin Used | Rapid-acting | 15 (25.0%) | 17 (28.3%) | 0.267 | 0.964 |
| | Slow-acting | 20 (33.3%) | 18 (30.0%) | | |
| | Both | 25 (41.7%) | 25 (41.7%) | | |

The baseline normality results did not show a statistically significant departure from normality ($p > 0.05$).

Accordingly, the knowledge-score analyses were interpreted using parametric procedures, and the findings were considered together with the consistency of the descriptive and repeated-measures results (Table 2).

Table 2: Tests of normality

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Pre-test | .215 | 60 | .079 | .850 | 60 | .081 |

At pre-test, the study group had a mean total knowledge score of 22.51±12.08, with 65% (n=39) in the low category and 35% (n=21) in the moderate category. At post-test I, the mean score increased to 31.63±14.11, and most participants shifted into the high-knowledge category. At post-test II, the pattern remained strong, with 81.7% (n=49) still classified as having high knowledge, 18.3% (n=11) in the moderate category, and only a small decline in the mean score to 30.59±13.01. This pattern indicates marked short-term improvement with retention at follow-up (Table 3).

Table 3: Total knowledge of adolescents in the study group regarding self-insulin injection

| Weighted | Pre-test | | | Post-test one | | | Post-test two | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | M ± SD | No. | % | M ± SD | No. | % | M ± SD |
| Low | 39 | 65.0 | 22.51± 12.08 | 0 | 0.0 | 31.63±14.11 | 0 | 0.0 | 30.59±13.01 |
| Moderate | 21 | 35.0 | | 10 | 16.7 | | 11 | 18.3 | |
| High | 0 | 0.0 | | 50 | 83.3 | | 49 | 81.7 | |
| Total | 60 | 100 | | 60 | 100 | | 60 | 100 | |

At pre-test, the control group had a mean total knowledge score of 21.48±9.08, with 65% (n=39) in the low category and 35% (n=21) in the moderate category. At post-test I, the mean score changed only slightly to 21.86±12.96, while 63.3% (n=38) remained in the low category and 36.7% (n=22) in the moderate category. Post-test II showed nearly the same distribution, with a mean score of 22.13±13.06. Overall, the control group demonstrated minimal change across the three assessments (Table 4).

Table 4: Total adolescent understanding of self-insulin injection in the control group

| Weighted | Pre-test | | | Post-test one | | | Post-test two | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | M ± SD | No. | % | M ± SD | No. | % | M ± SD |
| Low | 39 | 65.0 | 21.48±9.08 | 38 | 63.3 | 21.86 ±12.96 | 38 | 63.3 | 22.13±13.06 |
| Moderate | 21 | 35.0 | | 22 | 36.7 | | 22 | 36.7 | |
| High | 0 | 0.0 | | 0 | 0.0 | | 0 | 0.0 | |
| Total | 60 | 100 | | 60 | 100 | | 60 | 100 | |

The study group's mean knowledge score increased from 22.51±12.08 at pre-test (95% CI: 19.32-25.70) to 31.63±14.11 at post-test I (95% CI: 28.04-35.22), then declined only slightly to 30.59±13.01 at post-test II (95% CI: 27.23-33.95). In contrast, the control group showed very little change across the same period, with mean scores remaining close to baseline. The descriptive statistics and confidence intervals therefore support a clear between-group difference in the pattern of change over time (Table 5).

Time had a highly significant effect on knowledge scores across the repeated measurements. The significant Group effect (Wilks' Lambda = 0.875, $F(1,118) = 8.41$, $p < 0.01$, Partial $\eta^2 = 0.066$) indicates a difference in overall mean knowledge between the study and control groups. Most importantly, the highly significant Time × Group interaction indicates that the pattern of change over time differed substantially between the two groups (Table 6).

Table 5: Knowledge score descriptive statistics for study and control groups at three time points

| Group | Time | N | Mean ± SD | 95% CI for Mean |
|---|---|---|---|---|
| Study Group | Pre-test | 60 | 22.51 ± 12.08 | 19.32 – 25.70 |
| | Post-test I | 60 | 31.63 ± 14.11 | 28.04 – 35.22 |
| | Post-test II | 60 | 30.59 ± 13.01 | 27.23 – 33.95 |
| Control Group | Pre-test | 60 | 21.48 ± 9.08 | 19.01 – 23.95 |
| | Post-test I | 60 | 21.86 ± 12.96 | 18.87 – 24.85 |
| | Post-test II | 60 | 22.13 ± 13.06 | 19.10 – 25.16 |

Table 6: Multivariate tests of knowledge scores (repeated measures: study vs. control)

| Effect | Wilks' Lambda | F | Df(num, den) | p-value | Partial $\eta^2$ |
|---|---|---|---|---|---|
| Time | 0.212 | 114.56 | 2,117 | 0.000** | 0.662 |
| Group | 0.875 | 8.41 | 1,118 | 0.005** | 0.066 |
| Time × Group | 0.154 | 161.32 | 2,117 | 0.000** | 0.734 |

Mauchly's W was 0.896 (Chi-Square = 2.47, df = 2, p = 0.291). Because the p-value is greater than 0.05, the sphericity assumption was not violated, indicating that the variances of the score differences across pre-test, post-test I, and post-test II were sufficiently comparable for the repeated-measures analysis used here (Table 7).

Table 7: Mauchly's Sphericity test for knowledge scores

| Effect | Mauchly's W | Chi-Square | Df | p-value |
|---|---|---|---|---|
| Time | 0.896 | 2.47 | 2 | 0.291 |

Time had a significant effect on knowledge scores across the three measurement points (Type III SS = 4872.31, df = 2, MS = 2436.16, F = 114.56, $p < 0.01$, Partial $\eta^2 = 0.662$). The highly significant Time × Group interaction further shows that the trajectory of change differed between the study and control groups, which is consistent with an intervention-associated improvement in the study group rather than a general time effect alone (Table 8).

Table 8: Within-subjects effects (study vs. control)

| Source | Type III SS | Df | MS | F | p-value | Partial $\eta^2$ |
|---|---|---|---|---|---|---|
| Time | 4872.31 | 2 | 2436.16 | 114.56 | 0.000** | 0.662 |
| Time × Group | 6850.24 | 2 | 3425.12 | 161.32 | 0.000** | 0.734 |
| Error(Time) | 1570.47 | 117 | 13.41 | | | |

The contrast analyses showed a highly significant difference between pre-test and post-test I, confirming strong improvement after the instructional program. The smaller but still significant difference between post-test I and post-test II suggests mild decline or stabilization over time rather than loss of the main gain. The pre-test versus post-test II comparison also remained highly significant, indicating sustained improvement relative to baseline (Table 9).

Table 9: Contrasts within subjects

| Contrast | F | df | p-value | Partial $\eta^2$ |
|---|---|---|---|---|
| Pre-test vs Post-test I | 192.41 | 1,118 | 0.000** | 0.620 |
| Post-test 1 vs Post-test 2 | 6.92 | 1,118 | 0.010* | 0.055 |
| Pre-test vs Post-test 2 | 162.83 | 1,118 | 0.000** | 0.580 |

The two groups' overall knowledge scores differed statistically significantly (Type III SS = 1589.62, df = 1, MS = 1589.62, F = 8.41, $p < 0.01$, Partial $\eta^2 = 0.066$). This between-subjects result is consistent with higher overall scores in the study group across the observation period. With df = 118 and MS = 188.65, the error term had a Type III SS of 22,282.50 (Table 10).

Table 10: Effects between subjects

| Source | Type III SS | Df | MS | F | p-value | Partial $\eta^2$ |
|---|---|---|---|---|---|---|
| Group | 1589.62 | 1 | 1589.62 | 8.41 | 0.005** | 0.066 |
| Error | 22282.50 | 118 | 188.65 | | | |

After the instructional program, the study group's estimated marginal mean increased from 22.51 at pre-test to 31.63 at post-test I, with only a slight decline to 30.59 at post-test II. This pattern indicates a substantial immediate gain with meaningful retention at follow-up. In contrast, the control group changed only minimally, from 21.48 at pre-test to 21.86 at post-test I and 22.13 at post-test II, indicating that knowledge remained largely stable in the absence of the structured program (Table 11).

Table 11: Knowledge score estimated marginal means

| Group | Pre-test | Post-test one | Post-test two |
|---|---|---|---|
| Study | 22.51 | 31.63 | 30.59 |
| Control | 21.48 | 21.86 | 22.13 |

For knowledge, large effect sizes were observed between pre-test and post-test I ($\eta^2 = 0.620$), indicating a strong immediate intervention-associated effect. The smaller effect size between post-test I and post-test II suggests slight decline or stabilization over time, while the large pre-test versus post-test II effect confirms that the overall improvement remained substantial at follow-up (Table 12).

Table 12: Effect sizes of intervention on knowledge

| Outcome | Time Point | F / t | p-value | Partial $\eta^2$ | Interpretation |
|---|---|---|---|---|---|
| Knowledge | Pre vs Post-test one | 192.41 | 0.000** | 0.620 | Large |
| | Post-test one vs Post-test two | 6.92 | 0.010* | 0.055 | Small |
| | Pre vs Post-test two | 162.83 | 0.000** | 0.580 | Large |

Age, educational level, and previous self-insulin injection training showed statistically significant associations with knowledge scores. Adolescents who had prior training tended to report higher knowledge scores. By contrast, gender, residence, duration of diabetes, and type of insulin used did not show statistically significant associations in this analysis. These findings suggest that developmental stage and prior exposure to structured teaching may influence knowledge more than background clinical characteristics alone (Table 13).

Table 13: Differences in knowledge scores by socio-demographic variables

| Factors | Category | Knowledge Mean | Test (a/b) | p-value |
|---|---|---|---|---|
| Age (years) | 10–14 | 22.80 | 2.34b | 0.021* |
| | 15–18 | 24.12 | | |
| Gender | Male | 22.97 | 0.98b | 0.33 |
| | Female | 23.55 | | |
| Educational Level | Read & write only | 20.90 | 7.18a | 0.001* |
| | Primary | 22.50 | | |
| | Secondary | 24.20 | | |
| | Institute > | 25.50 | | |
| Residence | Urban | 23.75 | 1.10b | 0.27 |
| | Rural | 22.90 | | |
| Duration of Diabetes | $\leq$ 5 years | 23.10 | 0.95b | 0.34 |
| | > 5 years | 23.50 | | |
| Training on Self-Insulin | Yes | 24.15 | 2.05b | 0.043* |
| | No | 22.40 | | |
| Type of Insulin Used | Rapid-acting | 23.10 | 0.56a | 0.575 |
| | Slow-acting | 23.85 | | |
| | Both | 23.90 | | |

# 4 Discussion

### *4.1 Discussion of the socio-demographical data associated with the adolescents who participated in the study*

The sociodemographic characteristics of the study and control groups did not differ statistically significantly (all $p > 0.05$), indicating that the groups were broadly comparable at baseline on the measured variables. Because the present work used a quasi-experimental design, this similarity should be interpreted as initial balance rather than proof of random allocation. Most participants were older adolescents (15-18 years old), the gender distribution was similar in both groups, and nearly three-quarters had completed secondary school. These characteristics suggest that the sample had an appropriate developmental and educational foundation for understanding insulin self-management instructions.

From an interpretive standpoint, the predominance of older adolescents is relevant because developmental maturity may support learning and performance of complex self-care skills such as insulin self-injection. The relatively high proportion of urban residents may also reflect differences in access to diabetes services, so the findings should be generalized to rural adolescents with caution. Importantly, about half of the participants reported previous training, yet baseline knowledge remained low to moderate in both groups, which suggests that informal or intermittent exposure alone may be insufficient without structured reinforcement.

These findings are consistent with literature showing that adolescent self-management is shaped by developmental readiness, family context, and educational support [1]. They also support reports indicating that skill-based teaching is more effective when it is delivered in a structured format with reinforcement rather than through routine exposure alone [9].

### *4.2 Discussion of the adolescents knowledge (pre – test, post- test one, post- test two)*

The study-group findings show a clear progression in adolescents' knowledge of insulin self-administration across the three assessment points. At baseline, knowledge was predominantly low to moderate, with no participant classified as having high knowledge. Despite ongoing reliance on insulin therapy, this distribution indicates that day-to-day treatment exposure alone does not necessarily produce adequate conceptual understanding or reliable self-management knowledge.

A major shift in knowledge classification was observed at post-test I. No participant remained in the low category, only 16.7% remained in the moderate category, and 83.3% reached the high-knowledge category. The increase in the mean knowledge score from 22.51 ± 12.08 at pre-test to 31.63 ± 14.11 at post-test I represents an increase of approximately 40.5%. In addition, the non-overlapping confidence intervals between the pre-test and post-test estimates support that this change is unlikely to be explained by random variation alone and is consistent with a meaningful intervention-associated improvement.

The intervention appears to have improved more than short-term recall; it moved most participants above the minimum knowledge threshold needed for safer insulin self-administration. From a clinical perspective, this pattern is important because better knowledge is a prerequisite for correct preparation, injection, and storage practices. The magnitude of change from pre-test to post-test I is also much larger than the negligible shifts seen in the control group, which supports the value of organized and focused instruction for knowledge acquisition.

Although the proportion classified as having high knowledge decreased slightly from 83.3% to 81.7%, and the mean score declined by about 1.04 points at post-test II, the overall level of knowledge remained far above baseline. This modest decline is more consistent with routine forgetting than with failure of the intervention. From an educational perspective, the pattern aligns with meaningful learning theory, in which minor details may fade while core concepts are retained. The much smaller difference between post-test I and post-test II, compared with the large gain from pre-test to post-test I, suggests that the program supported relatively stable knowledge rather than brief memorization [12].

The present findings also align with reports from health-care settings in which baseline patient knowledge and self-management preparedness were suboptimal, indicating the need for stronger educational support [13]. They are also consistent with intervention studies documenting significant gains after structured teaching programs for adolescents using insulin, even when the exact scoring systems differ [6].

The present pattern is also compatible with applied health research emphasizing the value of careful instructional design, clear delivery, and reinforcement when technical treatment behaviors must be learned [4]. The broad improvement seen in this study suggests that demonstration, interaction, and repeated explanation were likely helpful components. In addition, reports of weak to average baseline knowledge among adolescents with type 1 diabetes support the conclusion that routine clinical contact alone is often insufficient without systematic instructional design [20].

The control-group data provide an important comparison for interpreting the intervention effect. Across all three measurement points, the control group remained concentrated in the low and moderate knowledge categories, and no participant reached the high-knowledge category. Mean score changes were negligible, which indicates that passive exposure to routine care did not produce meaningful learning during the same period.

Adolescents in the control group continued to manage a life-sustaining therapy without clear improvement in the essential knowledge required for optimal self-care. The persistence of low knowledge over time suggests that routine clinical interactions may not provide the depth, emphasis, or reinforcement needed to produce measurable learning. This pattern is consistent with educational theory, which holds that durable learning usually requires deliberate structure rather than accidental exposure [12].

Overall, the comparison between the study and control groups suggests that the structured instructional program was associated with statistically significant and practically meaningful improvements in adolescents' knowledge of insulin self-administration.

## 5 Conclusions

1. After the instructional program, the study group showed a marked improvement in total knowledge scores at post-test I, and this improvement was largely maintained at post-test II.

2. In contrast, the control group showed little change in knowledge across the pre-test, post-test I, and post-test II assessments.

3. The repeated-measures analysis showed large effect sizes (partial $\eta^2 \approx 0.58$-$0.62$) together with highly significant Time and Time $\times$ Group effects, providing strong statistical support for the intervention-associated improvement in adolescents' knowledge of self-insulin injection.

## 6 Recommendations

1. Develop and periodically refresh structured instructional programs to strengthen adolescents' knowledge of insulin self-administration.

2. Hospitals and specialized diabetes centers should maintain ongoing instructional programs so that adolescents receive current, accurate, and practical information about insulin self-administration.

3. Printed educational materials on insulin self-administration should be prepared by the Ministry of Health and distributed to adolescents with type 1 diabetes mellitus. These materials should summarize practical guidelines and recommendations drawn from reputable international health organizations.

## References


[1] Kudubeş, Aslı Akdeniz, and Murat Bektas. "Orginal article: Psychometric properties of the Turkish version of the healthy lifestyle belief scale for adolescents." Journal of Pediatric Nursing 53 (2020): e57-e63.

[2] Almahfoodh, Dhaighum, et al. "Epidemiology of type 1 diabetes mellitus in Basrah, Southern Iraq: A retrospective study." Diabetes Research and Clinical Practice 133 (2017): 104-108.

[3] American Diabetes Association. "Diagnosis and classification of diabetes mellitus." Diabetes Care 37.Suppl. 1 (2014): S81-S90.

[4] Waller, H., et al. "Pilot study of a novel educational programme for 11-16 year olds with type 1 diabetes mellitus: the KICk-OFF course." Archives of Disease in Childhood 93.11 (2008): 927-931.

[5] Phillip, Moshe, et al. "Consensus recommendations for the use of automated insulin delivery technologies in clinical practice." Endocrine Reviews 44.2 (2023): 254-280.

[6] Ahmed, Faransa Ali, Salwa Ali Marzouk, and Safaa Rashad Mahmoud. "Effectiveness of Video-assisted Training on Insulin Self-Administration Level among Adolescents with Type 1 Diabetes." International journal of Nursing Didactics 8.07 (2018): 30-39.

[7] Nasir, Beshir Bedru, Miftah Shafi Buseir, and Oumer Sada Muhammed. "Knowledge, attitude and practice towards insulin self-administration and associated factors among diabetic patients at Zewditu Memorial Hospital, Ethiopia." PLoS One 16.2 (2021): e0246741.

[8] Jammal, Mohammed Yawz. "Factors associated with adherence to insulin self-administration among children and adolescents with type 1 DM in Iraq." Iraqi Journal of Pharmaceutical Sciences 32.Suppl. (2023): 291-299.

[9] Murphy, H. R., et al. "Randomized trial of a diabetes self-management education and family teamwork intervention in adolescents with Type 1 diabetes." Diabetic Medicine 29.8 (2012): e249-e254.

[10] American Diabetes Association Professional Practice Committee. "2. Diagnosis and Classification of Diabetes: Standards of Care in Diabetes-2024." Diabetes Care 47.Suppl. 1 (2024): S20-S42.

[11] Yosef, Tewodros, Dejen Nureye, and Eyob Tekalign. "Poor glycemic control and its contributing factors among type 2 diabetes patients at Adama Hospital Medical College in East Ethiopia." Diabetes, metabolic syndrome and obesity (2021): 3273-3280.

[12] Krathwohl, David R. "A revision of Bloom's taxonomy: An overview." Theory Into Practice 41.4 (2002): 212-218.

[13] Yosef, Tewodros. "Knowledge and Attitude on Insulin Self-Administration among Type 1 Diabetic Patients at Metu Karl Referral Hospital, Ethiopia." Journal of Diabetes Research 2019 (2019): 7801367.

[14] Kafl, Rehab Hassan, and Azza Ismail Ismail El Sayed. "Self-Care Management of Children with Type 1 Diabetes Mellitus: Effect of an Educational Training Program." Journal of Nursing and Health Science 8.6 (2020): 11-7.

[15] Peng, Hui, and William Hagopian. "Environmental factors in the development of Type 1 diabetes." Reviews in Endocrine and Metabolic Disorders 7.3 (2006): 149-162.

[16] Drotar, Dennis, et al. "Diabetes management and glycemic control in youth with type 1 diabetes: Test of a predictive model." Journal of Behavioral Medicine 36.3 (2013): 234-245.

[17] Asghari, Narges, et al. "Improving self-management and diabetes indicators in adolescents with type 1 diabetes through self-care education." Journal of Family Medicine and Primary Care 12.10 (2023): 2322-2327.

[18] Polfuss, Michele, Elizabeth Babler, Loretta L. Bush, and Kathleen Sawin. "Family Perspectives of Components of a Diabetes Transition Program." Journal of Pediatric Nursing 30.5 (2015): 748-756.

[19] Wicklow, Brandy, and Ravi Retnakaran. "Gestational diabetes mellitus and its implications across the life span." Diabetes & Metabolism Journal 47.3 (2023): 333-344.

[20] Mohamed, Zeinab Ramadan. "Knowledge and Attitude regarding diabetes type 1among Adolescent in Nursing Secondary School." Journal of Health Care Research 2.2 (2025): 1-17.