

A study of the effects of insulin pump therapy on body mass index and glycaemic control in children with type 1 diabetes

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Abstract

Aim

This retrospective study aimed to evaluate changes in body mass index (BMI) and haemoglobin A1c (HbA1c) levels among children and adolescents with type 1 diabetes mellitus (T1DM) transitioning from multiple daily injections (MDI) to insulin pump therapy over one year.

Methods

Data were collected from chart reviews of 33 T1DM patients. BMI z-scores were calculated using WHO charts, and HbA1c levels were recorded at pump initiation, 6 months, and 1 year thereafter.

Results

At pump initiation, mean HbA1c was 7.81% (95% CI: 7.49-8.12), improving to 7.41% (95% CI: 7.13-7.68) at 6 months ($p=0.0068$) and 7.42% (95% CI: 7.12-7.72) at 1 year ($p=0.009$). The initial BMI z-score was 0.65 (95% CI: 0.24-1.06), with a trend toward weight gain at 6 months (0.76, 95% CI: 0.45-1.26, $p=0.097$) but no significant change at 12 months (0.73, 95% CI: 0.34-1.12, $p=0.377$).

Conclusion

Insulin pump therapy significantly improved glycaemic control within 6 months and maintained it at 1 year, though BMI z-scores showed no significant change.

Introduction

Type 1 Diabetes Mellitus (T1DM) necessitates continuous insulin administration to manage blood sugar levels and prevent complications. Insulin is typically delivered through multiple daily injections (MDI), using different insulin types for basal and mealtime needs, with doses adjusted based on food intake, physical activity, and glucose levels. The insulin pump, however, significantly enhances diabetes management by mimicking natural insulin delivery from the pancreas¹. It provides a continuous supply of basal insulin and bolus doses for meals, allowing for more precise delivery. This technology is particularly beneficial for children, as it reduces the number of daily injections and allows for greater dietary flexibility. However, it may also carry a risk of increasing BMI^{2,3}. This study examines changes in BMI z-scores and Haemoglobin A1C (HbA1C) levels over six months and one year following the initiation of pump therapy.

Methods

This retrospective observational study was conducted at the Department of Paediatrics, University Hospital Waterford, Ireland. It aimed to evaluate changes in body mass index (BMI) z-scores and glycaemic control, measured by HbA1c, in children with Type 1 Diabetes Mellitus (T1DM) who transitioned from multiple daily injections (MDI) to insulin pump therapy over a one-year period.

Data were extracted retrospectively from medical records of children with T1DM who attended the paediatric diabetes clinic and were commenced on insulin pump therapy. Inclusion criteria were: (1) diagnosis of T1DM, (2) transitioned to insulin pump from MDI for at least one year, and (3) availability of HbA1c and BMI data at three time points—pre-pump initiation (T0), 6 months, and 12 months post-initiation.

Out of the 52 children who were using an insulin pump and attending the diabetes clinic, 13 had already been on pump therapy before joining the clinic and there are no pre-pump initiation records of them (Figure 1). Hence, of the 52 children on pump, 39 had available baseline data. However, 6 of these had missing data at either the 1-month or 6-month follow-up. A total of 33 children met the full inclusion criteria, having complete data at all three time points. Missing chart data were primarily due to missed in-person follow-up visits as well as interruptions in therapy related to pump malfunction or patient choice, which were documented in three patients during the first year. Missed physical follow-up in clinics after pump start was also influenced by COVID-19 lockdowns in 2021.

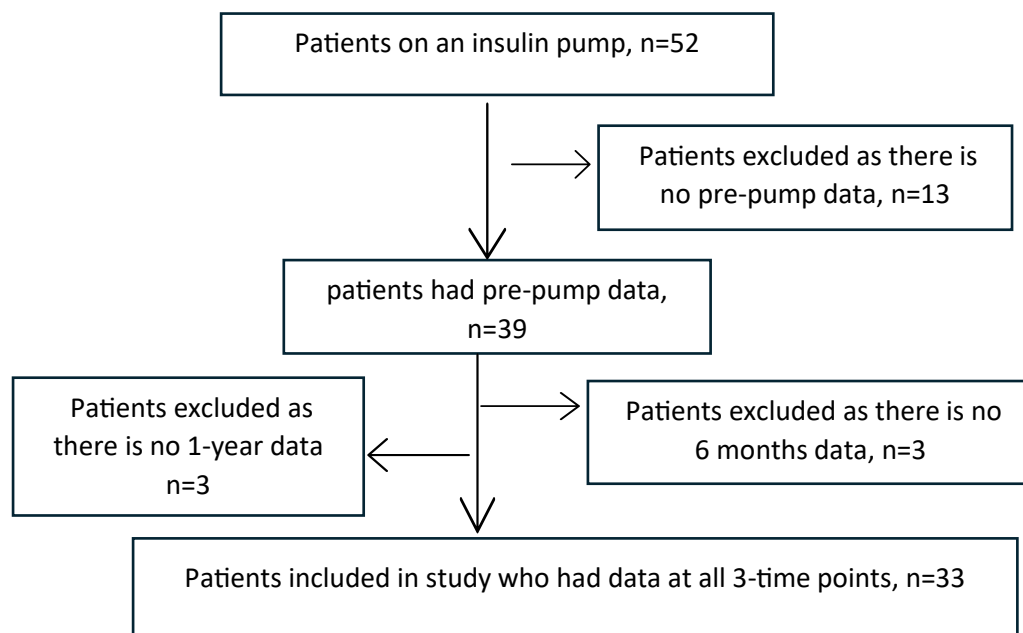


Figure 1. Inclusion Flow chart

Participants ranged in age from 19 months to 17 years and 9 months (mean: 139 months; SD: 51.4). The cohort included 16 females and 17 males. Clinical data were obtained from both electronic medical records and paper charts, ensuring completeness and cross-validation. Data collection included patient demographics, BMI z-scores (calculated using WHO growth standards), and HbA1c levels. Various insulin pump models were used based on individual patient, parents and provider preference; however, all provided continuous subcutaneous insulin infusion (CSII).

Statistical Analysis-Paired t-tests were employed to compare BMI z-scores and HbA1c levels at each time point relative to baseline. Mean values, 95% confidence intervals (CIs), and p-values were calculated using Stata 11. A p-value of <0.05 was considered statistically significant. Clinical significance for HbA1c changes was defined as a reduction of $\geq 0.5\%$, in line with established thresholds.

Results

Outcome	Baseline (T0)	6 Months	12 Months	p (T0 vs 6M)	p (T0 vs 12M)	p (6M vs 12M)
HbA1c (%)	7.81 (7.49–8.12)	7.41 (7.13–7.68)	7.42 (7.12–7.72)	0.0068	0.009	0.898
BMI z- score	0.65 (0.24–1.06)	0.76 (0.45–1.26)	0.73 (0.34–1.12)	0.097	0.377	0.658

Table 1: Comparison of data of 33 patients who had 6 months (6M) and 12 months (12M) data with their baseline (T0).

Out of the 52 patients on insulin pump therapy during the study period, 33 met full eligibility criteria, with complete data at baseline, 6 months, and 12 months. The cohort was nearly equally split by sex (16 females, 17 males), with an age range of 19 months to 17 years and 9 months (mean 139 months SD 51.4 months)

At pump initiation (T0), the mean HbA1c was 7.81% (95% CI: 7.49–8.12), there is statistically significant improved at 6 months, decreasing to 7.41% (95% CI: 7.13–7.68, $p = 0.0068$), and remained stable at 12 months at 7.42% (95% CI: 7.12–7.72, $p = 0.009$). The difference between the 6-month and 12-month HbA1c values was not statistically significant ($p = 0.898$), indicating that most of the glycaemic improvement occurred in the first six months of pump use. For clinical significance 0.4% reduction in HbA1c from baseline to 6 and 12 months is near the 0.5% threshold that is generally considered clinically significant, indicating a potential improvement in glycaemic control.

The mean baseline BMI z-score was 0.65 (95% CI: 0.24–1.06). At 6 months, there was a slight increase to 0.76 (95% CI: 0.45–1.26), which did not reach statistical significance ($p = 0.097$). At 12 months, the BMI z-score was 0.73 (95% CI: 0.34–1.12), also not significantly different from baseline ($p = 0.377$). The change between 6 and 12 months was minimal ($p = 0.658$), suggesting no progressive weight gain after initial adaptation to pump therapy. This suggests that, despite the slight upward trend at 6 months no statistically or clinically significant weight change occurred over the one-year period

Discussion

It was previously believed that BMI might increase with insulin therapy due to insulin's anabolic effects, with a more pronounced rise observed in those using insulin pumps compared to multiple daily injections (MDI), potentially due to greater flexibility in eating habits and insulin delivery^{2,3}. Several observational studies have reported higher BMI or BMI

z-scores in children with type 1 diabetes treated with insulin pumps compared to those on MDI. For instance, one study observed higher BMI among pump users in a tertiary care centre⁴. Another study examining 340 children using both cross-sectional and longitudinal data found similar trends⁵, and a large Nordic cohort of over 2,000 subjects also reported consistent findings⁶.

However, other studies have found no significant change in BMI after initiation of insulin pump therapy. A study in Kuwait involving 326 patients found no significant change after one year⁷. Similarly, a randomized trial of children under five found no BMI difference between MDI and pump groups⁸. A Cochrane review of 23 studies with 976 participants also reported no significant weight change but noted an improvement in HbA1c among pump users, although BMI was not directly measured⁹. A randomized controlled trial supported these findings, showing no significant BMI change but improved glycaemic control with pump therapy¹⁰.

A large multicentre registry-based cohort study of 5,133 children and adolescents with type 1 diabetes applied multi-trajectory modelling to follow glycaemic control, BMI, and insulin dose. In the study, some groups experienced BMI increases, particularly those with better glycaemic control or rising insulin doses, while others showed BMI stability or even reduction, often linked to poor metabolic control or lower insulin use. Puberty, sex differences (with females showing greater BMI increases), and insulin dosing patterns were significant modifiers. These findings highlight the complexity of predicting BMI outcomes and the need for individualized monitoring after pump initiation.

In our study, the mean BMI z-score increased slightly at 6 months, but this trend was not statistically significant, and no significant change was observed at 12 months. These findings align with studies suggesting that insulin pump therapy does not universally lead to weight gain. On the other hand, HbA1c levels improved significantly within the first six months of pump therapy, and this improvement was sustained at 12 months. The mean HbA1c decreased from 7.81% at baseline to 7.41% at 6 months and remained nearly unchanged at 7.42% at 12 months which were both statistically and meaningfully clinically significant. The difference between 6 and 12 months was not significant, indicating that most of the glycaemic improvement occurs early after pump initiation. This pattern is consistent with previous literature, including both observational and randomized controlled trials, which have shown that insulin pump therapy is as effective or superior to MDI in achieving glycaemic control^{8,9,10,12}.

This study also has some limitations. The relatively small sample size (n=33) may limit the statistical power and generalizability of our findings. The population was heterogeneous, ranging in age from 19 months to over 17 years, encompassing varying stages of growth, puberty, and insulin sensitivity. We did not account for potential medical or psychological comorbidities, such as coeliac disease or eating disorders, which could impact BMI or

glycaemic control. The BMI itself is an unreliable measure of body fat or cardiometabolic risk for children with diabetes. It cannot distinguish between fat and muscle mass, nor account for changing fat distribution especially during puberty and growth spurts. Additionally, BMI does not indicate important cardiometabolic risk factors such as lipid profile, blood pressure or visceral fat, which may better predict long-term outcomes. Some studies have shown that BMI in newly diagnosed type 1 diabetes patients is often determined by premorbid measurements, suggesting genetic influence rather than effects from treatment¹³. In our study, participants had been on multiple daily injection regimes prior to starting pump therapy and might have stabilised BMI by MDI regimen before we changed them to insulin pump. Due to small size of our sample, the optimal pre- and post-pump initiation BMI cannot be determined. Another limitation was the differences in the types of insulin pump systems used were not analysed, nor was data on total daily insulin doses from MDI and CSII included—both of which could influence outcomes.

In conclusion, our study supports the use of insulin pump therapy as an effective intervention for improving glycaemic control in children and adolescents with type 1 diabetes, without a significant impact on BMI over the first year. We feel BMI alone should not be used as the sole marker for treatment success or risk. More detailed measure like waist-to-height ratio, body composition, lipid levels, or continuous glucose monitoring may provide greater insight into long-term health outcomes.

Declarations of Conflicts of Interest:

None declared.

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