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Metabolic Optimization in Total Joint Arthroplasty: A Single-Centre Retrospective Cohort Pilot Study on the Safety and Feasibility of a Digitally Supported Perioperative Diet Modification

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Metabolic Optimization in Total Joint Arthroplasty: A Single-Centre Retrospective Cohort Pilot Study on the Safety and Feasibility of a Digitally Supported Perioperative Diet Modification

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Abstract

Background/Objectives: Obesity and type 2 diabetes are increasingly common among patients undergoing hip and knee arthroplasty and are associated with higher risks of prosthetic joint infection, impaired wound healing, and prolonged hospitalization. Dietary carbohydrate restriction has demonstrated benefits in glycemic control and weight reduction, but its feasibility and safety in the perioperative arthroplasty population remain underexplored. This pilot study evaluated the safety, feasibility, and short-term metabolic effects of a low-carbohydrate diet supported by WhatsApp-based meal photo-logging in patients undergoing total hip or knee arthroplasty. **Methods**: A retrospective cohort analysis was performed on 43 patients enrolled in a carbohydrate-restricted dietary programme between 2021 and 2024. Patients submitted photographs of all meals via WhatsApp with a minimum contact frequency of four times daily, enabling real-time feedback and medication adjustment. Anthropometric and metabolic parameters, including weight, BMI, HbA1c, renal function, and lipid profile, were assessed before and after the intervention. **Results**: Participants (mean age 69.12 ± 7.51 years) demonstrated significant improvement across several metabolic markers. Mean weight decreased by 5.74 kg ($p < 0.001$), BMI by 2.26 kg/m^2 ($p < 0.001$), and HbA1c by 0.72% ($p < 0.001$). No episodes of severe hypoglycemia or perioperative discharge delays related to glycemic instability were observed. Renal function remained stable, with no significant change in eGFR ($p = 0.442$). Among patients with available lipid data, LDL-cholesterol and total cholesterol increased, while triglycerides showed a non-significant downward trend. **Conclusions**: A low-carbohydrate diet combined with high-frequency digital monitoring appears feasible and safe in an elderly arthroplasty population, achieving meaningful short-term improvements in weight and glycemic control without adverse renal or hypoglycemic events. The lipid changes observed warrant cautious interpretation. Larger prospective studies are needed to confirm the clinical impact of this approach and its relevance to perioperative optimization.

Keywords: diabetes; digital health; low-carbohydrate diet; perioperative optimization; total joint arthroplasty; weight loss

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1. Introduction

Diabetes represents a major global health challenge, with the IDF Diabetes Atlas (2024) reporting that approximately 1 in 9 adults aged 20–79 years currently lives with diabetes worldwide and projecting a substantial further increase by 2050, with four in five affected individuals residing in low- and middle-income countries [1]. In Malaysia, this burden is particularly pronounced: national

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data indicate an age-standardised adult diabetes prevalence of about 21%, alongside a high and rising prevalence of obesity documented in The Malaysian Cohort and reflected in the Ministry of Health's Clinical Practice Guidelines on obesity management [1,2].

These metabolic comorbidities are highly relevant to hip and knee arthroplasty, as obesity and suboptimal glycaemic control have been associated with increased risks of prosthetic joint infection, impaired wound healing, cardiovascular events, and prolonged length of stay, and several large arthroplasty studies have demonstrated that elevated preoperative HbA1c and perioperative hyperglycaemia correlate with higher rates of postoperative infection and early complications [3–9].

In response, orthopaedic and endocrine guidelines—such as the AAOS Clinical Practice Guideline on the management of knee osteoarthritis and recommendations on perioperative diabetes care—now emphasise optimisation of weight and glycaemic control before elective arthroplasty, often advocating weight loss and postponement of surgery when HbA1c exceeds defined thresholds [2–4,6–9].

However, achieving stable glucose levels in the perioperative period remains challenging because of stress-induced insulin resistance, variability in perioperative carbohydrate intake, and the limitations of traditional sliding-scale insulin protocols [8,10,11]. These challenges have prompted growing interest in low-carbohydrate and ketogenic dietary strategies, which have demonstrated improvements in weight and HbA1c in patients with type 2 diabetes, and in digital health tools such as smartphone-based coaching, mobile social networking applications, and continuous glucose monitoring as potential adjuncts for safer and more effective perioperative metabolic optimisation in total joint arthroplasty candidates [5,12–21].

2. Materials and Methods

2.1. Study Design & Population

A retrospective cohort analysis was performed on 43 patients treated at a single centre between 2021 and 2024. This study was conducted in accordance with current legislation and ethical standards for clinical research and was approved by the Medical Research Ethics Committee of University of Malaya Medical Centre on 22 June 2025 (MREC ID NO.: 2025320-14882). Patients included were informed about the rationale of the treatment and provided informed consent. They were then recruited into the low carbohydrate diet program in Arthro Associates Clinic and underwent elective primary TJA (Hip or Knee) in Quill Orthopedic Specialist Centre (Figure 1).

Inclusion criteria were those age ≥ 18 years; type II diabetes or overweight patients; patients who underwent total joint arthroplasty (hip or knee) and those who were willing and able to provide informed consent. The exclusion criteria were those age < 18 years; type I diabetes; history of bariatric surgery for weight loss; factors that may affect HbA1c: haemoglobin < 11 mg/dl (cut point for moderate-to-severe anaemia, which could lead to falsely elevated or lowered HbA1c), recent blood donation or blood transfusion (self-reported, past 4 months), human immunodeficiency virus (self-report); self-reported history of intensive care unit stays due to COVID-19 3 months prior to initiation of dietary plan, as severe COVID-19 may affect blood glucose levels; and for women - pregnancy, breastfeeding [6].

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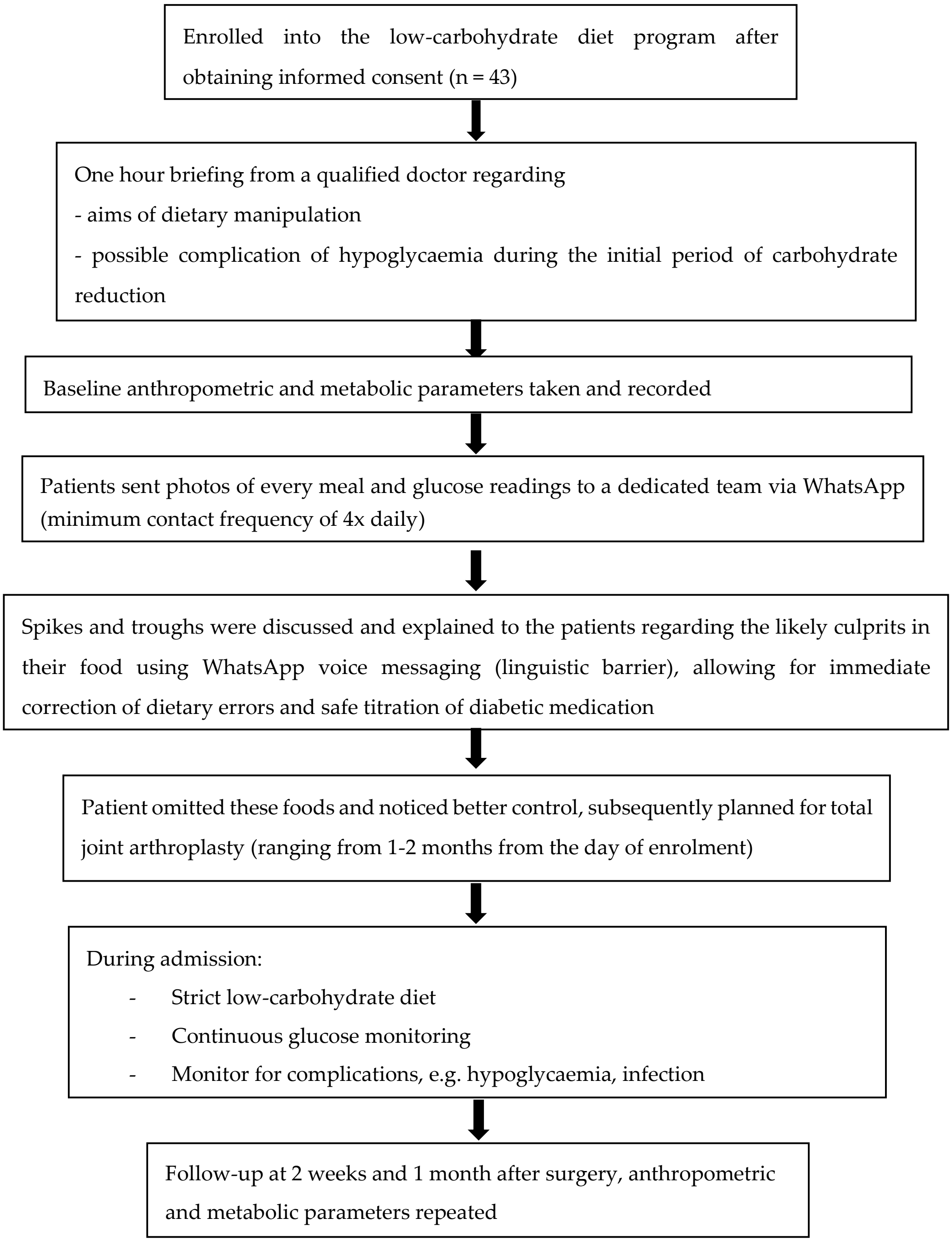

Figure 1. Flow diagram.

2.2. Intervention Protocol

1. Dietary Substrate: One portion of carbohydrate, one portion of protein ~ 40g (fish or chicken), one portion of simple protein (egg or tofu) and vegetables, with a calorie between 300-400 kcal. Rice was replaced with cauliflower rice.
2. Digital Liaison: Patients were required to send photos of every meal and glucose readings to a dedicated team via WhatsApp when they are in the program, lasting between 2-4 months.
3. Frequency: A minimum contact frequency of 4x daily was enforced. This allowed for immediate correction of dietary errors and safe titration of diabetic medication.
4. Monitoring: Transition from finger-prick to Continuous Glucose Monitoring (CGM) pre-operatively.

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2.3. Primary & Secondary Outcomes

1. Primary: (a) occurrence of severe hypoglycaemia; (b) discharge delay due to glycaemic instability.
2. Secondary: changes in weight, BMI, HbA1c, FBS, lipid and renal parameters, perioperative RBS range.

2.4. Statistical Analysis

Data was collected and managed using Microsoft Excel and analyzed using IBM SPSS Statistics (version 31) software. Descriptive statistics were utilized to summarize the data. Continuous variables were expressed as mean ± standard deviation or median with interquartile range (IQR). Categorical variables were presented as frequencies and percentages. Differences in baseline characteristics were analysed using independent and paired sample T-tests, while categorical data were compared using Fisher exact test. A P-value of < 0.05 was taken as statistically significant.

3. Results

3.1. Patient Demographic

The mean age of our study population is 69.12 ± 7.5 years; with 69.8% of them female. 23 patients underwent bilateral TKR, 14 underwent unilateral TKR and 6 underwent unilateral THR. 27 patients were diabetic, in which 23 of them were on oral agents and 4 were on insulin. The rest were under the non-diabetic/overweight category (Table 1).

Table 1. Patient demographic.

Demographics			Total (n=43)
Age	69.12 ± 7.51		43
Gender	Male	13 (30.2%)	43
	Female	30 (69.8%)	
Category	Non-diabetic	12 (27.9%)	43
	Diabetic (not on insulin)	23 (53.5%)	
	Diabetic (on insulin)	4 (9.3%)	
	Parkinson's	2 (4.7%)	
	Defaulter	2 (4.7%)	
Surgery	Unilateral TKR	14 (32.6%)	43
	Bilateral TKR	23 (53.5%)	
	Unilateral THR	6 (14.0%)	
Medication	Not on diabetic medication	13 (30.2%)	43
	OHA	26 (60.5%)	
	Insulin	4 (9.3%)	

Many patients were able to reduce or stop diabetic medications after the low-carbohydrate intervention. Among the 26 patients on OHA, 11 patients (42.3%) reduced the number of OHA used and 7 patients (26.9%) were able to completely stop all OHA. This indicates that about 69% either reduced or discontinued their oral diabetic medications, consistent with improved glycaemic control.

Among 4 patients on insulin, 1 patient reduced insulin dose and 3 patients were able to stop insulin completely and switch to OHA (Table 2). This suggests that, in this small insulin-treated subgroup, most patients improved enough to de-escalate from insulin to oral therapy, which supports the metabolic effectiveness of the intervention while maintaining safety.

Table 2. Changes in oral hypoglycaemic agents and insulin requirements following the low-carbohydrate intervention.

	Medication		Total (n)
OHA	No change in the number of OHA	8 (30.8%)	26
	Reduction in the number of OHA	11 (42.3%)	
	Complete stop of all OHA	7 (26.9%)	
Insulin	Reduction in insulin units	1 (25%)	4
	Complete stop of insulin, change to OHA	3 (75%)	

3.2. Anthropometric & Metabolic Efficacy (Table 3)

The intervention delivered rapid, statistically significant optimization:

- Weight: Mean loss of 5.74 ± 4.10 kg ($p < 0.001$), ranging from 0.7 - 22.0 kg
- BMI: Reduction of 2.26 ± 1.47 kg/m^2 ($p < 0.001$), ranging from 0.27 – 7.18 kg/m^2
- HbA1c: Improved by 0.72 ± 0.49% ($p < 0.001$), ranging from -0.2 – 1.9%, with the highest HbA1c post intervention recorded at 7.2%

Table 3. Parameters measured pre- and post-intervention.

Parameters	Before	After	Difference	*p-value*	Total (n)
Height (m)		1.58 ± 0.08		-	43
Weight (kg)	75.13 ± 17.18	69.38 ± 15.21	5.74 ± 4.10	<0.001	43
BMI (kg/m2)	29.86 ± 5.66	27.60 ± 5.16	2.26 ± 1.47	<0.001	43
Waist circumference	39.76 ± 5.32	35.47 ± 4.82	3.83 ± 2.14	<0.001	18
HbA1c	6.36 ± 0.81	5.82 ± 0.49	0.72 ± 0.49	<0.001	24
FBS	7.23 ± 2.49	5.91 ± 0.84	1.30 ± 2.12	0.002	27
Total cholesterol	4.79 ± 0.97	5.35 ± 1.45	0.71 ± 1.24	0.26	14
Triglyceride	1.88 ± 1.01	1.50 ± 0.65	0.38 ± 0.89	0.065	14
HDL	1.49 ± 0.45	1.37 ± 0.33	0.12 ± 0.22	0.032	14
LDL	2.77 ± 0.83	3.60 ± 1.37	0.81 ± 1.20	0.012	14
Urea	6.38 ± 3.08	9.01 ± 4.51	1.59 ± 3.36	0.030	18
Creatinine	85.70 ± 33.35	92.65 ± 26.26	8.44 ± 25.76	0.080	20
eGFR	75.49 ± 23.19	62.94 ± 20.40	0.63 ± 16.91	0.442	16

*Baseline anthropometric and metabolic parameters were taken and recorded during enrolment. During follow-up after surgery, ranging from 1-3 months, these parameters were repeated.

3.3. The Safety Profile

Safety was the primary endpoint of this pilot study.

- Hypoglycaemia: Despite 27 patients being on diabetic medication, none experienced dangerous hypoglycaemia (< 4.0 mmol/L) requiring rescue intervention.
- Discharge Delays: none of the patients had their discharge delayed due to glycaemic instability.
- Renal Stability: While Urea increased significantly ($p=0.030$), likely due to protein turnover, Creatinine ($p=0.080$) and eGFR ($p=0.442$) showed no significant change. This confirms that renal filtration function was preserved.

3.4. The Lipid Profile

The data revealed a distinct divergence in lipid markers:

- LDL-C: Increased significantly by 0.81 mmol/L ($p=0.012$).
- Total Cholesterol: Increased significantly ($p=0.026$).
- Triglycerides: Remained low (1.50 ± 0.65 mmol/L) with a trend toward reduction ($p=0.065$).
- HDL: decreased modestly but remained within generally favorable ranges (1.37 mmol/L).

The most critical finding for the orthopaedic community is the absence of life-threatening hypoglycaemia. In standard care, the combination of carbohydrate intake (raising sugar) and insulin (lowering sugar) creates glycaemic volatility. This approach may have contributed to a more stable perioperative glycaemia, preventing perioperative discharge delays and rendering it cost-effective.

The elevation in LDL-cholesterol (p=0.012) observed in this cohort warrants careful interpretation. Lipid elevations during active weight loss have been described in other low-carbohydrate or ketogenic diet studies, and several mechanistic models, including the Lipid Energy Model [22], propose physiologic explanations for this pattern. However, these hypotheses remain under active investigation, and the long-term cardiovascular implications of LDL changes in this specific population cannot be determined from this short-term study. Importantly, lipid measurements were available for only a subset of participants, underscoring the need for more complete data collection in future work.

4. Discussion

To our knowledge, this retrospective pilot study is among the first to examine the use of a carbohydrate-restricted dietary intervention supported by high frequency WhatsApp monitoring for patients with type 2 diabetes or obesity undergoing hip and knee arthroplasty. The findings suggest that this combined approach is feasible in an elderly surgical cohort and may contribute to improvements in weight, glycaemic control and several perioperative metabolic parameters.

Metabolic comorbidities such as obesity and diabetes are well-established risk factors for perioperative complications, notably prosthetic joint infection (PJI), the most devastating complication in arthroplasty . Furthermore, glycemic variability — the rapid fluctuation between high and low blood sugar — has been identified as a potent pro-inflammatory stressor that impairs wound healing , increasing length of hospital stay.

Traditional perioperative glycaemic management relied on reactive insulin titration. Patients are often admitted with suboptimal metabolic parameters, and hyperglycaemia is managed perioperatively using sliding-scale insulin. This approach presents a dual risk:

1. Inefficacy: It treats the symptom (high sugar) without addressing the root cause (insulin resistance/dietary input).
2. Safety: Aggressive insulin therapy increases the risk of iatrogenic hypoglycaemia, which is associated with arrhythmias, falls, and increased mortality in the elderly.

In contrast, dietary carbohydrate restriction targets the primary driver of hyperglycaemia and may offer a more physiologic method to mitigate perioperative glycaemic volatility. In this study, patients achieved significant reductions in body weight and HbA1c over a short preoperative window without observed episodes of severe hypoglycaemia, supporting the potential safety of this approach.

A notable component of this intervention was the use of a WhatsApp-based “tight feedback loop,” requiring patients to submit meal photographs and glucose readings several times daily. This strategy appeared to enhance engagement and adherence, demonstrating that elderly patients can successfully utilise simple digital tools when appropriately guided [15–19]. Digital health applications have been increasingly recognised as valuable adjuncts in chronic disease management, and the present study extends this concept into the preoperative optimisation phase for major orthopaedic surgery.

This pilot study aimed to:

1. Establish Safety: Verify that strict carbohydrate restriction does not cause hypoglycaemia or renal impairment in a surgical cohort.
2. Evaluate Feasibility: Assess the efficacy of WhatsApp-based photo-logging for elderly patients.
3. Analyse Lipid Physiology: Interpret the “Lipid Paradox” (rising LDL with weight loss) through the lens of the Lipid Energy Model [22].

Major orthopaedic surgery induces a hypermetabolic stress response characterized by the release of cortisol, catecholamines, and glucagon . This state induces transient insulin resistance, often termed "stress hyperglycaemia." In patients with poor baseline metabolic health, this response is exaggerated, significantly increasing the risk of deep infection . Despite this, this intervention gives value in reducing the fluctuations of peri-operative blood sugar.

The Ketogenic Diet shifts the body's primary fuel source from glucose to ketones and fatty acids . While effective for weight loss and diabetes reversal, it is often criticized for raising Low-Density Lipoprotein Cholesterol (LDL-C). In a carbohydrate-restricted state, the liver packages triglycerides into Very Low-Density Lipoproteins (VLDL) to fuel peripheral tissues. As lean tissue (muscle) rapidly hydrolyses these triglycerides for energy, the VLDL particle shrinks and becomes an LDL particle.

In this context, elevated LDL is a "remnant" of high energy trafficking (fat burning), not a marker of broken cholesterol metabolism. The profile of High LDL + Low Triglycerides + High HDL is characteristic of the Lean Mass Hyper-Responder phenotype , which differs fundamentally from the atherogenic triad (High TG, Low HDL, Small LDL) associated with cardiovascular disease.

The success of this intervention relied on "Digital Dosage." The requirement to photograph every meal created a Hawthorne Effect (behaviour change due to observation). This transformed the diet from a static prescription into a dynamic, managed process, suggesting that elderly patients can successfully engage with digital health tools [15–19].

This study also has several limitations inherent to its retrospective design. Selection bias is possible, as individuals who agreed to intensive dietary monitoring may differ from typical arthroplasty patients in motivation or digital literacy. Missing data, particularly for lipid and renal parameters, reduce the robustness of some conclusions. The dietary intervention was not strictly standardised, and meal assessments relied on photographs rather than objective nutritional analysis. Finally, the study did not include a control group, preventing causal inference regarding the superiority of this approach relative to standard care.

Despite these limitations, the results support the feasibility of implementing a digitally supported low-carbohydrate diet in the perioperative setting and suggest potential metabolic benefits that may justify further study. Prospective, controlled trials with larger sample sizes, complete biochemical data, and longer postoperative follow-up will be necessary to determine the true clinical impact of this protocol on surgical outcomes, complication rates, and healthcare utilisation.

5. Conclusions

A low-carbohydrate diet combined with high-frequency digital monitoring appears feasible and safe in an elderly arthroplasty population, achieving meaningful short-term improvements in weight and glycemic control without adverse renal or hypoglycemic events. The lipid changes observed warrant cautious interpretation. Larger prospective studies are needed to confirm the clinical impact of this approach and its relevance to perioperative optimization.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Author Contributions: Each author has made substantial contributions to the work. More specifically, each author has developed the following roles: Conceptualization, S.K.C.; methodology, V.H.; validation, S.K.C.; formal analysis, H.W.O.; investigation, V.H.; resources, S.K.C.; data curation, H.W.O.; writing—original draft preparation, H.W.O.; writing—review and editing, H.W.O.; visualization, H.W.O.; supervision, S.K.C. and K.A.A.; project administration, S.K.C. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AAOS	American Academy of Orthopaedic Surgeons
BMI	Body mass index
CGM	Continuous Glucose Monitoring
CPG	Clinical Practice Guidelines
eGFR	Renal filtration
FBS	Fasting blood sugar
HbA1c	Glycated hemoglobin
HDL	High-density lipoprotein
IDF	International Diabetes Federation
IQR	Interquartile range
LDL	Low-density lipoprotein
LEM	Lipid Energy Model
OHA	Oral hypoglycaemic agents
RBS	Random blood sugar
TG	Triglyceride
THR	Total hip replacement
TJA	Total joint arthroplasty
TKR	Total knee replacement
TMC	The Malaysian Cohort
PJI	Prosthetic joint infection
RCT	Randomized Controlled Trial
VLDL	Very low-density lipoprotein

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