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Original article

Assessment of Nutritional Literacy, Self-Management Practices, and Lifestyle Determinants Among Patients with Type 2 Diabetes Mellitus at Misurata Medical Centre, Libya

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Abstract
Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder representing a major public health challenge globally and in Libya. While pharmacological management and clinical follow-up are fundamental, a substantial gap frequently persists between medical consultations and day-to-day lifestyle self-management, driven primarily by deficits in functional nutritional literacy. To evaluate prior nutritional education exposure, functional dietary literacy, eating patterns, and clinical self-management behaviours among patients with T2DM in Misrata, Libya, and to examine their statistical associations with dietary adherence and metabolic health indicators. A hospital-based, analytical cross-sectional study was conducted across outpatient internal medicine clinics in Misrata, primarily at Misurata Medical Centre, between March and June 2026. Using systematic random sampling, 200 adults (aged ≥30 years) with confirmed T2DM were enrolled and assessed via a validated, interviewer-administered structured questionnaire alongside clinical and anthropometric review. Statistical analyses were performed in IBM SPSS Statistics (Version 24.0) using descriptive frequencies (n, %), exact 95% binomial confidence intervals (95% CI), Pearson's correlation coefficient (r), and one-way ANOVA measures of association (Eta [η] and Eta-squared [η^2]) with a two-tailed significance threshold of $\alpha = 0.05$. Most participants were aged >50 years (68.0%, n = 136), female (52.0%, n = 104), and had a disease duration of >5 years (58.0%, n = 116). Adherence to routine clinical protocols was high: 87.5% (n = 175) attended monthly physician follow-ups, 90.5% (n = 181) reported consistent medication adherence, and 82.0% (n = 164) performed regular self-monitoring of blood glucose (SMBG). Although 86.5% (n = 173) reported prior exposure to general nutritional counseling and >95% recognized the value of dietary fiber, whole grains, and portion control, severe deficits in applied nutritional literacy were observed: 83.5% (n = 167; 95% CI: 77.6%–88.4%) lacked knowledge of the glycemic index (GI) and high-GI foods, and 71.5% (n = 143; 95% CI: 64.7%–77.6%) never read food nutrition labels. Furthermore, restricted eating patterns were prevalent, with 65.0% (n = 130) consuming two or fewer meals daily (60.5%, n = 121 consuming two meals and 4.5%, n = 9 consuming only one meal daily), whereas 33.5% (n = 67) consumed three meals daily. Nutritional education score correlated positively with dietary adherence ($r = 0.381$, 95% CI: 0.256–0.493, $t(198) = 5.79$, $p < 0.001$, $r^2 = 0.145$) and demonstrated a large effect size in explaining variance across the standardized composite metabolic index (derived via mathematical z-score transformation of HbA1c and body weight; $\eta = 0.669$, $\eta^2 = 0.447$, $p < 0.001$). High pharmacological and clinical compliance alone does not guarantee optimal glycemic control when functional nutritional literacy is lacking. Widespread inability to interpret nutrition labels or apply glycemic index principles impedes effective postprandial glucose regulation. Integrating structured, culturally tailored Medical Nutrition Therapy (MNT) and visual low-literacy teaching tools into routine outpatient care is essential to bridge this clinical-behavioural gap.
Keywords. Type 2 Diabetes Mellitus; Nutritional Literacy; Glycemic Index; Medical Nutrition Therapy.

Introduction

Diabetes mellitus (DM) is a complex, chronic cardiometabolic disorder characterised by persistent hyperglycemia resulting from progressive defects in pancreatic β-cell insulin secretion, peripheral and hepatic insulin action, or both [1]. Sustained chronic hyperglycemia induces systemic endothelial dysfunction, oxidative stress, and non-enzymatic protein glycation, culminating in debilitating microvascular complications (diabetic retinopathy, nephropathy, and peripheral neuropathy) and accelerated macrovascular disease, conferring a two- to four-fold elevation in cardiovascular morbidity and all-cause mortality [1,2]. Type 2 Diabetes Mellitus (T2DM) accounts for approximately 90% to 95% of all diagnosed diabetes cases worldwide. While historically prevalent predominantly among older adults, the incidence of T2DM has risen sharply across younger demographics over recent decades, driven by rapid urbanisation, sedentary behaviours, and the widespread nutritional transition toward energy-dense, ultra-processed diets [1,3].

Excess adiposity represents the foremost modifiable pathogenic driver of T2DM. Epidemiological and metabolic investigations demonstrate an exponential rise in diabetes risk with increasing body mass index (BMI), wherein individuals with severe obesity (BMI ≥ 35 kg/m^2) face an approximately 20-fold to 40-fold higher likelihood of developing T2DM compared to those maintaining a normal BMI (18.5–24.9 kg/m^2) [4,5]. According to the twin-cycle hypothesis, chronic caloric surplus promotes hepatic de novo lipogenesis and ectopic triacylglycerol accumulation within hepatocytes and pancreatic islets, blunting hepatic insulin sensitivity and progressively impairing acute glucose-stimulated insulin secretion [5]. Furthermore, adipose tissue dysfunction (adiposopathy) exacerbates systemic inflammation, dyslipidemia, and cardiometabolic risk in patients with established T2DM [6,7]. Landmark evidence from the Diabetes Prevention Program (DPP) established that structured lifestyle interventions targeting a 7% reduction in baseline body weight and at least 150

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minutes of moderate-intensity physical activity per week reduced the 3-to-4-year incidence of T2DM by 58%—surpassing pharmacological prophylaxis alone [8,9]. In North Africa and the Middle East, including Libya, the burden of T2DM continues to escalate alongside shifting dietary traditions. Although specialised clinical and pharmacological services are accessible through regional referral institutions such as the Misurata Medical Centre and the Ras Al-Touba Diabetes Centre, a substantial proportion of outpatients persistently exhibit suboptimal glycemic control (elevated glycated haemoglobin [HbA1c]) and preventable acute metabolic decompensations. This clinical paradox suggests that pharmacological adherence and routine physician consultations alone are insufficient when uncoupled from structured Diabetes Self-Management Education and Support (DSMES) and individualised Medical Nutrition Therapy (MNT) [10,11]. In routine clinical settings, patients frequently receive brief, generic dietary advice (e.g., 'avoid sugar') but lack the functional nutritional literacy required to interpret food labels, estimate glycemic load, or modify traditional Libyan carbohydrate-rich staples without sacrificing cultural acceptability. Consequently, this study aimed to evaluate nutritional education exposure, functional dietary literacy, eating behaviours, and clinical self-management determinants among patients with T2DM in Misrata, Libya, and to quantify the statistical relationships linking nutritional education to dietary adherence and metabolic outcomes.

Materials and Methods

Study Design and Setting

A hospital-based, analytical cross-sectional study was conducted in adherence with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Fieldwork was carried out across outpatient internal medicine and diabetes follow-up clinics in Misrata, Libya—primarily at the Misrata Medical Centre—over four months from March 2026 to June 2026.

Study Population, Eligibility Criteria, and Sampling Strategy

The target population comprised ambulatory adult patients attending routine outpatient follow-up visits for T2DM. Inclusion criteria were: (1) a confirmed clinical diagnosis of T2DM established according to American Diabetes Association (ADA) or World Health Organisation (WHO) diagnostic criteria; (2) age ≥ 30 years at the time of enrollment; and (3) cognitive and communicative capacity to provide informed consent and complete a structured clinical interview. Exclusion criteria included Type 1 Diabetes Mellitus, gestational diabetes mellitus, acute hyperglycemic emergencies requiring inpatient hospitalisation at the time of recruitment, or severe cognitive impairment. Sample size adequacy was verified using Cochran's single-proportion formula ($n = Z^2 \cdot p \cdot (1 - p) / d^2$) assuming a 95% confidence level ($Z = 1.96$), a conservative expected prevalence of adequate nutritional literacy of $p = 0.50$, and a margin of error of $d = 0.07$, yielding a minimum required sample of 196 participants. Additionally, an a priori power calculation for bivariate correlation indicated that $N = 200$ provides >99% statistical power ($1 - \beta = 0.999$ at $\alpha = 0.05$, two-tailed) to detect a moderate correlation of $r \geq 0.30$. A total of 200 eligible patients were recruited via systematic random sampling from the daily outpatient clinic registration rosters.

Data Collection Instrument and Fieldwork Procedures

Data were collected using a structured, interviewer-administered questionnaire developed through an extensive literature review of validated diabetes nutrition assessment instruments and clinical practice guidelines [10,11]. Content and face validity were established by an expert panel comprising therapeutic nutritionists, internal medicine specialists, and a biostatistician at Misurata University. Before formal data collection, the instrument was pilot-tested on a preliminary sample of diabetic outpatients to verify clarity, cultural relevance, and reliability. The questionnaire encompassed five structured domains: (1) Sociodemographic profile (age, sex, and formal educational attainment); (2) Clinical diabetes history and medical self-management (disease duration, frequency of physician follow-up, self-reported medication adherence, routine self-monitoring of blood glucose [SMBG], and recognition/management of acute hypo- and hyperglycemic episodes); (3) Nutritional literacy and education (prior receipt of structured nutritional counseling, conceptual knowledge of balanced meals, portion control, whole grains, dietary fiber, sugar-sweetened beverages, and applied literacy regarding the Glycemic Index [GI] and nutrition label reading); (4) Daily dietary habits (meal frequency, vegetable and fruit intake, and sweetened beverage consumption); and (5) Lifestyle and objective metabolic records (recent laboratory HbA1c values and measured body weight/BMI retrieved from outpatient clinical charts). Fieldwork was conducted three days per week during five-hour clinic sessions. Each individualised face-to-face interview and clinical chart verification lasted approximately 45 to 60 minutes, enrolling 1 to 3 patients per day until the target cohort of N = 200 was completed.

Ethical Considerations

The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Health Sciences, Misurata University, Libya, and conducted in accordance with the ethical principles of the Declaration of Helsinki. All participants received a clear verbal and written explanation of the study objectives, procedures, and confidentiality safeguards, and provided informed consent before participation. All clinical and anthropometric data were anonymised before statistical coding.

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Statistical Analysis

Data entry, verification, and statistical analyses were executed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA). Categorical sociodemographic, clinical, nutritional knowledge, and dietary behaviour variables were summarised as absolute frequencies (n) and percentages (%), accompanied by exact 95% Clopper–Pearson binomial confidence intervals (95% CI) for key prevalence estimates. To evaluate inferential relationships, composite indices were derived for nutritional education/literacy and dietary adherence. The linear association between nutritional education and dietary adherence scores was evaluated using Pearson's product-moment correlation coefficient (r), with its corresponding coefficient of determination (r^2), t-statistic (df = 198), and 95% Fisher's z-transformed confidence interval. To evaluate the relationship between categorical nutritional education exposure and objective clinical metabolic outcomes while accounting for variables possessing fundamentally different measurement scales and physical units—specifically, laboratory glycated hemoglobin (HbA1c, measured in percentage units, %) and measured body weight (measured in kilograms, kg)—mathematical standardization was conducted prior to composite modeling. Raw HbA1c and body weight values were converted into dimensionless standard scores (z-scores: $z = [X - \mu] / \sigma$), yielding standardized variables with a mean of 0 and standard deviation of 1. A unified Standardized Composite Metabolic Index was then computed for each participant as the arithmetic mean of the standardized scores ($Z_{composite} = [Z_{HbA1c} + Z_{weight}] / 2$), ensuring equal weighting and dimensional compatibility. The association between categorical nutritional education exposure and this standardized composite metabolic outcome was quantified using the Eta coefficient (η) and Eta-squared ($\eta^2 = SS_{between} / SS_{total}$) derived from one-way Analysis of Variance (ANOVA), where η^2 represents the proportion of total variance explained. Following Cohen's conventions, η^2 values of 0.01, 0.06, and ≥0.14 were interpreted as small, medium, and large effect sizes, respectively. All hypothesis tests were two-tailed, with statistical significance defined as $p < 0.05$ (exact p-values < 0.001 are reported as $p < 0.001$ in accordance with international biostatistical reporting standards).

Results

Sociodemographic Profile and Clinical Self-Management Characteristics

A total of 200 adult outpatients with diagnosed T2DM completed the study (100% response rate among enrolled participants). (Table 1) presents the consolidated sociodemographic distribution, disease duration, and clinical self-management behaviours of the cohort (consolidating baseline demographic and clinical parameters). The sample exhibited a pronounced skew toward older adulthood: more than two-thirds of the participants were aged >50 years (68.0%, n = 136; 95% CI: 61.0%–74.4%), 25.0% (n = 50) were aged 41–50 years, and 7.0% (n = 14; 95% CI: 3.9%–11.5%) were aged 30–40 years, meaning that 93.0% of the cohort comprised middle-aged and older adults aged >40 years. The sex distribution was nearly balanced, with 52.0% females (n = 104) and 48.0% males (n = 96). Regarding formal educational attainment, one-third of the participants held a university degree (33.0%, n = 66) and 28.0% (n = 56) had completed secondary schooling, whereas 17.5% (n = 35) had basic education and 21.5% (n = 43) had no formal schooling (illiterate or basic read-and-write ability only). Evaluation of clinical history revealed a predominance of long-standing diabetes: 58.0% (n = 116) had lived with T2DM for >5 years, 32.0% (n = 64) for 1–5 years, and only 10.0% (n = 20) had been diagnosed within the preceding year. Routine medical compliance was remarkably high across the cohort. Specifically, 87.5% (n = 175) attended physician follow-up consultations on a monthly basis, 90.5% (n = 181) reported always adhering to their prescribed antihyperglycemic medications, and 82.0% (n = 164) performed regular home SMBG. Furthermore, 97.0% (n = 194) accurately recognised the clinical warning signs and symptoms of acute hyperglycemia and hypoglycemia (Table 1). Despite this high adherence to medical appointments and pharmacotherapy, clinical chart verification indicated that participants consistently presented with elevated recent blood glucose values, highlighting a discrepancy between medical compliance and actual glycemic normalisation.

Table 1. Sociodemographic profile, disease duration, and clinical self-management characteristics of the study cohort (N = 200).

Variable / Domain	Category	n (%)	95% CI (%)
Sociodemographic Characteristics			
Age group (years)	30–40	14 (7.0%)	3.9% – 11.5%
	41–50	50 (25.0%)	19.2% – 31.6%
	>50	136 (68.0%)	61.0% – 74.4%
Sex	Female	104 (52.0%)	44.8% – 59.1%
	Male	96 (48.0%)	40.9% – 55.2%
Educational attainment	No formal schooling (Read & write)	43 (21.5%)	16.0% – 27.8%
	Basic education	35 (17.5%)	12.5% – 23.5%
	Secondary education	56 (28.0%)	21.9% – 34.8%
	University level	66 (33.0%)	26.5% – 40.0%
Clinical & Self-Management Profile			
Duration of T2DM	<1 year	20 (10.0%)	6.2% – 15.0%
	1–5 years	64 (32.0%)	25.6% – 39.0%
	>5 years	116 (58.0%)	50.8% – 64.9%

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Physician follow-up frequency	Monthly	175 (87.5%)	82.1% – 91.7%
	Every 3 months	23 (11.5%)	7.4% – 16.8%
	Every 6 months	2 (1.0%)	0.1% – 3.6%
Adherence to prescribed medication	Always	181 (90.5%)	85.6% – 94.2%
	Sometimes	16 (8.0%)	4.6% – 12.7%
	Never	3 (1.5%)	0.3% – 4.3%
Regular blood glucose monitoring (SMBG)	Yes	164 (82.0%)	76.0% – 87.1%
	No	36 (18.0%)	12.9% – 24.0%
Awareness of hypo-/hyperglycemia symptoms	Yes	194 (97.0%)	93.6% – 98.9%
	No	6 (3.0%)	1.1% – 6.4%

Note. Data are presented as frequency (n), percentage (%), and exact Clopper–Pearson 95% confidence intervals (95% CI). SMBG = Self-Monitoring of Blood Glucose; T2DM = Type 2 Diabetes Mellitus.

Nutritional Education Exposure and Functional Dietary Literacy

(Table 2) summarises the participants' prior exposure to nutritional education, general conceptual knowledge, and functional food-selection skills (consolidating nutritional knowledge and food label reading parameters). Overall, 86.5% (n = 173; 95% CI: 81.0%–90.9%) of the cohort reported having received prior nutritional guidance regarding diabetes. Consistent with this exposure, awareness of general, foundational dietary principles was high: 96.5% (n = 193) knew that dietary fibre aids glycemic regulation, 96.0% (n = 192) acknowledged the necessity of portion size control, 95.0% (n = 190) recognised whole grains as superior to refined carbohydrates for diabetes management, and 84.0% (n = 168) understood the general concept of a balanced meal. In stark contrast to this high general awareness, severe deficits emerged in functional and applied nutritional literacy (Table 2). Specifically, 83.5% of the participants (n = 167; 95% CI: 77.6%–88.4%) had no knowledge of the Glycemic Index (GI) and could not identify high-GI foods or explain their rapid hyperglycemic impact. Similarly, when evaluating practical retail food-selection behaviour, nearly three-quarters of the cohort (71.5%, n = 143; 95% CI: 64.7%–77.6%) reported that they never read nutrition facts labels on packaged foods, 18.5% (n = 37) read them only sometimes, and merely 10.0% (n = 20; 95% CI: 6.2%–15.0%) consistently inspected nutritional labels before purchase or consumption.

Table 2. Nutritional education exposure, conceptual dietary knowledge, and functional nutrition literacy among participants (N = 200).

Assessment Item	Affirmative / Category n (%)	Negative n (%)	95% CI for Affirmative (%)
Dichotomous Knowledge & Exposure Domains			
Prior exposure to diabetes nutritional education	173 (86.5%)	27 (13.5%)	81.0% – 90.9%
Aware that dietary fibre aids blood glucose regulation	193 (96.5%)	7 (3.5%)	92.9% – 98.6%
Acknowledges the importance of portion size control	192 (96.0%)	8 (4.0%)	92.3% – 98.3%
Recognises whole grains as preferred carbohydrate sources	190 (95.0%)	10 (5.0%)	91.0% – 97.6%
Understands the composition of a balanced meal	168 (84.0%)	32 (16.0%)	78.2% – 88.8%
Understands the Glycemic Index (GI) and high-GI foods	33 (16.5%)	167 (83.5%)	11.6% – 22.4%
Functional Label Literacy (Ordinal Practice)			
Reads nutrition labels on packaged food products: Always	20 (10.0%)	—	6.2% – 15.0%
Reads nutrition labels on packaged food products: Sometimes	37 (18.5%)	—	13.4% – 24.6%
Reads nutrition labels on packaged food products: Never	143 (71.5%)	—	64.7% – 77.6%

Note. Data are presented as frequency (n), percentage (%), and exact Clopper–Pearson 95% confidence intervals (95% CI). GI = Glycemic Index.

Daily Meal Patterns and Food Group Consumption Frequencies

(Table 3) Details the daily meal frequency and food group consumption patterns of the study sample (consolidating daily meal frequency, vegetable intake, fruit consumption, and sweetened beverage habits). Assessment of meal spacing revealed a restricted eating frequency: the majority of participants consumed only two meals per day (60.5%, n = 121; 95% CI: 53.4%–67.3%), while one-third consumed three meals daily (33.5%, n = 67), 4.5% (n = 9) ate only once daily, and 1.5% (n = 3) consumed more than three meals per day. Regarding protective and high-risk dietary components, 88.0% (n = 176) reported daily vegetable consumption. Fruit consumption occurred on a weekly basis in 49.0% (n = 98) of participants and daily in 40.0% (n = 80), whereas 11.0% (n = 22) rarely consumed fruits and none (0.0%) reported complete avoidance. Encouragingly, avoidance of sugar-sweetened beverages was widespread: 57.0% (n = 114) never consumed sweetened beverages, and 30.0% (n = 60) consumed them rarely, while only 10.5% (n = 21) and 2.5% (n = 5) reported weekly and daily consumption, respectively (Table 3).

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Table 3. Daily meal frequency and food group consumption patterns among participants with T2DM (N = 200).

Dietary Behaviour Variable	Consumption Frequency	n (%)	95% CI (%)
Daily Meal Frequency			
Number of meals consumed per day	One meal	9 (4.5%)	2.1% – 8.4%
	Two meals	121 (60.5%)	53.4% – 67.3%
	Three meals	67 (33.5%)	27.0% – 40.5%
	More than three meals	3 (1.5%)	0.3% – 4.3%
Vegetable Intake Pattern			
Daily vegetable consumption	Yes (Daily)	176 (88.0%)	82.7% – 92.2%
	No (Non-daily)	24 (12.0%)	7.8% – 17.3%
Fruit Intake Frequency			
Fresh fruit consumption	Daily	80 (40.0%)	33.2% – 47.2%
	Weekly	98 (49.0%)	41.9% – 56.2%
	Rarely	22 (11.0%)	7.0% – 16.2%
	Never	0 (0.0%)	0.0% – 1.8%
Sugar-Sweetened Beverage (SSB) Intake			
Sweetened beverage consumption	Daily	5 (2.5%)	0.8% – 5.7%
	Weekly	21 (10.5%)	6.6% – 15.6%
	Rarely	60 (30.0%)	23.7% – 36.9%
	Never	114 (57.0%)	49.8% – 64.0%

Note. Data are presented as frequency (n), percentage (%), and exact Clopper–Pearson 95% confidence intervals (95% CI). SSB = Sugar-Sweetened Beverage.

Inferential Associations Between Nutritional Education, Dietary Adherence, and Metabolic Outcomes

(Table 4) presents the inferential statistical models evaluating the impact of nutritional education on dietary adherence and objective clinical health indicators (HbA1c and body weight). Bivariate parametric analysis revealed a statistically significant, moderate positive linear correlation between nutritional education and adherence to recommended dietary practices (Pearson's r = 0.381, 95% CI: 0.256–0.493, t(198) = 5.79, p < 0.001). The corresponding coefficient of determination ($r^2 = 0.145$) indicates that variations in nutritional education account for 14.5% of the variance in self-reported dietary adherence. Furthermore, to appropriately evaluate objective clinical markers without dimensional unit confounding, one-way ANOVA was conducted on the mathematically standardized composite metabolic index (z-score normalized HbA1c [%] and body weight [kg]). This analysis demonstrated a strong, statistically significant association with nutritional education status, yielding an Eta coefficient of $\eta = 0.669$ and an Eta-squared value of $\eta^2 = 0.447$ ($p < 0.001$; Table 4). Based on standard biostatistical effect-size benchmarks (where $\eta^2 \geq 0.14$ denotes a large effect), nutritional education status explained approximately 44.7% of the total between-group variance in the standardized composite metabolic profile among the studied T2DM outpatients.

Table 4. Inferential statistical associations between nutritional education, dietary adherence, and the standardized composite metabolic index (z-score normalized HbA1c and body weight) (N = 200).

Statistical Procedure	Variables Evaluated	Association Metric	Explained Variance & Effect Size	Test Statistic & p-value
Pearson Product-Moment Correlation	Nutritional Education Score vs. Dietary Adherence Score	r = 0.381 (95% CI: 0.256–0.493)	$r^2 = 0.145$ (14.5% variance; Moderate positive)	t(198) = 5.79 p < 0.001
One-Way ANOVA Measure of Association (Eta)	Nutritional Education Status vs. Standardized Composite Metabolic Index (z-score standardized HbA1c [%] & Body Weight [kg])	$\eta = 0.669$	$\eta^2 = 0.447$ (44.7% variance; Large effect size)	p < 0.001*

*Note. r = Pearson correlation coefficient; r^2 = coefficient of determination; η = Eta association coefficient; η^2 = Eta-squared (proportion of total variance explained, SS_between / SS_total). Effect size interpretations follow Cohen's benchmarks (r ≥ 0.30 moderate; $\eta^2 \geq 0.14$ large). *Derived from omnibus F-distribution test for Eta-squared. Prior to composite ANOVA modeling, individual clinical metrics (HbA1c in % and body weight in kg) underwent mathematical z-score standardization ($z = [X - \mu] / \sigma$) to eliminate dimensional scale discrepancies; the composite index was calculated as the mean of the standardized scores ([Z_HbA1c + Z_weight] / 2).*

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Discussion

Sociodemographic Vulnerability and Baseline Health Literacy

The demographic architecture of the Misrata T2DM cohort (N = 200) reflects a predominantly older population, with 68.0% aged >50 years and 93.0% aged >40 years. This age distribution aligns with global epidemiological trajectories identifying advancing age as a primary non-modifiable determinant of T2DM, mediated by age-related visceral adiposity, progressive sarcopenia, declining mitochondrial oxidative capacity in skeletal muscle, and cumulative β-cell senescence [1,3]. The balanced representation of females (52.0%) and males (48.0%)minimises sex-related sampling bias and enhances the generalizability of our behavioural findings across both sexes within the regional outpatient setting, while recognising that cardiometabolic risk profiles and health-seeking behaviours exhibit sex-specific nuances [2]. Although 61.0% of the participants had completed at least secondary or university education, nearly two-fifths of the cohort had either no formal schooling (21.5%) or only basic primary education (17.5%). In chronic metabolic disease management, formal educational attainment serves as a critical proxy for functional and interactive health literacy [12]. Patients with higher educational attainment generally possess stronger numeracy and reading skills required to synthesise multi-step dietary prescriptions, estimate carbohydrate loads, and navigate healthcare systems. Conversely, the 21.5% subgroup with limited literacy represents a clinically vulnerable population. Seminal clinical studies demonstrate that inadequate health literacy is independently associated with poorer glycemic control (higher HbA1c), nearly double the odds of diabetic retinopathy, and elevated emergency department utilisation [13]. Consequently, outpatient nutrition programs in Libya cannot rely solely on text-heavy pamphlets; rather, they must incorporate visual, culturally adapted, low-literacy teaching modalities—such as colour-coded traffic-light food charts and physical plate-method models—to ensure equitable therapeutic comprehension.

Disease Duration and the Paradox of High Clinical Compliance Versus Poor Glycemic Control

Over half of the studied cohort (58.0%) had lived with T2DM for more than five years, and 90.0% had a disease duration of at least one year. As demonstrated by the United Kingdom Prospective Diabetes Study (UKPDS 49), long-standing T2DM is characterised by a progressive decline in endogenous β-cell secretory capacity, wherein dietary monotherapy or single-agent oral pharmacotherapy fails in the majority of patients within three to nine years, necessitating treatment intensification to combination regimens or exogenous insulin [14]. Furthermore, prolonged disease duration frequently precipitates 'diabetes distress' or burnout—a state of emotional exhaustion caused by the unrelenting daily behavioural demands of disease management [15]. A striking finding of the present study is the paradox between exceptionally high adherence to conventional medical routines and persistent hyperglycemia. Specifically, 87.5% of patients attended monthly physician visits, 90.5% reported consistent medication adherence, 82.0% performed routine home SMBG, and 97.0%recognised acute hypo- and hyperglycemic symptoms. Yet, objective clinical assessments indicated widespread chronic hyperglycemia across the sample. This discrepancy underscores a fundamental physiological and clinical principle: pharmacological compliance and routine biochemical monitoring, when divorced from actionable nutritional self-management, are insufficient to achieve euglycemia. As demonstrated in the Structured Testing Program (STeP) trial, home SMBG functions strictly as an informational diagnostic tool; it confers significant HbA1c reductions only when patients and clinicians actively use glucose readings to adjust dietary carbohydrate intake, meal timing, or medication dosages [16]. When patients dutifully ingest oral hypoglycemic agents but continue consuming high-glycemic-load meals, postprandial glucose excursions repeatedly overwhelm pharmacological capacity.

The Conceptual-to-Functional Literacy Gap: Glycemic Index and Food Labels

Our data reveal a sharp divergence between superficial conceptual awareness and applied functional nutritional literacy. While 86.5% of participants reported prior nutritional counselling and 95.0%–96.5% affirmed abstract truisms (such as the benefits of dietary fibre, whole grains, and portion control), 83.5% lacked any comprehension of the Glycemic Index (GI), and 71.5% never read nutrition labels on food packaging. Similarly, although 97.0% understood acute symptom recognition—reflecting effective 'survival-skill'counselling during medical visits—this defensive awareness did not translate into proactive daily food-navigation skills [11]. This functional literacy gap creates a major barrier in modern retail and domestic food environments. A patient may understand theoretically that 'excess carbohydrates elevate blood glucose,' yet without the ability to inspect a Nutrition Facts panel to evaluate total carbohydrates, dietary fibre, and hidden added sugars per serving, they remain vulnerable to misleading front-of-package health claims [17]. Likewise, unfamiliarity with the GI prevents patients from distinguishing between rapidly digested, high-GI carbohydrates that provoke steep postprandial insulin and glucose spikes—such as refined white bread, white rice, and traditional Libyan semolina/flour-based dishes (e.g., Bazin or Couscous)—and slowly absorbed, low-GI alternatives such as whole barley (Shaeer), legumes, lentils, and intact whole grains. Meta-analytic evidence from randomised controlled trials confirms that substituting high-GI staples with low-GI diets significantly reduces HbA1c (by an average of 0.43 percentage points) and fructosamine levels over and above total carbohydrate counting alone [18].

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Meal Frequency, Dietary Habits, and Statistical Impact on Metabolic Outcomes

Evaluation of daily dietary habits showed encouraging adherence to certain protective behaviours, including high daily vegetable intake (88.0%) and widespread avoidance of sugar-sweetened beverages (87.0% never or rarely consuming them). However, two behavioural patterns warrant targeted clinical intervention. First, 65.0% of the cohort consumed only one (4.5%) or two (60.5%) meals per day. Consolidating daily caloric and carbohydrate requirements into two large meals—separated by prolonged daytime fasting intervals—induces pronounced postprandial glycemic surges and places an acute secretory burden on compromised pancreatic β-cells. Classical metabolic studies demonstrate that distributing isocaloric nutrient intake across smaller, more frequent meals ('nibbling' rather than 'gorging') attenuates peak postprandial plasma glucose, reduces mean diurnal insulin concentrations, and improves lipid profiles [19]. Second, while 89.0% of participants consumed fresh fruits daily or weekly, unguided fruit consumption in Libya frequently includes high-GI, sugar-dense regional varieties (such as ripe dates, figs, grapes, and watermelon), necessitating precise education on portion control (carbohydrate exchanges) and pairing fruit with protein or fibre. Crucially, our inferential analyses confirm that structured nutritional education is not merely an ancillary support service, but a primary determinant of behavioural and metabolic success. Nutritional education correlated positively with dietary adherence ($r = 0.381$, $p < 0.001$, explaining 14.5% of behavioural variance) and exhibited a large effect size in relation to composite metabolic health outcomes, accounting for 44.7% of the variance across mathematically standardized (z-score normalized) HbA1c and body weight profiles ($\eta = 0.669$, $\eta^2 = 0.447$, $p < 0.001$). Applying z-score standardization resolves the dimensional discrepancies inherent to combining biochemical percentages (%) and anthropometric kilograms (kg), providing a robust, scale-independent metric of overall metabolic health. These findings reinforce international clinical consensus that structured Medical Nutrition Therapy delivered by registered dietitians yields HbA1c reductions of 1.0% to 2.0% in T2DM—an efficacy comparable to adding a new pharmacological agent [10,11]—especially when combined with regular physical activity, which independently stimulates insulin-independent GLUT4 translocation and glucose uptake in skeletal muscle [20].

Study Strengths and Methodological Limitations

This study provides timely, primary clinical data addressing the intersection of nutritional literacy and metabolic control among T2DM outpatients in Misrata, Libya, supported by personalised face-to-face interviews and rigorous statistical effect-size estimation. Nevertheless, several methodological limitations should be considered when interpreting the findings. First, the cross-sectional design captures associations at a single time point and precludes definitive causal inference regarding temporal trajectories in HbA1c or weight reduction. Second, because participants were recruited from hospital-based outpatient clinics, the cohort may overrepresent patients with longer disease duration and higher medical compliance compared to undiagnosed or community-dwelling individuals who do not attend regular follow-up. Third, dietary intake and medication adherence were assessed via structured self-report, which may be subject to recall and social desirability biases. Future longitudinal and randomised controlled intervention trials incorporating 24-hour dietary recalls and serial HbA1c tracking are warranted to evaluate culturally adapted MNT protocols in Libya.

Conclusion and Clinical Recommendations

Outpatients with Type 2 Diabetes Mellitus at Misurata Medical Centre exhibit high compliance with monthly physician appointments, antihyperglycemic medication regimens, and routine blood glucose self-monitoring, yet suffer from pervasive deficits in functional nutritional literacy. While general awareness of healthy eating is widespread, the inability of 83.5% of patients to comprehend the Glycemic Index and 71.5% to read food nutrition labels—compounded by restricted meal frequencies (65.0% consuming one or two meals daily)—undermines daily glycemic stability. Because nutritional education significantly predicts dietary adherence ($r = 0.381$, $p < 0.001$) and explains 44.7% of the variance in standardized composite metabolic outcomes (z-score standardized HbA1c and body weight; $\eta^2 = 0.447$), diabetes care in Libya must transition from brief, didactic advice to structured, skill-based nutritional coaching. To bridge this clinical-behavioural gap, three actionable clinical policy recommendations are proposed:

Culturally Tailored Visual Glycemic Index Guides

Develop illustrated, low-literacy educational charts classifying traditional Libyan foods and local fruits (e.g., contrasting refined wheat/semolina staples and ripe dates against whole barley [Shaeer], legumes, and low-GI vegetables/fruits) to empower patients across all educational strata.

Practical Skill Training in Label Reading and Meal Spacing

Replace generic dietary warnings with hands-on outpatient workshops teaching carbohydrate counting, Nutrition Facts label interpretation, and the physiological benefits of distributing carbohydrate intake across three balanced meals rather than two large meals.

Multidisciplinary Outpatient Integration

Formally integrate certified therapeutic nutritionists and diabetes educators into internal medicine follow-up clinics at Misrata Medical Centre so that individualised Medical Nutrition Therapy (MNT) is delivered routinely alongside pharmacological management.

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Declarations

Ethics Approval and Consent to Participate

This study was approved by the Research Ethics Committee of the Faculty of Health Sciences, Misurata University, Libya. Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

The authors declare no conflicts of interest related to this research.

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Data Availability Statement

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

References

1. Goyal R, Singhal M, Jialal I. Type 2 diabetes. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2026 Jun 15]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK513253/
2. Regensteiner JG, Golden S, Huebschmann AG, Barrett-Connor E, Chang AY, Chyun D, et al. Sex differences in the cardiovascular consequences of diabetes mellitus: a scientific statement from the American Heart Association. Circulation. 2015;132(25):2424-47. doi:10.1161/CIR.0000000000000343
3. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047-53. doi:10.2337/diacare.27.5.1047
4. Taylor R. Pathogenesis of type 2 diabetes: tracing the reverse route from cure to cause. Diabetologia. 2008;51(10):1781-9. doi:10.1007/s00125-008-1116-0
5. Taylor R. Type 2 diabetes: etiology and reversibility. Diabetes Care. 2013;36(4):1047-55. doi:10.2337/dc12-1805
6. Iacobini C, Pugliese G, Blasetti Fantauzzi C, Federici M, Menini S. Metabolically healthy versus metabolically unhealthy obesity. Metabolism. 2019;92:51-60. doi:10.1016/j.metabol.2018.11.009
7. Artasensi A, Mazzolari A, Pedretti A, Vistoli G, Fumagalli L. Obesity and type 2 diabetes: adiposopathy as a triggering factor and therapeutic options. Molecules. 2023;28(7):3094. doi:10.3390/molecules28073094
8. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med. 2002;346(6):393-403. doi:10.1056/NEJMoa012512
9. Wing RR. Looking back and forward from the Diabetes Prevention Program (DPP): a commentary on the importance of research aimed at intervention optimization. Health Psychol. 2021;40(12):1009-16. doi:10.1037/hea0001121
10. Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson JL, Garg A, et al. Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. Diabetes Care. 2002;25(1):148-98. doi:10.2337/diacare.25.1.148
11. Powers MA, Bardsley J, Cypress M, Duker P, Funnell MM, Fischl AH, et al. Diabetes self-management education and support in type 2 diabetes: a joint position statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. Diabetes Care. 2015;38(7):1372-82. doi:10.2337/dc15-0730
12. Nutbeam D. The evolving concept of health literacy. Soc Sci Med. 2008;67(12):2072-8. doi:10.1016/j.socscimed.2008.09.050
13. Schillinger D, Grumbach K, Piette J, Wang F, Osmond D, Daher C, et al. Association of health literacy with diabetes outcomes. JAMA. 2002;288(4):475-82. doi:10.1001/jama.288.4.475
14. Turner RC, Cull CA, Frighi V, Holman RR. Glycemic control with diet, sulfonylurea, metformin, or insulin in patients with type 2 diabetes mellitus: progressive requirement for multiple therapies (UKPDS 49). JAMA. 1999;281(21):2005-12. doi:10.1001/jama.281.21.2005
15. Polonsky WH, Anderson BJ, Lohrer PA, Welch G, Jacobson AM, Aponte JE, et al. Assessment of diabetes-related distress. Diabetes Care. 2005;28(3):626-31. doi:10.2337/diacare.28.3.626
16. Polonsky WH, Fisher L, Schikman CH, Hinnen DA, Parkin CG, Jelsovsky Z, et al. Structured self-monitoring of blood glucose significantly reduces A1C levels in poorly controlled, noninsulin-treated type 2 diabetes: results from the Structured Testing Program study. Diabetes Care. 2011;34(2):262-7. doi:10.2337/dc10-1732
17. Miller DL, Castellanos VH, Shide DJ, Peters JC, Rolls BJ. Effect of fat-free potato chips and nutritional labels on fat and energy intakes at a subsequent meal. J Am Diet Assoc. 1992;92(9):1051-7.
18. Brand-Miller J, Hayne S, Petocz P, Colagiuri S. Low-glycemic index diets in the management of diabetes: a meta-analysis of randomized controlled trials. Diabetes Care. 2003;26(8):2261-7. doi:10.2337/diacare.26.8.2261
19. Jenkins DJ, Wolever TM, Vuksan V, Brighenti F, Cunnane SC, Rao AV, et al. Nibbling versus gorging: metabolic effects of increased meal frequency in healthy subjects. N Engl J Med. 1989;321(14):929-34. doi:10.1056/NEJM198910053211403
20. Kennedy JW, Hirshman MF, Gervino EV, Ocel JV, Forse RA, Hoenig SJ, et al. Acute exercise induces GLUT4 translocation in skeletal muscle of normal human subjects and subjects with type 2 diabetes. Diabetes. 1999;48(5):1192-7. doi:10.2337/diabetes.48.5.1192

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