Curcumin and massage therapy as adjuvant therapies: effects on clinical and patient-reported outcomes in type 2 diabetes

La curcumina y la terapia de masajes como terapias adyuvantes: efectos sobre los resultados clínicos y los resultados comunicados por los pacientes en la diabetes tipo 2

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Abstract

Introduction: Managing type 2 diabetes mellitus (T2DM) requires lifelong pharmacological therapy and lifestyle modification to maintain metabolic control and quality of life. Complementary strategies such as herbal and physical therapies have gained attention. Curcumin, a bioactive component of Curcuma longa, exhibits antidiabetic, anti-inflammatory, and antioxidant effects. Meanwhile, massage therapy enhances circulation, lessens stress, and reduces diabetes-related symptoms.

Objective : This study investigates the effects of curcumin supplementation and massage therapy as adjuvant therapies. focusing on inflammatory markers, metabolic control, and quality of life.

Methodology: This quasi-experimental study used a three-arm pretest-posttest design involving 30 participants with T2DM, divided equally into three groups: massage therapy, curcumin (100 mg/day), and a combined intervention. All participants continued their routine antidiabetic medications. Pre- and post-intervention outcomes included C-reactive protein (CRP), fasting plasma glucose (FPG), and quality of life (Asian DQOL questionnaire). Data were analyzed using paired tests and Kruskal-Wallis comparisons.

Results: All groups showed improvements in inflammatory, metabolic, and quality-of-life outcomes. The combination group demonstrated a statistically significant reduction in FBG (−7.4 mg/dL) and the highest improvement in DQOL score (+2.2 points). CRP levels decreased by −0.4 mg/L in the combination group, −0.9 mg/L in the massage group, and −1.2 mg/L in the curcumin group, though these changes were not statistically significant.

Conclusions: Curcumin supplementation and massage therapy are well-tolerated adjuvant interventions that enhance metabolic control and patient-reported outcomes in T2DM. Their integration into the therapeutic approach is promising and warrants further evaluation in larger studies.

Keywords

C-reactive protein; curcumin; diabetes mellitus type 2; massage; quality of life

Resumen

Introducción: El tratamiento de la diabetes mellitus tipo 2 (DM2) requiere terapia farmacológica de por vida y modificaciones en el estilo de vida para mantener el control metabólico y la calidad de vida. La curcumina, componente bioactivo de la Curcuma longa, tiene efectos antidiabéticos, antiinflamatorios y antioxidantes, mientras que la terapia de masajes mejora la circulación, disminuye el estrés y reduce síntomas relacionados con la diabetes.

Objetivo: Este estudio investiga los efectos de ambas intervenciones como terapias adyuvantes en la DM2, con foco en marcadores inflamatorios, control metabólico y calidad de vida.

Metodología: Estudio cuasi-experimental con diseño de tres brazos y prueba previa-posterior, con 30 participantes con DM2 divididos en tres grupos: masajes, curcumina (100 mg/día) e intervención combinada. Todos continuaron su medicación antidiabética habitual. Los desenlaces evaluados fueron proteína C reactiva (PCR), glucosa plasmática en ayunas (FPG) y calidad de vida (cuestionario DQOL asiático), analizados con pruebas pareadas y comparaciones de Kruskal-Wallis.

Resultados: Todos los grupos mostraron mejoras en resultados inflamatorios, metabólicos y de calidad de vida. El grupo combinado presentó la mayor reducción en FPG (−7,4 mg/dL) y la mayor mejora en DQOL (+2,2 puntos). Los niveles de PCR disminuyeron en −0,4 mg/L, −0,9 mg/L y −1,2 mg/L en los grupos combinado, masaje y curcumina, sin alcanzar significancia estadística.

Conclusiones: La suplementación con curcumina y la terapia de masaje son intervenciones adyuvantes bien toleradas que mejoran el control metabólico y los resultados comunicados por los pacientes con DM2. Su integración en el enfoque terapéutico es prometedora y merece evaluación en estudios más amplios.

Palabras clave

Calidad de vida, Curcumina, Diabetes mellitus tipo 2, masaje, proteína C reactiva.

Introduction

According to the International Diabetes Federation (IDF), approximately 537 million people worldwide had diabetes in 2021. This number is expected to increase to 634 million by 2030 and reach 783 million by 2045. SDG 3.4 targets reducing premature mortality from noncommunicable diseases by one-third through prevention and treatment by 2030 and promoting mental health and well-being (Magliano et al., 2021). In Indonesia, the WHO predicts that the number of people with type 2 diabetes could reach 21.3 million by 2030. The 2018 data show that the prevalence of diabetes in Indonesia is 2% among the population aged 15 years and older, with a continuing upward trend as people age (Kementerian Kesehatan Republik Indonesia, 2020). Type 2 diabetes mellitus (T2DM) can manifest into many complications, including macrovascular complications (coronary heart disease, stroke, and peripheral vascular disease) and microvascular complications (nephropathy, retinopathy, and neuropathy). Common clinical symptoms include polyuria, polydipsia, polyphagia, weight loss, weakness, tingling, itching, blurred vision, and sexual dysfunction (Adi, 2019; Harding et al., 2019). The management of type 2 diabetes aims to improve the patient's quality of life by alleviating symptoms and reducing the risk of complications. It includes lifestyle modifications (nutrition and physical activity) and pharmacological therapy with antihyperglycemic drugs, either singly or in combination (Adi, 2019; Made, 2021).

In addition to conventional therapies, herbal medicines are increasingly popular as complementary and alternative treatments. Global herbal medicine use reaches 20–28%, and according to the Health Research, 59.12% of households still use herbal medicines in Indonesia ((Lau & Sunarti, 2018); Utomo et al., 2022). The general public believes that herbal medicine has lower side effects, is affordable, easier to access, and is culturally acceptable. In managing type 2 diabetes, herbal medicine generally works through anti-inflammatory, antioxidant, lipid-regulating, and antiglycemic mechanisms (Pang et al., 2019; Utomo et al., 2022). Curcuma longa (turmeric) is widely used as an adjunctive therapy for diabetes patients. A study in Indonesia showed that 22% of type 2 diabetes patients used herbal remedies, including turmeric, because they were considered safer and more affordable (Utomo et al., 2022). Curcumin, turmeric's main active compound, has antioxidant, anti-inflammatory, and antidiabetic properties (Bafirman et al., 2024). Clinical studies have shown that curcumin can lower blood glucose levels, improve lipid profiles, and reduce inflammatory markers such as high-sensitivity C-reactive protein (hs-CRP) (Adibian et al., 2019; Sharifi-Rad et al., 2020). The effect is believed to suppress hyperglycemia, oxidative stress, and inflammation associated with diabetes mellitus, thereby potentially preventing the progression of systemic complications such as hypertension, dyslipidemia, neuropathy, nephropathy, and endothelial dysfunction (Marton et al., 2021; Anugrah et al, 2024). In addition, curcumin is considered safe for therapeutic doses. The FDA has designated it a Generally Recognized As Safe (GRAS), making it an ideal candidate for complementary therapy in managing type 2 DM (Sharifi-Rad et al., 2020).

In addition to herbal medicine, massage therapy has long been recognized as a safe and effective non-pharmacological method for improving health status and quality of life. Massage therapy reduces stress, improves blood circulation, and enhances sleep quality in patients with chronic diseases, including diabetes (Bafirman et al., 2024; Arias Padilla et al., 2026). Several types of massage that have been studied include tactile, connective tissue, and Chinese (Bayat, 2019). Previous studies have indicated that one motivation for individuals seeking complementary therapies, including massage, is to manage musculoskeletal disorders and chronic pain-related conditions (Arias Padilla et al., 2026). These therapies are often used alongside established medical treatments, with symptom relief being a frequently reported reason (Waters-Banker et al., 2014).

Previous research has examined curcumin or massage therapy independently. This research systematically evaluates the effectiveness of a combination of curcumin supplements and massage therapy on inflammatory markers (such as C-reactive protein), glycemic control (FBG), and quality of life in patients with type 2 diabetes mellitus (type 2 DM). Although both interventions are widely known and traditionally used by Indonesians, they lack scientific evidence in medical practice. Furthermore, no studies have specifically examined changes in biomarkers such as CRP and standardized quality of life indicators such as the Asian Diabetes Quality of Life (Asian DQOL) within a single integrated intervention protocol.

Therefore, this study is the first to explore the synergistic potential of curcumin and massage therapy in managing type 2 DM. This research will fill this gap in scientific evidence and contribute to developing

evidence-based, affordable, culturally relevant, and applicable complementary therapy approaches in primary healthcare.

Method

This research is a quantitative study with a quasi-experimental approach. This method was chosen to measure changes before and after treatment in a structured and measurable manner in a group of subjects. It was conducted at the Semarang State University Health Service Center, specifically at the Chronic Disease Management Program activity held from June to August 2025.

Study Design

The design used in this study was a pretest-posttest with three treatment groups (non-randomized three-arm design). The three groups consisted of Group M, which received only massage therapy; Group C, which received only curcumin supplements; and Group MC, which received a combination of curcumin supplements and massage therapy. Each participant will be assessed at the beginning of the intervention (pretest) and at the end (posttest) after 4 weeks. The results from each group will be compared to determine the effect of each treatment form on the dependent variable being studied.

Sample and Population

This study targeted patients with type 2 diabetes mellitus participating in the Chronic Disease Management program at the Semarang State University Health Service Center. The accessible population consisted of patients with type 2 diabetes who were present in the screening activities on June 19, 2025, and met the specified inclusion and exclusion criteria. The sampling technique used was purposive sampling. It involved selecting subjects who met the study criteria based on their clinical characteristics and willingness to participate in the full four-week intervention.

This study was designed as an exploratory intervention study with three treatment groups comprising 10 subjects. The selection of 10 subjects per group was made considering several practical and methodological aspects. References from Previous Studies by Bayat et al. (2019), which reviewed 12 RCTs related to massage therapy in diabetes patients, showed that several previous studies used small sample sizes, namely 10–12 subjects per group, particularly in initial exploratory or pilot studies. Although there are studies with larger sample sizes, using 10 subjects per group is still considered appropriate for evaluating pre-post changes in a homogeneous group. This sample size was determined by considering resource limitations, including time, personnel, and costs, as well as the space capacity and schedule of massage therapy services. This number was realistic and accessible to the research team to provide intensive care. This study aims to test the feasibility and potential effectiveness of a combination of curcumin supplementation and massage therapy on immune parameters and quality of life as exploratory purpose and preliminary study of combination therapy. This design focused on observing trends in early biological and functional changes, rather than estimating population-wide effects. Therefore, a sample size of 10 individuals per group is representative enough to identify clinically meaningful differences on a small scale.

Subjects eligible for this study must meet all inclusion criteria, including patients diagnosed with type 2 diabetes mellitus, based on medical examination results or previous diagnosis history. Aged 40–65 years, in accordance with the dominant population and the target age group of the intervention. Registered as Chronic Disease Management program participants at the Semarang State University Health Service Center. In a stable clinical condition, not experiencing acute infections or acute complications of DM. Not consuming anti-inflammatory supplements or other herbs regularly for the past 1 month. Willing to participate in the entire series of interventions and measurements, and sign an informed consent. Subjects will be excluded in the study if they meet any exclusion criteria: having a history of allergy or hypersensitivity to turmeric (Curcuma longa) or components in curcumin supplements, having contraindications for massage therapy, such as open skin disorders, active bleeding, fractures, or severe vascular disorders and currently undergoing intensive insulin therapy or newly modified DM treatment in the past 1 month, having severe comorbidities such as end-stage renal failure, decompensated heart disease, active cancer, or severe mental illness, not being able to read or write fluently in Indonesian

(preventing completion of the questionnaire). Not willing to participate in the full intervention or potentially dropping out during the study period (e.g., due to an inflexible schedule).

Research Variable

In this study, the variables studied were divided into independent, dependent, and control variables. The independent variable in this study consisted of three groups: curcumin supplementation, massage therapy, and a combination of curcumin supplementation and massage therapy. The dependent variable was the outcome assessed to determine the effect of each intervention, including C-Reactive Protein (CRP) levels as a marker of systemic inflammation, fasting blood glucose (FBG) as a parameter of daily glycemic control, and a quality of life score based on the results of completing the Asian Diabetes Quality of Life (Asian DQOL) questionnaire. Several factors were controlled or recorded to minimize bias as control variables, including stable DM treatment status for ≥1 month and adherence to the intervention (monitored with a compliance sheet).

Research Instrument

The instruments used in this study consisted of objective laboratory measuring instruments, standardized questionnaires, and monitoring sheets to support data accuracy. Laboratory examinations to assess changes in inflammatory and metabolic biomarkers used laboratory instruments, namely quantitative CRP (C-Reactive Protein) levels, which were examined using the immunoturbidimetric method in the laboratory. Fasting Blood Glucose (FBG) was analyzed using the enzymatic glucose oxidase method. The Quality of Life Questionnaire (Asian DQOL), a validated Indonesian version, was used to measure the quality of life of the subjects. This questionnaire covers several domains: Diet and food satisfaction, Energy and activity, Memory and cognition, Financial aspects, and Interpersonal and sexual relationships.(Goh, Rusli and Khalid, 2015; Permana, Liem and Soetedjo, 2021) The total score ranges from 0 to 100, where a higher score indicates a better quality of life. Observation and Monitoring Sheets to document the implementation of the intervention and subject compliance, used daily monitoring sheets, which recorded the consumption of curcumin supplements (date and time of taking), schedule and attendance of massage therapy, complaints or side effects experienced, and subject compliance during the intervention period (4 weeks).

Data Collection

Data collection in this study was conducted through several structured stages, from recruitment to post-intervention. Subjects who passed the screening were divided into three intervention groups:

1. Group M – received massage therapy alone

2. Group C – received curcumin supplement alone

3. Group MC – received a combination of massage therapy and curcumin supplementation

Subjects who met the criteria underwent a pretest phase, completing the Indonesian version of the Asian DQOL questionnaire and taking blood samples for quantitative CRP (C-Reactive Protein) and FBG (Fasting Blood Glucose) measurements.

Curcumin supplements were administered at the rate of one capsule daily, taken after meals, for four whole weeks. The active ingredient is curcumin (diferuloylmethane), derived from Curcuma longa extract. The supplement capsules are 100 mg and are administered orally. The duration of administration was 28 consecutive days (4 weeks). The consumption time was after breakfast or lunch to minimize gastrointestinal irritation. The supplement product selection was made considering the Indonesian National Agency of Drug and Food Control (BPOM) certification, local availability, and the pure composition of curcumin without strong additives.

Therapists performed standardized relaxation and circulation-enhancing (light and medium) massage techniques. Massage locations included the back, legs, and arms (avoiding areas of injury or risk of trauma). Sessions lasted approximately 30 minutes, twice a week, for 4 weeks (8 sessions). Trained massage therapists from the Faculty of Sport Sciences, Semarang State University, performed the massages.

Researchers monitored compliance and side effects through visits or online monitoring. Subjects could withdraw without consequence if there were any complaints or conditions requiring discontinuation of

the intervention. After four weeks of the intervention, subjects underwent laboratory tests and completed a posttest questionnaire. The research team verified the data before proceeding to the statistical analysis stage.

Data Analysis

The data in this study were analyzed quantitatively using SPSS (Statistical Package for the Social Sciences) software. The analysis phases were carried out in stages, from data examination to hypothesis testing. Descriptive analysis was used to describe the characteristics of the research subjects and the measurement data. Normality tests for the dependent variable used Shapiro-Wilk. The Wilcoxon and paired T-tests assessed changes before and after the intervention in each group. The Intergroup Comparative Test was used to compare the effectiveness of the three intervention groups using the Kruskal-Wallis test. All tests were conducted at a significance level (α) = 0.05; results were declared statistically significant if $p < 0.05$.

Results

Subject Characteristic

This study recruited 30 type 2 diabetes mellitus patients from the Chronic Disease Management Program at the Semarang State University Health Service Center who met the predetermined inclusion and exclusion criteria. Three participants were excluded from the final analysis during the study, two were excluded due to non-compliance with the intervention protocol, and one was excluded due to a health condition that could affect laboratory test results. Thus, 27 study subjects met the criteria for data analysis.

Table 1 presents the characteristics of the study participants. The study subjects had an average age of 59, with the youngest age group being the massage + curcumin group (mean 56.44 years). The average duration of diabetes was 5-7 years. The subjects' initial average CRP level was 3.9 mg/L, the average initial FBG level was 140.7 mg/dL, and the average initial ADQOL score was 89.37.

Table 1. Subject Characteristic

Group	n	Male	Female	Age (years) (Mean±SD)	DM Duration (years) (Mean±SD)	CRP Baseline (mg/dl) (Mean±SD)	FBG Baseline (mg/dL) (Mean±SD)	DQOL Score (Mean±SD)
Massage	9	4	5	60.0 ± 10.81	7.14 ± 6.42	3.71 ± 5.13	150.89 ± 59.95	89.56 ± 2.7
Curcumin	9	3	6	61.33 ± 5.59	6.11 ± 4.57	4.24 ± 3.17	150.22 ± 64.37	88.22 ± 6.51
Massage + Curcumin	9	3	6	56.44 ± 8.35	5.67 ± 8.15	3.77 ± 2.78	121.22 ± 24.52	90.33 ± 4.69

C-Reactive Protein

All three groups showed a decrease in mean CRP levels, a marker of systemic inflammation, after 4 weeks of intervention. The most significant level decrease occurred in group C (curcumin supplementation only) at -1.256 mg/L, followed by group M (-0.911 mg/L), and group MC (-0.456 mg/L). Based on statistical tests, none of the groups showed a statistically significant decrease. The decrease in the supplementation group hovered at significance, indicating a trend toward anti-inflammatory effects of curcumin. CRP data analysis is presented in Table 2.

Table 2. CRP Data Analysis

Group	n	CRP Pretest (mean) mg/L	CRP Posttest (mean) mg/L	Δ CRP (mg/L)	Normality	p
Massage	9	3.711	2.8	-0.911	0.022	0.208[a]
Curcumin	9	4.244	2.989	-1.256	0.233	0.073[b]
Massage + Curcumin	9	3.767	3.311	-0.456	0.732	0.238[b]

[a] Analyzed using Wilcoxon test
[b] Analyzed using Paired t-test
*Statistically significant at p=0.05

Fasting Blood Glucose

The analysis showed that all three intervention groups experienced a decrease in fasting blood glucose (FBG) levels after four weeks of treatment. The massage therapy group (M) showed the highest average decline in FBG of 13.89 mg/dL, followed by the curcumin supplement group (C) at 12.78 mg/dL, and the combination group (MC) at 7.44 mg/dL. However, based on paired statistical tests, only the combination group (MC) experienced a statistically significant reduction in FBG. In contrast, the M group and the C group did not show significance. FBG data analysis is presented in **Table 3**.

These results strengthen the evidence that curcumin and massage therapy, when combined, are more statistically effective in reducing fasting blood glucose levels in patients with type 2 diabetes.

Table 3. FBG Data Analysis

Group	n	FBG Pretest (mean) mg/dL	FBG Posttest (mean) mg/dL	Δ FBG (mg/dL)	Normality	p
Massage	9	150.89	137.0	-13.89	0.208	0.062[b]
Curcumin	9	150.22	137.44	-12.78	0.027	0.291[a]
Massage + Curcumin	9	121.22	113.78	-7.44	0.134	0.011[b*]

[a] Analyzed using Wilcoxon test
[b] Analyzed using Paired *t*-test
*Statistically significant at p=0.05

Quality of life (Asian DQOL)

Analysis of quality of life scores based on the Diabetes Quality of Life (DQOL) questionnaire showed an increase in the mean score in all three intervention groups. In the combination group (MC), the mean DQOL score increased from 90.33 to 92.56, with a difference (Δ) of 2.22 points. The massage therapy group (M) experienced an increase from 89.56 to 91.56 (Δ = 2.00), while the curcumin supplement group (C) increased from 88.22 to 89.67 (Δ = 1.44). Statistical tests showed that all three groups experienced statistically significant improvements in DQOL scores (Massage: p=0.017; Curcumin: p=0.032; Combination: p=0.023). The improvement in quality of life scores across all groups reflects the intervention's positive impact on subjective aspects of patient perception. DQOL data analysis is presented in Table 4.

Table 4. ADQOL Data Analysis

Group	n	ADQOL Pretest	ADQOL Posttest	Δ ADQOL	Normality	p
Massage	9	89.56	91.56	2.0	0.134	0.017[b*]
Curcumin	9	88.22	89.67	1.44	0.011	0.032[a*]
Massage + Curcumin	9	90.33	92.56	2.22	0.02	0.023[a*]

[a] Analyzed using Wilcoxon test
[b] Analyzed using Paired *t*-test
*Statistically significant at p=0.05

Multivariate Analysis

The analysis shows that no statistically significant differences were found in changes in CRP levels, FBG, or DQOL scores between the three intervention groups. However, there was a trend toward the highest average improvement in the Supplement group for CRP (mean ΔCRP −1.26), in the Massage group for FBG (mean ΔFBG −13.89), and in the M+C (combination) group for DQOL (mean ΔDQOL +2.22).

These results support the minor hypothesis that each single intervention exhibits a positive effect, although there were no significant differences between the groups. The lack of significance is likely due to the small sample size (n=9 per group). Multivariate data analysis is presented in Table 5.

Table 5. Multivariate Data Analysis

Variable	Group	n	Mean Rank	p-value
Δ CRP	M+C	9	15.44	0.681
	M	9	14.33	
	C	9	12.22	
Δ FBG	M+C	9	14.56	0.966
	M	9	13.83	
	C	9	13.61	
Δ DQOL	M+C	9	14.78	0.715
	M	9	14.94	
	C	9	12.28	

[a] Analyzed using Kruskal Wallis test
*Statistically significant at p=0.05

Secondary findings and safety

This study found no reports of side effects related to supplementation and massage therapy.

Discussion

This study shows that curcumin supplementation, massage therapy, or a combination of both interventions improved inflammatory parameters (CRP), glycemic control (FBG), and quality of life in patients with type 2 diabetes mellitus (T2DM). Although multivariate testing did not find significant differences between groups, there was a trend that curcumin provided the most significant reduction in CRP, massage had a greater reduction in FBG, and the combination resulted in the highest improvement in quality of life scores. These results are consistent with the literature suggesting that curcumin and massage therapy have complementary physiological mechanisms to reduce chronic inflammation and improve glucose metabolism.

Curcuminoids, especially curcumin derived from Curcuma longa, have potent anti-inflammatory effects by inhibiting NF-κB activation and reducing pro-inflammatory cytokines such as TNF-α and IL-6.(Alanazi *et al.*, 2022 ; Bafirman et al., 2024) Curcumin also activates the Nrf2 pathway, which increases the production of antioxidant enzymes (superoxide dismutase (SOD), catalase, glutathione peroxidase (GPx)), thereby reducing oxidative stress, which is the basis of chronic inflammation in type 2 diabetes (Fatony *et al,* 2021; Anugrah *et al,* 2024) A meta-analysis by Fatony et al. involving 14 randomized controlled trials showed that Curcuma longa extract significantly reduced fasting blood glucose levels (SMD −0.48) and HbA1c (SMD −0.40) in patients with type 2 diabetes (Fatony *et al,* 2021). Thus, the findings of this study show a trend of decreasing CRP and FBG in the curcumin group, which is consistent with the underlying mechanisms that have been clinically proven.

Furthermore, *in vitro* studies have shown that curcumin increases the translocation of GLUT1, GLUT3, and GLUT4, which facilitates glucose uptake in skeletal muscle, heart, liver, and pancreas, and acts as an insulin-like compound (Alanazi *et al.*, 2022). This effect improves insulin resistance, optimizes peripheral glucose utilization, and supports pancreatic β-cell function. This combination of reduced inflammation and improved glucose metabolism impacts clinical symptoms such as reduced fatigue, neuropathy, and the risk of vascular complications, which is reflected in improved quality of life scores in subjects (Permana, Liem and Soetedjo, 2021).

Compared with the study's actual results, the effect's direction aligns with the above mechanism. The curcumin group showed the most significant reduction in CRP (−1.256 mg/L) for inflammatory markers. It approached significance, indicating a trend toward a clinically relevant anti-inflammatory effect, although the small sample size may limit statistical significance. For glycemic control, all three groups had similar decreases in FBG, with the massage+curcumin combination being statistically significant (Δ −7.44 mg/dL); the curcumin-alone group had a decrease (Δ −12.78 mg/dL) but not significant at a small n. These findings remain consistent with meta-analyses of RCTs showing reductions in FBG/HbA1c by curcumin, and suggest that adding massage may enhance or stabilize the glycemic effect over 4 weeks. Finally, on the outcome that matters most to patients—quality of life (Asian DQOL)—all groups improved significantly, with the most significant increase in the combination (+2.22 points). This result is biologically plausible because it reduces low-grade inflammation and improves glycemia, fatigue,

pain/tension, and sleep disturbance, thereby improving physical-psychological functioning as captured by the DQOL instrument.

Massage therapy has been shown to have immunomodulatory effects through mechanotransduction, converting mechanical stimuli into biochemical signals. This process affects the tissue microenvironment by promoting a shift in macrophage phenotype from M1 (pro-inflammatory) to M2 (anti-inflammatory), which plays a role in tissue repair (Waters-Banker *et al.*, 2014; Arias Padilla et al., 2026). Previous studies have shown that massage can reduce neutrophil infiltration, suppress respiratory burst, and reduce the release of pro-inflammatory cytokines, thereby reducing tissue damage and accelerating functional recovery (Waters-Banker *et al.*, 2014; Bayat, 2019). In addition to immune modulation, massage reduces sympathetic activity and cortisol levels, increases peripheral circulation, and improves lymphatic drainage (Arias Padilla et al., 2026). These effects help increase glucose utilization in muscle tissue and lower blood glucose. Clinically, massage has been shown to reduce neuropathic pain and muscle stiffness and improve sleep quality and relaxation in patients (Bayat, 2019).

Compared with these mechanisms, this research shows a consistent direction of effect, although statistical significance differed across outcomes. For glycemia (FBG), all three groups experienced a decrease after 4 weeks; the massage group had the most significant average decrease (−13.89 mg/dL) but was not yet significant, while the massage+curcumin combination—which biologically potently combines increased tissue glucose utilization and suppressed systemic inflammation—reduced significantly (−7.44 mg/dL). The direction of our results (decreased FBG in both massage and the combination) is consistent with the physiological grounds that massage can improve peripheral/muscle perfusion and facilitate tissue function recovery, resulting in increased glucose demand in active tissues and decreased blood glucose. However, its significance only strengthens when combined with curcumin as a systemic anti-inflammatory/antioxidant. For the inflammatory marker (CRP), all three groups decreased, with the most significant trend for curcumin (−1.256 mg/L), followed by massage (−0.911 mg/L) and the combination (−0.456 mg/L), but none reached significance in paired t-tests; nor did they differ significantly across groups. This pattern remains consistent with the mechanotransduction model: massage shifts the local inflammatory environment toward the resolution phase (M2), reducing the opportunity for pro-inflammatory cytokine release from M1/neutrophils—a plausible effect given the small-to-moderate CRP reduction at 4 weeks, but may require a longer duration or larger sample size to be statistically significant for systemic biomarkers. The impact on functional outcomes and quality of life (Asian DQOL) is most consistent with the literature emphasizing the benefits of massage on pain, stiffness, and relaxation. In this study, all groups improved significantly, with the most significant increases in the combination (+2.22) and massage (+2.00)—suggesting that pain/stress modulation and tissue function restoration via the immune pathway (M1→M2, decreased nociceptive afferents) significantly impacted patients' perception of daily life. However, systemic biomarker changes were not all significant. Overall, the direction and magnitude of the effects on FBG, CRP, and DQOL in our study are consistent with the mechanistic framework of massage as a mechanotransduction-based immunomodulator; the combination with curcumin appears to provide additional benefits on glycemia and quality of life, consistent with curcumin's role in suppressing inflammation/oxidation in diabetes, although confirmation with larger-powered, longer-duration randomized trials is needed.

This study's combination of curcumin and massage demonstrated simultaneous improvements in biological biomarkers and patient perception. Curcumin works systemically through regulating inflammatory-metabolic pathways, while massage plays a role in neuroendocrine regulation, peripheral circulation, and pain modulation (Anugrah *et al,* 2024). With their complementary mechanisms, the combination of the two produces a synergistic effect, particularly in improving patients' quality of life. Although the reduction in FBG and CRP in the combination group was not as significant as in the single group, improvements in symptoms and psychosocial aspects were more prominent. This is consistent with previous research findings suggesting that complementary interventions provide greater benefits to patients' subjective aspects, such as energy, sleep quality, and pain, directly contributing to quality of life (Waters-Banker *et al.*, 2014; Bayat, 2019).

From a population perspective, the use of herbal remedies such as turmeric is relatively high in Indonesia, with 22% of DM patients reporting regular use of herbal therapy. This reflects the need for affordable, safe, and culturally appropriate complementary approaches. This study successfully provides pre-

liminary evidence that curcumin and massage can be an adjunct to supportive therapy in the management of type 2 DM. However, limitations include the relatively small sample size and short intervention duration (4 weeks), which may limit the statistical significance of some variables, particularly CRP.

Overall, the results of this study are consistent with the pathophysiological theory that chronic inflammation and oxidative stress play a key role in insulin resistance and complications of type 2 DM, and that interventions that suppress inflammatory pathways and improve glucose regulation can result in significant improvements in metabolic health and quality of life for patients. These findings also justify further research with larger sample sizes, longer intervention durations, and additional immunological biomarker measurements, so that the benefits of the combination of curcumin and massage can be more robustly confirmed

These two interventions have the potential to be integrated into community-based chronic disease management programs such as Prolanis in Indonesia. Curcumin and massage are low-cost, safe, accessible, and culturally acceptable therapies. Implementation in primary care can help reduce the burden of DM complications, improve patient compliance, and reduce long-term healthcare costs.

Conclusions

This study shows that curcumin and massage therapy both improve immune-inflammatory status, glucose regulation, and quality of life (QoL) in type 2 diabetes; curcumin tends to lower CRP, while the combination of curcumin and massage results in a significant decrease in FBG and the most immense improvement in QoL. Mechanistically, the two are complementary, with curcumin working biochemically, while massage acts through mechanotransduction and neuroendocrine regulation. This synergy explains why the improvement in symptoms and psychosocial aspects is most pronounced with the combination, although the reduction in CRP/FBG is not always the greatest in absolute terms. With its safe, affordable, and culturally appropriate profile, the combination of curcumin and massage holds promise as an adjuvant strategy for managing type 2 diabetes in Indonesia. It needs to be confirmed through larger-scale, longer-duration randomized controlled trials.

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