RESEARCH PAPER

Impact of Clinical Pharmacist-Led Structured Education on Diabetic Foot Self-Care Behaviors in Patients with Diabetic Foot Ulcers: A Randomized Controlled Trial.

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ABSTRACT

Background and Aims: Diabetic foot ulcers (DFUs) are major complications of diabetes mellitus and are frequently associated with inadequate self-care practices. This study evaluated the effect of structured clinical pharmacist-led education on diabetic foot self-care behaviors among patients with DFUs via the Diabetic Foot Self-Care Questionnaire–University of Malaga (DFSQ-UMA).

Methods: A randomized controlled trial was conducted among 60 patients with uninfected DFUs receiving either standard of care (SoC; n=30) or topical esmolol hydrochloride (14% w/w) plus SoC (n=30). Both groups received pharmacist-led education through multilingual patient information leaflets and individualized counseling. DFSQ-UMA scores were assessed at baseline and week 4 across three domains: physical self-care, footwear & stocks, and self-assessment.

Results: Significant improvements were observed in all the DFSQ-UMA domains from baseline to week 4 in both groups ($p<0.001$). The physical self-care scores increased from 13.07±1.70 to 25.93±1.41 in the SoC group and from 13.40±2.24 to 26.07±1.57 in the Esmolol+SoC group. Similar improvements were observed in the Footwear & Socks and Self-Assessment domains. No significant between-group differences were identified ($p>0.05$).

Conclusion: Significant improvements in diabetic foot self-care behaviors were observed in both treatment groups receiving structured pharmacist-led education. These findings support the potential value of pharmacist-led educational interventions as part of multidisciplinary diabetic foot ulcer management.

Trial Registration:
Clinical Trials Registry–India (CTRI), CTRI/2025/11/097829. Registered on 21 November 2025. Prospectively registered.

Keywords: Clinical pharmacist; Diabetic foot ulcer; Self-care; Patient education; DFSQ-UMA; Randomized controlled trial.

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Conflict of interest: None

1. INTRODUCTION

Diabetes mellitus (DM) affects approximately 589 million individuals globally, with India alone accounting for approximately 101 million cases, which is among the highest national burdens worldwide (IDF, 2025; Anjana et al., 2023). Persistent hyperglycemia drives a pathological cascade of oxidative stress, advanced glycation end-product (AGE) accumulation, and endothelial dysfunction, culminating in both microvascular and macrovascular complications (Kazi Islam et al., 2025).

Diabetic foot ulcers (DFUs) represent one of the most clinically consequential complications. The multifactorial pathogenesis of this disease involves peripheral neuropathy, peripheral arterial disease, immune dysregulation, and impaired wound healing (Raja et al., 2023). Neuropathy — present in up to 50% of long-standing patients with DM — abolishes protective sensation, whereas concurrent microvascular insufficiency impedes tissue repair. Hyperglycemia further promotes AGE-mediated collagen cross-linking, attenuates fibroblast migration, and suppresses angiogenesis (Lin et al., 2025). Globally, DFUs account for more than 50% of nontraumatic lower-extremity amputations, with Indian studies reporting incidence rates of up to 25% and an up to 20-fold higher amputation risk than nondiabetic individuals do (Armstrong et al., 2023; Kayal et al., 2023).

Emerging evidence supports the use of topical beta-blockers as pharmacological adjuncts in DFU healing. Esmolol hydrochloride, a selective β1-adrenoceptor antagonist with an ultrashort half-life, reverses receptor-mediated inhibition of keratinocyte epithelialization, inhibits aldose reductase, reduces AGE formation, and facilitates fibroblast migration (Kulkarni et al., 2022; Pullar et al., 2006). A phase 3 RCT by Rastogi et al. (2023a) confirmed superior wound area reduction with topical esmolol (14% w/w) versus SoC alone.

Patient self-care behaviors—foot inspection, hygiene, footwear selection, and glycemic monitoring—are equally critical determinants of DFU outcomes. However, adherence remains poor, driven by inadequate health literacy and insufficient structured education (Khunkaew et al., 2019; Lavery et al., 2022). Clinical pharmacists are uniquely positioned to address this gap, with pharmacist-led interventions consistently demonstrating improvements in glycemic control and medication adherence in DM patients (Bukhsh et al., 2022). However, evidence specifically evaluating pharmacist-delivered foot self-care education in active DFU patients within the Indian tertiary care context remains limited.

The DFSQ-UMA is a validated psychometric instrument that assesses self-care across three domains: physical self-care, footwear & Socks, and self-assessment (Navarro-Flores et al., 2015). The present study, embedded within a parent RCT evaluating topical esmolol efficacy, reports exclusively on the secondary objective: evaluating whether structured pharmacist-led counseling improves DFSQ-UMA self-care scores from week 0 to week 4 equally across both treatment arms.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A prospective, randomized, open-label, parallel-group, active-controlled trial was conducted per CONSORT guidelines in the General Medicine and Surgery wards of KLES Dr. Prabhakar Kore Hospital & MRC, Belagavi—a 2,400-bed tertiary care teaching hospital. The study spanned nine months: eight months of data collection and one month of analysis.

2.2 Sample size and eligibility.

A total of 72 participants (30 per arm) were enrolled, informed by an a priori power analysis based on healing rates from Rastogi et al. (2023a): SoC arm 41.7% vs. Esmolol arm 60.3% (Δ=18.6%). At α=0.05 and 1:1 allocation, this provided approximately 65% power, which was considered acceptable for a pilot investigation.

The inclusion criteria for adults were as follows: aged 18–75 years with type 1 or 2 DM; below-knee, full-thickness ulcer of 4–52 weeks' duration; noninfected, 1.5–10 cm² area; Wagner grade 1 or 2.

The exclusion criteria were as follows: infection or ischemic ulcers, osteomyelitis, HbA1c ≥12%, unstable cardiac conditions, active malignancy, or revascularization within 4 weeks.

2.3 Randomization and Blinding

Eligible participants were randomized 1:1 via computer-generated random numbers, with allocation concealment by sequentially numbered, opaque, sealed envelopes (SNOSE method). The envelopes were opened only after irreversible baseline data lock. Blinding of patients and pharmacists was not feasible given the open-label design; the biostatistician remained masked until database lock.

2.4 Interventions

Group 1 (Esmolol+SoC, n=30): Topical esmolol hydrochloride (14% w/w) gel (Diulcus®, NovaLead Pharma) was applied once daily plus the full SoC regimen.

Group 2 (SoC alone, n=30): Institutional SoC comprising surgical debridement, normal saline cleansing, moist wound dressings, systemic antimicrobials as indicated, and pressure offloading.

Pharmacist intervention (both groups): A clinical pharmacist delivered individualized

face-to-face counseling via a multilingual patient information leaflet (PIL) available in English, Hindi, Kannada, and Marathi. Initial counseling was provided at baseline and reinforced during weekly follow-up visits (days 7, 14, 21, and 28). The educational content focused on five key areas: (i) foot hygiene and daily foot inspection; (ii) appropriate footwear and sock usage; (iii) glycemic monitoring and adherence to antidiabetic therapy; (iv) wound care and dressing compliance; and (v) recognition of warning signs requiring prompt medical attention. Counseling sessions lasted 15–20 minutes, whereas the reinforcement sessions typically required 5–10 minutes. Education was provided in the patient's preferred language, and family members or caregivers were encouraged to participate whenever available to support adherence to recommended self-care practices.

The multilingual PIL was developed by investigators based on published diabetic foot care guidelines and was reviewed by experts in Pharmacy Practice and General Medicine for content validity, accuracy, and patient readability prior to implementation. Educational interventions were provided to both treatment arms in accordance with the Declaration of Helsinki. The PIL and structured counseling checklist are available in the Supplementary Materials.

2.5 Outcome Measure

The primary outcome for this analysis was the change in the DFSQ-UMA score from week 0 to week 4. The DFSQ-UMA comprises 16 items distributed across three domains: Physical Self-Care (7 items), Footwear and Socks (4 items), and Self-Assessment (5 items). The instrument was administered by the clinical pharmacist at both time points. Higher scores indicate better diabetic foot self-care behavior. Scores were calculated according to the original instrument methodology (Navarro-Flores et al., 2015).

2.6 Statistical analysis

The data were analyzed via SPSS v26.0 (IBM Corp.) and GraphPad Prism v5.0. Continuous variables are expressed as means ± SDs; categorical variables are expressed as frequencies and percentages. Within-group changes were assessed via paired-samples t tests or Wilcoxon signed-rank tests; between-group comparisons via independent t tests or Mann–Whitney U tests; and categorical variables via chi–square tests or Fisher's exact tests. Repeated-measures ANOVA were used to examine time, group, and time × group effects. $p<0.05$ (two-tailed) was considered significant.

2.7 Ethical Considerations

The protocol was approved by the Institutional Ethics Committee/IRB on 20 September 2025 (Ref. No. KLECOPBGMEC/D001-2025) and was prospectively registered with CTRI (CTRI/2025/11/097829). The trial adhered to the Declaration of Helsinki, CDSCO guidelines, and ICMR ethical guidelines. Written informed consent was obtained in the patient's preferred language. Patient identifiers were replaced with sequential alphanumeric codes throughout.

3. RESULTS

3.1. Participant flow and baseline characteristics

Eighty-six prospective candidates were clinically screened for eligibility, 14 of whom were excluded because of medical contraindications or refusal to participate, leaving 72 patients for formal 1:1 randomization. Six participants within each arm were lost to follow-up or withdrawn during the active observation phase due to unrelated medical variations, leaving a final per-protocol completion cohort of 60 participants (30 in the Topical Esmolol + SoC group and 30 in the SoC alone group).

Biostatistical checking confirmed perfect baseline equivalence across all evaluated sociodemographic, anthropometric, and clinical glycemic parameters ($p > 0.05$), validating the structural homogeneity of the trial cohorts at enrollment (Table 1).

3.2. DFSQ-UMA Self-Care Behavioral Outcomes

Repeated-measures ANOVA demonstrated highly significant within-subject time effects across all three DFSQ-UMA domains: Domain 1 ($F=7863.18$, $p<0.001$), Domain 2 ($F=1245.06$, $p<0.001$), and Domain 3 ($F=22538.36$, $p<0.001$). Pre- and posttest scores for both groups are presented in Table 2; repeated-measures ANOVA effects are presented in Table 3.

At week 4, both groups demonstrated near-doubling Domain 1 (physical self-care) scores from baseline (SoC: 13.07±1.70 → 25.93±1.41; Esmolol+SoC: 13.40±2.24 → 26.07±1.57). Comparable improvement trajectories were observed in Domain 2 (Footwear & Socks) and Domain 3 (Self-Assessment). Critically, no significant between-group differences were detected for Group Effect (Domain 1: $F=0.29$, $p=0.590$; Domain 2: $F=1.26$, $p=0.266$; Domain 3: $F=1.32$, $p=0.255$) or Time × Group Interaction (Domain 1: $F=0.48$, $p=0.490$; Domain 2: $F=0.26$, $p=0.615$; Domain 3: $F=1.48$, $p=0.229$) across all domains.

4. DISCUSSION

4.1. Key Findings and Interpretation

The principal finding of this RCT is that a structured four-week clinical pharmacist-led educational intervention produced highly significant and statistically equivalent improvements in all three DFSQ-UMA self-care domains in both the SoC and Esmolol+SoC groups. The extraordinarily high values (Domain 1: 7863.18; Domain 2: 1245.06; Domain 3: 22538.36; all $p<0.001$), coupled with nonsignificant group effects and time × group interactions (all $p>0.05$), unambiguously attributed the observed behavioral gains to the pharmacist intervention rather than to any differential pharmacological effect. This finding provides robust empirical evidence for the standalone therapeutic value of clinical pharmacist-delivered patient education in DFU management.

The nearly doubling of the DFSQ-UMA scores within four weeks, particularly in a population with low baseline self-care knowledge, reflected the high educational responsiveness of DFU patients to structured, personalized counseling delivered consistently by a resolute healthcare professional. This finding is not attributable to regression to the mean, given the highly significant F values and the equitable improvement across both arms. Notably, self-care improvements were equivalent across all the modified Kuppuswamy SES strata, confirming the educational model's equity and scalability in resource-limited Indian tertiary care settings.

4.2. Pharmacist intervention mechanism

The PIL-based multilingual counseling framework addressed five operationally critical self-care domains, ensuring comprehensive behavioral reinforcement at each weekly visit. The independence of self-care gains from wound healing outcomes—despite the Esmolol+SoC arm achieving significantly superior wound area reduction (60.3% vs. 41.7%, $p<0.05$)—confirms that knowledge acquisition and behavioral change constitute a distinct therapeutic dimension decoupled from the biological wound environment.

Both cohorts maintained exceptionally high therapeutic compliance (SoC: 96%; Esmolol+SoC: 97%; $p=0.730$), which was partly attributable to systematic pharmacist follow-up addressing adherence barriers at each visit. Interestingly, older patients demonstrated greater adherence ($r=-0.37$, $p=0.0036$), challenging assumptions about age-related noncompliance and suggesting that targeted counseling strategies may be warranted for younger patients. Three Grade 2 PEDIS-classified wound infections were identified and managed promptly by the pharmacist without study interruption: Naranjo ADR scores of zero confirmed that these represented expected disease complications rather than treatment-emergent events.

4.3. Contextualization with Literature

The present findings align with a growing body of evidence demonstrating that pharmacist-led patient education has a positive impact on diabetes self-management outcomes (Bukhsh et al., 2022; Rina et al., 2023). The deployment of the DFSQ-UMA here extends this evidence base specifically to diabetic foot self-care in active DFU patients — a context where comparable validated evidence remains limited. The instrument's sensitivity to change, as evidenced by the high time effect F values, further validates its utility as an outcome measure in interventional DFU research. Unlike prior studies employing heterogeneous educational methods and generic self-care instruments, the present RCT design enables causal inference that is unavailable from observational or single-arm studies.

The uniform self-care benefit across both treatment arms mirrors patterns from other pharmacist-led chronic disease interventions (hypertension, asthma, type 2 DM), where educational improvements are independent of and additive to concurrent pharmacological effects. Critically, this trial demonstrated that pharmacist education does not require coadministration of novel pharmacological agents to be clinically meaningful, supporting its independent implementation across all DFU management contexts.

4.4. Clinical implications and limitations

These findings make a compelling case for formally integrating clinical pharmacist-led structured education into all DFU management strategies as a primary, not supplementary, behavioral intervention. From a clinical pharmacy perspective, the findings highlight the potential contribution of pharmacists to multidisciplinary diabetic foot care services. Structured education, reinforcement of self-care behaviors, medication-related counseling, and regular follow-up interactions may improve patient engagement and support adherence to recommended foot-care practices. Given the increasing burden of diabetic foot complications, pharmacist-led educational interventions may represent a feasible and

scalable strategy for strengthening patient-centered care in resource-constrained healthcare settings. The model requires no specialized equipment or infrastructure beyond pharmacist competency, uses language-adaptable PIL materials, and achieves equitable outcomes across SES strata — characteristics particularly suited to resource-constrained Indian tertiary care environments.

Limitations include the open-label design (precluding patient and pharmacist blinding), potential Hawthorne effect contribution to self-reported DFSQ-UMA scores, a four-week follow-up insufficient to characterize long-term behavioral sustainability, and a sample size (n=60) limiting subgroup analyses. Future studies with longer follow-up periods and larger samples are needed to confirm the durability of self-care gains.

5. CONCLUSION

This randomized controlled trial provides compelling evidence that structured clinical pharmacist-led education — delivered via multilingual PIL-based counseling, glycemic monitoring guidance, and individualized foot care reinforcement — produces rapid, significant, and treatment-arm-independent improvements in diabetic foot self-care behaviors in DFU patients. The equivalent DFSQ-UMA gains across both the SoC and Esmolol+SoC groups, supported by highly significant within-group time effect F values ($p<0.001$), establish pharmacist-led education as the independent driver of behavioral change, irrespective of concurrent wound care pharmacology.

The nonsignificant between-group differences (group effect and time × group interaction: $p>0.05$ for all domains) represent evidence of treatment-arm-independent educational efficacy — not a null result. Combined with high compliance rates (96–97%), equitable outcomes across SES strata, and an absence of treatment-related adverse events, the data affirm that clinical pharmacist-led patient education is safe, feasible, scalable, and independently effective. In a country bearing one of the world's highest DFU burdens, the clinical pharmacist represents a cost-effective and accessible resource for driving meaningful self-care behavioral change.

Clinical pharmacist-led structured education should be recognized as an essential, evidence-based DFU management component. Future research should evaluate the long-term sustainability of these behavioral gains, optimize educational delivery formats across diverse populations, and examine the downstream impacts on wound recurrence and amputation rates.

6. STATEMENTS & DECLARATIONS

6.1. Funding:

This research received no external funding. The Diulcus® (Topical Esmolol Hydrochloride 14% w/w) used in the study was obtained as free samples from Novalead Pharma Pvt. The company had no role in the study design, data collection, data analysis, interpretation of results, manuscript preparation, or publication decisions.

6.2. Competing Interests:

The authors declare that they have no competing interests. The Diulcus® (Topical Esmolol Hydrochloride 14% w/w) used in the study was obtained as free samples from Novalead Pharma Pvt. The company had no role in the study design, conduct of the study, data collection, analysis, interpretation of data, manuscript preparation, or decision to publish.

6.3. Consent to Participate

Written informed consent was obtained from all participants before enrollment.

6.4. Data availability

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

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8. FIGURE AND TABLE LEGENDS

Fig. 1: CONSORT flow diagram

Participant enrollment, randomization, allocation, and follow-up across the Standard of Care (SoC) and Topical Esmolol arms. Created via BioRender.com.

Fig. 2: Changes in Diabetic Foot Self-Care Questionnaire–University of Malaga (DFSQ-UMA) scores from baseline (Week 0) to Week 4 in the standard of care (SoC) and standard of care plus topical esmolol (SoC+Esmolol) groups.

*(A) Physical self-care domain score, (B) footwear and socks domain score, (C) self-assessment domain score, and (D) overall standardized DFSQ-UMA score. The data are presented as the means ± SDs. Significant differences between groups are indicated by asterisks (***p < 0.001).*

Table 1: Baseline sociodemographic and glycemic characteristics

Parameter	SoC (n=30) n (%)	Esmolol+SoC (n=30) n (%)
Mean Age (Years)	56.16 ± 11.09	56.70 ± 12.03
Male Gender	21 (70.0%)	20 (66.7%)
Urban Residence	14 (46.7%)	11 (36.7%)
Upper-Middle SES	11 (36.7%)	13 (43.3%)
Diabetes Duration (Years)	11.10 ± 3.58	10.63 ± 3.09
HbA1c (%)	8.97 ± 0.01	9.05 ± 0.01
FBS (mg/dL)	176.60 ± 21.81	177.67± 23.48
PPBS (mg/dL)	260.40 ± 28.49	260.27± 32.17

Data are presented as the mean ± SD for continuous variables and n (%) for categorical variables. Comparisons between groups were performed via the independent t test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate. (a) Independent t test; (b) chi-square test; SES = socioeconomic status (modified Kuppuswamy scale); FBS = fasting blood sugar; PPBS = postprandial blood sugar.

Table 2: DFSQ-UMA Domain Scores – Pretest and Posttest by Group

DFSQ-UMA Domain	Time	SoC (n=30) Mean ± SD	Esmolol+SoC (n=30) Mean SD
Domain 1: Physical Self-Care (7 items)	Pretest	13.07 ± 1.70	13.40 ± 2.24
	Posttest	25.93 ± 1.41	26.07 ± 1.57

Domain 2: Footwear & Socks (4 items)	Pretest	7.03 ± 1.30
	Posttest	12.77 ± 1.07
Domain 3: Self-Assessment (5 items)	Pretest	9.90 ± 1.45
	Posttest	18.07 ± 1.48

*The data are presented as the means ± SDs. * p<0.001 (within-group paired comparison). The ANOVA p value reflects the between-group F test.*

Table 3: Repeated-measures ANOVA – Time, Group, and Interaction Effects (DFSQ-UMA)

DFSQ-UMA Domain	Effect	Type
Domain 1: Physical Self-Care	Time Effect	Within-
	Group Effect	Betwee
	Time × Group	Interact
Domain 2: Footwear & Socks	Time Effect	Within-
	Group Effect	Betwee
	Time × Group	Interact
Domain 3: Self-Assessment	Time Effect	Within-
	Group Effect	Betwee
	Time × Group	Interaction	1, 48	0.239

** Statistically significant at p<0.001.*

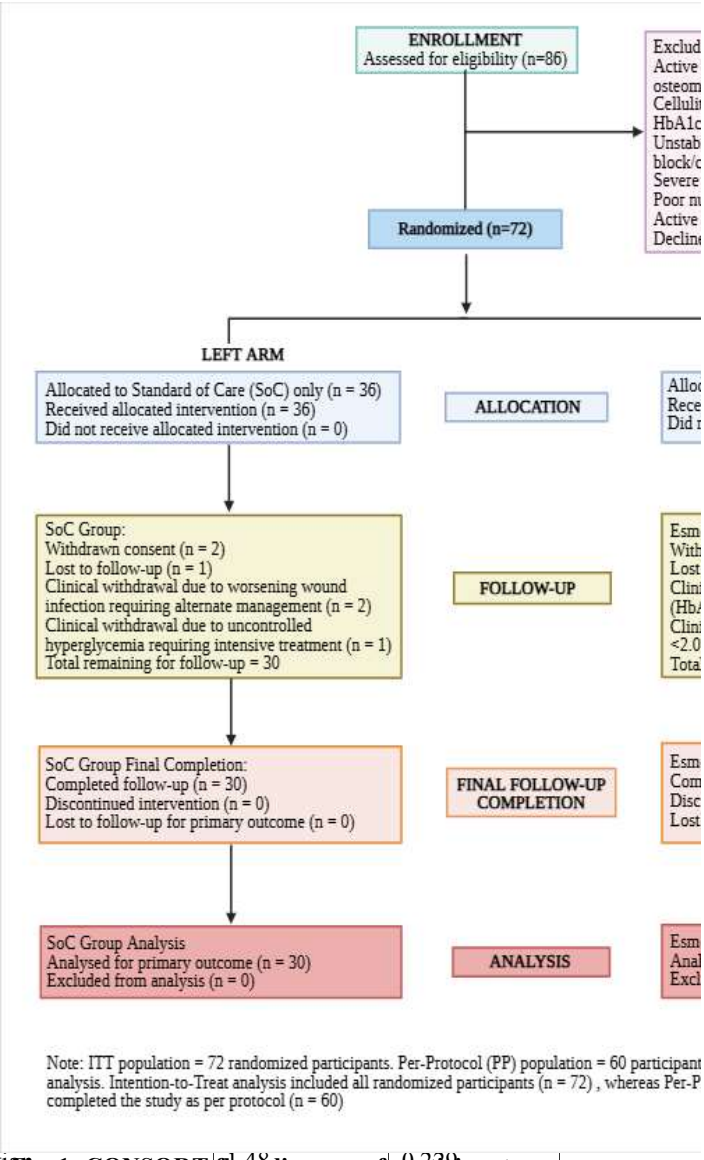

Fig. 1: CONSORT flow diagram of participant enrollment, allocation, and follow-up. Created in Biorender.com

This diagram delineates the flow of participants from the initial screening and eligibility assessment through randomization into the Standard of Care (SoC) and Topical Esmolol cohorts, highlighting completion rates and inclusion in the final statistical analysis.

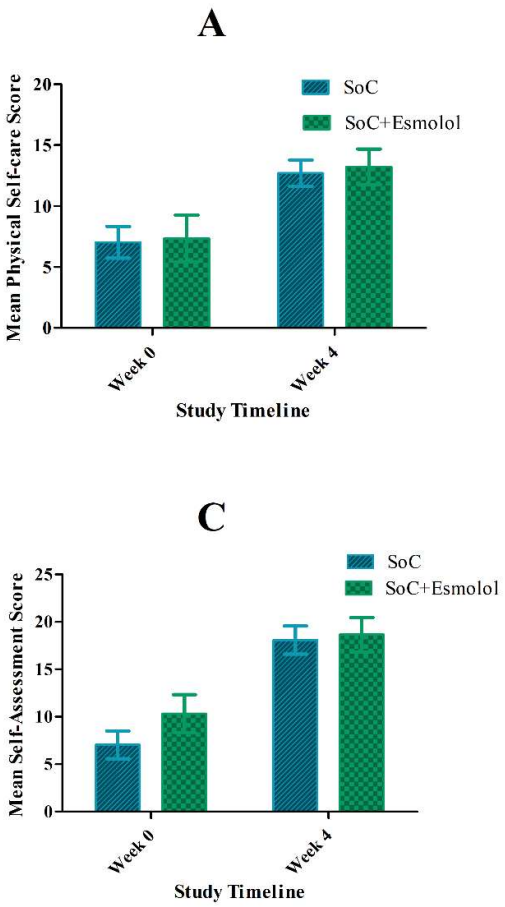

Fig. 2: Changes in Diabetic Foot Self-Care Questionnaire–University of Malaga (DFSQ-UMA) scores from baseline (Week 0) to Week 4 in the standard of care (SoC) and standard of care plus topical esmolol (SoC+Esmolol) groups.
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