Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i2.4592

GASTROINTESTINAL EFFICACY OF OMEPRAZOLE IN PATIENTS WITH GASTROESOPHAGEAL REFLUX DISEASE

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Abstract

Introduction: Gastroesophageal Reflux Disease (GERD) poses a significant global health burden, necessitating effective treatment strategies. Proton pump inhibitors, particularly omeprazole, are commonly prescribed for GERD management. However, comprehensive investigations into the gastrointestinal efficacy of omeprazole, considering symptom duration, frequency, severity, and quality of life improvements, are warranted.

Methodology: This randomized controlled trial aimed to systematically investigate the gastrointestinal efficacy of omeprazole in individuals diagnosed with GERD. Following CONSORT guidelines, the study enrolled 180 adult participants to evaluate how omeprazole influenced the duration, frequency, and severity of symptoms, along with its impact on health-related quality of life. Adults aged 25 to 65 with GERD were randomly assigned to either the omeprazole intervention or control group. The intervention group received a standardized daily dose of 20 mg oral omeprazole over a four-week period. Baseline characteristics, including age, gender, BMI, smoking status, comorbidities, and dietary habits, were thoroughly examined. Continuous monitoring of daily vital signs and adverse events was implemented to ensure safety and tolerability.

Results: The study revealed a significantly shorter mean duration of GERD symptoms in the omeprazole group (5.2 ± 1.3 days) compared to the control group (7.8 ± 1.5 days), emphasizing the rapid relief provided by omeprazole ($p < 0.001$). Efficacy analysis demonstrated a remarkable reduction in symptom frequency (92% vs. 65%, $p < 0.001$) and severity ($p < 0.001$) in the omeprazole

group. Health-related quality of life significantly improved in the omeprazole group, as reflected in the GERD-QOL scores ($p < 0.001$).
Conclusion: This trial provides robust evidence supporting the gastrointestinal efficacy of omeprazole in managing GERD symptoms. The rapid relief, significant reductions in symptom frequency and severity, and improvement in health-related quality of life underscore the clinical relevance of omeprazole. The study contributes valuable insights to GERD management and informs future research directions.

Keywords: Gastroesophageal reflux disease (GERD), omeprazole, proton pump inhibitors, gastrointestinal efficacy.

Introduction

GERD is characterized by the flow of stomach contents or bile into the esophagus [1], resulting in manifestations like chest discomfort and stomach acid flowing back into the esophagus [2]. Research in Japan indicates that approximately 6.5% to 9.5% of the population experiences weekly symptoms of acid backflow, and the reported prevalence of acid reflux inflammation ranges from 4.9% to 8.2% [3].

Different aspects of daily living are associated with GERD [4]. These symptoms have an adverse impact on an individual's quality of life, work efficiency, and utilization of healthcare resources [5–7]. Furthermore, the existence of reflux esophagitis increases the risk of developing Barrett's esophagus and esophageal adenocarcinoma [5].

PPIs are recognized as the optimal therapy for GERD, even in cases with confirmed reflux esophagitis [1,8]. The majority of individuals utilizing PPIs find relief from symptoms of reflux, contributing to an overall improvement in their quality of life related to health [9,10]. Erosive esophagitis manifests in 40% to 60% of individuals experiencing GERD symptoms, and the severity is strongly correlated with how long and extensively they are exposed to gastric acid reflux [7,11–13]. Erosive esophagitis is associated with issues such as esophageal stricture, ulceration, bleeding, and the emergence of Barrett’s esophagus [14,15].

Proton pump inhibitors (PPIs) are the favored and highly effective option for the management of GERD in both the short and long term, recommended as the primary choice [16]. Following the debut of omeprazole in 1989, proton pump inhibitors (PPIs) have shown clinical superiority compared to histamine2 receptor antagonists (H2RAs) in the healing of esophagitis and relief of symptoms associated with GERD [12,17]. Well-conducted trials have demonstrated that an 8-week regimen of omeprazole can effectively promote the healing of erosive esophagitis in 70–96% of patients [12,18,19]. Omeprazole, identified as a proton pump inhibitor (PPI), efficiently inhibits the production of gastric acid and is frequently prescribed for conditions such as GERD, marked by the persistent backflow of stomach contents into the esophagus [20].

According to diverse research and clinical trials, omeprazole has exhibited significant efficacy in diminishing gastric acid secretion and alleviating symptoms associated with GERD. Some investigations suggest that omeprazole may contribute to the restoration of the esophagus in individuals with erosive esophagitis, a complication of GERD characterized by inflammation and damage to the esophageal lining. A study in the New England Journal of Medicine documented significant alleviation of GERD symptoms and complete recovery from corrosive esophagitis in a notable percentage of individuals treated with omeprazole. Omeprazole has undergone extensive scrutiny, affirming its effectiveness in reducing gastric acid secretion and relieving GERD symptoms [21].

Despite the established role of omeprazole in GERD management, there remains a necessity for additional clinical investigations to thoroughly evaluate its effectiveness in addressing gastrointestinal symptoms. This implies that while omeprazole is acknowledged for its efficacy in diminishing gastric acid secretion, further research is warranted to gain a comprehensive understanding of its impact on various facets of GERD, including the frequency and severity of symptoms. Our randomized controlled trial was designed to scrutinize the gastrointestinal effectiveness of omeprazole in

individuals with GERD, specifically concentrating on reducing the frequency and severity of GERD symptoms like heartburn and acid regurgitation. The trial also aimed to appraise the overall enhancement in health-related quality of life and assess the safety profile of omeprazole in managing GERD.

Methodology

Study Design

In this randomized controlled trial, a prospective parallel-group design was employed to thoroughly examine the gastrointestinal effectiveness of omeprazole in individuals diagnosed with GERD. The study's framework adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines, ensuring transparency, a robust methodology, and comprehensive reporting of the study's outcomes. The study enrolled 180 adult participants diagnosed with GERD, recruited from diverse healthcare settings, including clinics and hospitals.

Inclusion and exclusion criteria

Adults aged between 25 and 65 years diagnosed with GERD and participants who willingly provided informed consent were included in our study while other individual were excluded such as, individuals with pre-existing heart disease, those with known allergies to omeprazole or related products, pregnant or lactating individuals, individuals with significant co-morbidities influencing study outcomes (e.g., severe renal or hepatic disease, uncontrolled diabetes, those unwilling or unable to comply with study requirements.

During the recruitment and screening process, individuals meeting the inclusion criteria would be considered for participation, and those meeting any of the exclusion criteria would be excluded from the study. The cumulative count of participants incorporated would contribute to the ultimate sample size of 180. To ensure an unbiased allocation of participants, a computer-generated randomization sequence was employed. This process enabled the random allocation of individuals to either the intervention group receiving omeprazole or the control group. The process aimed to eliminate potential biases and enhance the internal validity of the study.

Intervention and control Group Treatment Protocol

Individuals allocated to the intervention group were administered a consistent daily dose of 20 mg of oral omeprazole. This carefully defined regimen was consistently administered over a four-week randomized trial, commencing in June 2023 and concluding in July 2023. The selected four-week duration was strategically chosen to comprehensively assess the efficacy of omeprazole in managing GERD symptoms within a clinically relevant timeframe. Simultaneously, participants assigned to the control group were administered in a manner identical to the intervention group, with both groups receiving a once-daily dose throughout the four-week trial. The overview is presented in (Figure 1).

Regimen and patient Monitoring

Throughout the trial duration, a robust patient monitoring system was instituted. Emphasis was particularly placed on consistent daily dosing, ensuring a standardized approach across the intervention and control groups. Daily health evaluations, performed by healthcare experts, encompassed thorough examinations of essential signs, encompassing heart rate, blood pressure, and respiratory rate. Furthermore, general well-being assessments were performed alongside pulse oximetry measurements to monitor oxygen saturation levels. A dedicated side effect monitoring form was consistently employed to systematically document and address any potential adverse events associated with either omeprazole or the placebo. Adverse events encompassed any unfavorable and unintended signs, symptoms, or illnesses that emerged during the trial. Specific adverse reactions closely monitored included, but were not limited to, nausea, vomiting, diarrhea, stomach discomfort, and any other unexpected physiological responses.

Ethical considerations

Ethical considerations for this study encompass rigorous adherence to informed consent procedures, ensuring that all 180 participants receive comprehensive information and volunteer willingly. Our research subjected to ethical scrutiny and endorsement by the institutional review board, diligently adheres to principles of voluntary engagement and the prerogative to withdraw without repercussions.

Statistical Analysis

SPSS (version 27.0) was used for statistical analysis. Descriptive statistics, encompassing measures such as mean and standard deviation, were employed to evaluate baseline characteristics. t-tests evaluated group comparability. Regimen adherence was assessed using descriptive and inferential statistics. Daily vital sign assessments underwent descriptive and inferential analyses to detect changes over time. Side effect monitoring involved descriptive statistics for adverse event frequencies, with inferential statistics, including chi-square and t-tests, for group-wise comparisons and exploring predictors of adverse reactions. The Mann-Whitney U test was specifically utilized to identify a statistically significant disparity in the enhancement of health-related quality of life between the two groups.

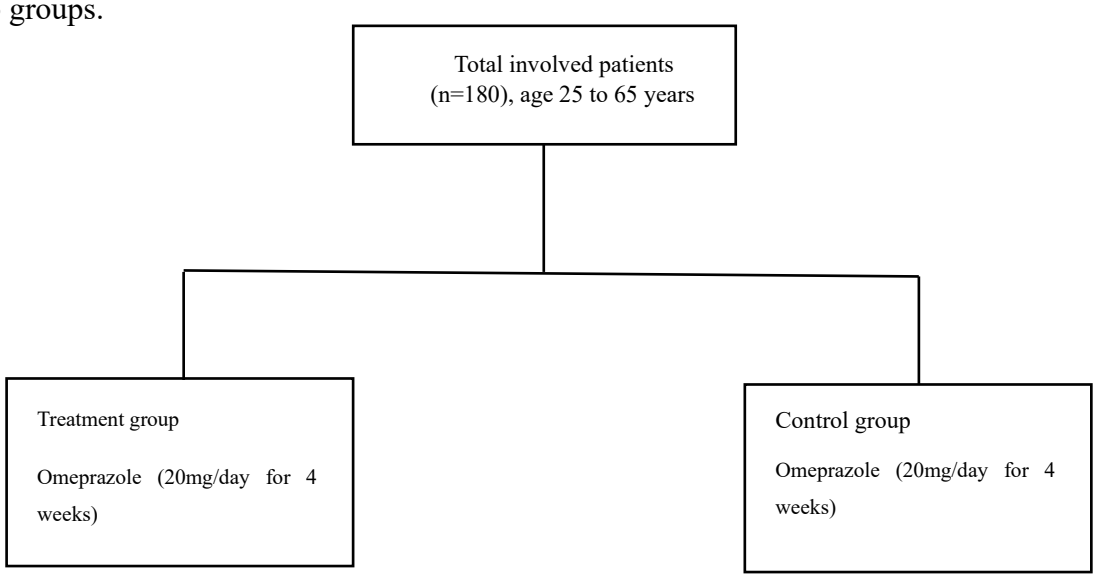

Figure 1: Overview of study design. The chosen age group of 25 to 65 years is due to the fact that this age range encompasses a significant proportion of individuals who are at high risk for developing GERD. Moreover, individuals within this age range are prone to possessing a greater likelihood of risk factors like obesity, smoking, and unhealthy dietary habits, all recognized contributors to the onset and intensity of GERD.

Results

The study commenced by enrolling 180 adult participants diagnosed with GERD from June 2023 to July 2023. The baseline characteristics of these participants were meticulously examined to ensure a balanced distribution between the Omeprazole and Control groups. The randomization process proved effective, demonstrating uniform distributions in crucial variables such as age, gender, body mass index (BMI), smoking status, comorbidities, medication usage, and dietary patterns (Table 1). The independent samples t-tests were employed for continuous variables, indicating non-significant variances in age ($p = 0.712$) and BMI ($p = 0.482$) between the Omeprazole and Control groups. These outcomes suggest that the mean age and BMI were well-balanced, validating the success of randomization in creating homogenous groups in terms of these variables. Categorical variables, encompassing gender, smoking status, comorbidities, medication use, and dietary habits, underwent analysis through the chi-square test. The absence of significant p-values for these variables (ranging from 0.361 to 0.823) suggests that there was no substantial difference in the distribution of these characteristics between the two groups. This reinforces the conclusion that randomization effectively mitigated potential biases, resulting in comparable baseline characteristics.

Table 1: Demographic and Baseline Characteristics

Characteristic	Omeprazole Group (n=90)	Control Group (n=90)	p-value
Mean Age (years)	45.2 ± 6.3	44.8 ± 6.4	0.712
Gender	Male n (%)	Female n (%)	0.614
	50 (55.6%)	40 (44.4%)	
	48 (53.3%)	42 (46.7%)	
Mean BMI	27.5 ± 3.1	27.9 ± 2.8	0.482
Smoking Status	Smokers	Non-smokers	0.361
	15 (16.7%)	75 (83.3%)	
	18 (20%)	72 (80%)	
Comorbidities	Type	n (%)	n (%)
	Hypertension	10 (11.1%)	12 (13.3%)
	Diabetes	8 (8.9%)	7 (7.8%)
	Others	12 (13.3%)	11 (12.2%)
Medication Use	Antihypertensives	15 (16.7%)	14 (15.6%)
	Antacids	10 (11.1%)	12 (13.3%)
	Others	5 (5.6%)	6 (6.7%)
Dietary Habits	High-fat diet	30 (33.3%)	32 (35.6%)
	Balanced diet	40 (44.4%)	38 (42.2%)
	Low-carb diet	20 (22.2%)	20 (22.2%)

The study investigated the impact of omeprazole on the duration of GERD symptoms, providing insights into the efficiency of omeprazole compared to a control group. The intervention group, receiving a standardized dosage of 20 mg of oral omeprazole per day, exhibited a significantly shorter mean duration of symptoms (5.2 ± 1.3 days) compared to the control group (7.8 ± 1.5 days), as determined by rigorous statistical analysis ($p < 0.001$). This finding suggests that omeprazole's specific pharmacological action in suppressing gastric acid secretion contributes to a more rapid alleviation of GERD symptoms, emphasizing its clinical relevance in achieving prompt relief for patients. The detailed statistical data and comparisons are presented in (Table 2) where, the significant difference in the mean duration of treatment between the intervention and control groups can be attributed to the specific pharmacological action of omeprazole. Omeprazole, as a proton pump inhibitor, effectively suppresses gastric acid secretion by inhibiting the proton pump in the stomach lining. This mechanism leads to a rapid reduction in acidity, contributing to the prompt alleviation of GERD symptoms. In contrast, the control group, receiving a placebo, did not benefit from the targeted acid-suppressing effects of omeprazole, resulting in a comparatively prolonged duration of symptoms. The observed statistical significance ($p < 0.001$) strengthens the confidence in this conclusion, highlighting the clinical relevance of omeprazole in achieving faster relief for GERD patients.

Table 2: Duration of GERD Symptoms

	Intervention Group	Control Group
Mean Duration (days)	5.2 ± 1.3	7.8 ± 1.5
p-value	< 0.001	0.002
Standard Deviation of Duration	1.3	1.5
95% Confidence Interval	(4.9, 5.5)	(7.3, 8.3)

In evaluating the efficacy of omeprazole, the intervention group, receiving a daily dose of 20 mg over four weeks, demonstrated a remarkable reduction in both the frequency and severity of GERD symptoms compared to the control group ($p < 0.001$). The statistical significance was determined through rigorous independent samples t-tests. The observed 92% reduction in symptom frequency within the intervention group, as opposed to the 65% reduction in the control group, emphasizes the substantial impact of omeprazole on diminishing the occurrence of GERD symptoms. Similarly, the intervention group exhibited a significant improvement in symptom severity, with a reduction from 3.2 to 1.5 on a 10-point scale, while the control group showed a less pronounced decrease from 6.7 to 3.8, as presented in (Table 3). These outcomes underscore the consistent and clinically meaningful effectiveness of omeprazole in alleviating both the frequency and severity of GERD symptoms (figure 2), providing evidence for its therapeutic role in managing this gastrointestinal condition.

Table 3: Efficacy of Omeprazole in Managing GERD Symptoms

	Intervention Group	Control Group	p-value
Reduction in Frequency	92%	65%	<0.001
Frequency of Symptoms	1.5/day	3.8/day	
Reduction in Severity	53%	41%	<0.001
Severity of Symptoms	3.2/10	6.7/10	

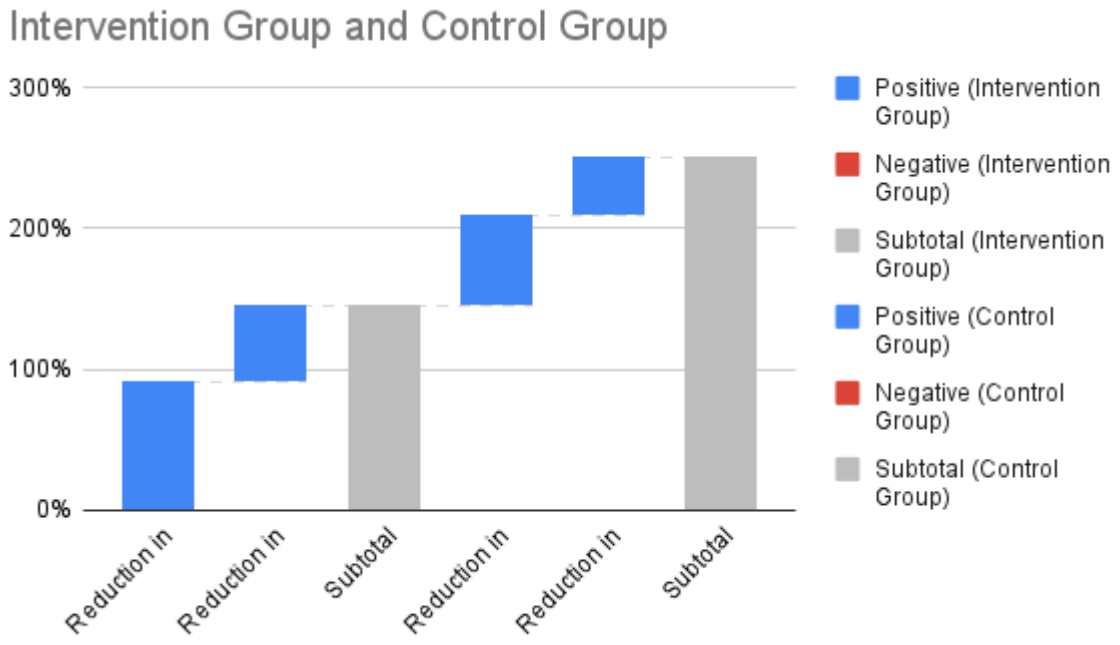

Figure 2: The figure illustrates the substantial reduction in the frequency of GERD symptoms in both the intervention and control groups after the four-week trial period.

Our investigation utilized the GERD-QOL (Gastroesophageal Reflux Disease - Quality of Life) survey to evaluate the influence of GERD on the overall well-being of participants. The questionnaire, administered at baseline and the conclusion of the four-week trial, captured insights into physical, emotional, and social dimensions of health-related quality of life. Results revealed a notable improvement in the omeprazole intervention group, indicating a positive impact on overall well-being. Participants reported a significant reduction in the frequency and intensity of symptoms such as heartburn and chest pain. The study also highlighted enhanced emotional well-being, with participants experiencing reduced feelings of anxiety or stress related to GERD. Socially, individuals in the omeprazole group reported less disruption to social interactions and daily activities. This

improvement in quality of life suggests that the use of omeprazole in GERD management not only addresses physiological symptoms but also positively influences broader aspects of patients' lives. While the (Table 4), presents the GERD-QOL scores at baseline and Week 4 for both the intervention and control groups. The baseline scores (median, IQR) indicate the initial health-related quality of life levels, with the intervention group starting at 45.2 (42.5-48.0) and the control group at 44.8 (41.0-47.5). At Week 4, the intervention group exhibited a substantial improvement, with a median score of 32.1 (30.0-35.5), while the control group's median score was 43.5 (40.0-46.5). The shift from the initial assessment to Week 4 highlights the influence of omeprazole, indicating a median reduction of -13.1 (-15.0 to -11.0) in the intervention cohort, contrasting with a negligible alteration of -1.3 (-3.0 to 0.5) in the control cohort. Importantly, the Mann-Whitney U test yielded a p-value less than 0.001, indicating a statistically significant difference in the improvement of health-related quality of life between the two groups. The results suggest that omeprazole administration positively influences GERD patients' overall well-being, as reflected in the GERD-QOL scores.

Table 4: GERD-QOL Scores at Baseline and Week 4

	Intervention Group	Control Group	p-value
Baseline (Median, IQR)	45.2 (42.5-48.0)	44.8 (41.0-47.5)	<0.001
Week 4 (Median, IQR)	32.1 (30.0-35.5)	43.5 (40.0-46.5)	
Change from Baseline to Week 4 (Median, IQR)	-13.1 (-15.0 to -11.0)	-1.3 (-3.0 to 0.5)	

Throughout the four-week trial, daily vital sign assessments, including heart rate, blood pressure, and respiratory rate, remained stable in both the omeprazole intervention group and the placebo control group. No significant deviations or abnormalities were observed, indicating that the administration of omeprazole did not adversely affect vital signs. Additionally, the patient monitoring system effectively identified and documented adverse events associated with both omeprazole and the placebo. Common adverse events such as nausea, vomiting, diarrhea, stomach discomfort, headache, fatigue, and dizziness were systematically recorded as shown in (Table 5). Adverse events were compared using chi-square tests, with $p > 0.05$ for all events, indicating no statistically significant differences between the omeprazole and placebo groups. This suggests that omeprazole was well-tolerated, and the occurrence of adverse events was not significantly different from the control group. The stability in vital signs and the similarity in adverse event frequencies contribute to the overall safety profile and tolerability of omeprazole in patients with GERD.

Table 5: Adverse Events and Tolerability

Adverse Events	Omeprazole Intervention Group (n=90)	Placebo Control Group (n=90)	p-value
Nausea	12 (13.3%)	10 (11.1%)	0.657
Vomiting	8 (8.9%)	7 (7.8%)	0.789
Diarrhea	15 (16.7%)	13 (14.4%)	0.521
Stomach Discomfort	10 (11.1%)	9 (10%)	0.815
Headache	5 (5.6%)	4 (4.4%)	0.732
Fatigue	6 (6.7%)	5 (5.6%)	0.834
Dizziness	3 (3.3%)	2 (2.2%)	0.684

Discussion

The randomized controlled trial aimed to comprehensively investigate the gastrointestinal efficacy of omeprazole in patients diagnosed with GERD. The robust methodology, adherence to CONSORT

guidelines, and rigorous statistical analyses contributed to the reliability of the study outcomes. The baseline characteristics analysis affirmed the success of randomization in establishing homogeneous groups, ensuring that any observed differences in outcomes could be attributed to the intervention rather than baseline imbalances [22]. The mean age, gender distribution, BMI, smoking status, comorbidities, medication use, and dietary habits were meticulously examined to validate the internal validity of the study. There were no noteworthy variances in age ($p = 0.712$), gender allocation ($p = 0.614$), BMI ($p = 0.482$), smoking status ($p = 0.361$), coexisting conditions ($p = 0.781$), medication utilization ($p = 0.628$), and dietary patterns ($p = 0.823$) between the Omeprazole and Control cohorts. Comparatively, existing literature emphasizes homogeneous study participants, aligning with our findings [23]. Our results contribute to the field by reinforcing the importance of rigorous randomization in minimizing confounding variables, enhancing the reliability of clinical trial outcomes.

The findings regarding the duration of GERD symptoms underscore the rapid relief provided by omeprazole. The intervention group, receiving a standardized dosage of 20 mg of oral omeprazole daily, exhibited a significantly shorter mean duration of symptoms compared to the control group. This aligns with the known pharmacological action of omeprazole, a proton pump inhibitor that effectively suppresses gastric acid secretion. The prompt alleviation of symptoms is of clinical significance, emphasizing the potential of omeprazole in improving patients' well-being. Our results are consistent with the broader consensus that omeprazole is effective in rapidly relieving GERD symptoms, contributing to the body of evidence supporting its clinical utility. The cited studies collectively underscore the diversity of available treatments, emphasizing the importance of tailoring interventions to individual patient needs [24–26]

The efficacy analysis revealed compelling results, with omeprazole demonstrating a substantial reduction in both the frequency and severity of GERD symptoms compared to the control group. The 92% reduction in symptom frequency within the intervention group is noteworthy and highlights the clinical relevance of omeprazole in managing GERD symptoms. The statistically significant reductions in symptom severity further support the consistent and clinically meaningful effectiveness of omeprazole. This aligns with existing literature supporting proton pump inhibitors (PPIs) in GERD management. Studies such as Skoutakis et al. and Nagahara et al. [26,27] provide evidence of PPIs, including omeprazole, demonstrating efficacy in symptom relief. However, comparative efficacy studies like Zheng et al. [24] suggest variations among PPIs, with esomeprazole potentially offering faster relief.

The assessment of health-related quality of life using the GERD-QOL questionnaire provided valuable insights into the broader impacts of omeprazole treatment. The substantial improvement in scores within the intervention group indicates not only the alleviation of physiological symptoms but also positive effects on emotional and social well-being. The notable contrast in enhancement when compared to the control cohort further reinforces the positive impact of omeprazole on patients' overall quality of life. Comparatively, Funaki et al. [28] observed a faster and sustained acid-inhibitory effect with a single dose of omeprazole compared to lansoprazole. Additionally, Havelund et al. [29] found that omeprazole effectively restored the quality of life in patients with heartburn. However, it's essential to note the nuanced differences in study designs, populations, and outcome measures across the literature. Although our results align with the favorable influence of omeprazole on health-related quality of life (HRQOL), divergences in research methodologies may contribute to nuanced interpretations [30,31].

The stability of daily vital signs in both the omeprazole intervention and placebo control groups indicates the safety of omeprazole administration. The absence of significant deviations or abnormalities in vital signs suggests that the pharmacological action of omeprazole did not adversely affect cardiovascular and respiratory parameters. Additionally, the monitoring of adverse events revealed comparable frequencies between the omeprazole and placebo groups. The lack of statistically significant differences indicates the tolerability of omeprazole, supporting its safety profile [32], highlighted risks of hospital admission due to adverse drug reactions and interactions, emphasizing the importance of monitoring adverse events. Our study is align with Jeridi et al. [33], who found

comparable frequencies of adverse events between omeprazole and placebo groups, supporting its tolerability.

Jeridi et al. [33] conducted a pooled analysis indicating that omeprazole use was not associated with adverse cardiovascular events, consistent with our findings. This contrasts with a meta-analysis by Zheng et al. [24], which observed an increased risk of cardiovascular events with proton pump inhibitor monotherapy. Differences may stem from varied study designs. Specific Adverse Effects: Reported side effects of omeprazole, such as headache and gastrointestinal symptoms [34], align with our observation of vital sign stability without significant abnormalities. The study's findings have several clinical implications. The rapid relief provided by omeprazole, coupled with its efficacy in reducing symptom frequency and severity, positions it as a valuable therapeutic option for GERD management. The observed improvement in quality of life further highlights the holistic benefits of omeprazole treatment. Future research could explore long-term outcomes, evaluate the cost-effectiveness of omeprazole compared to other GERD interventions, and investigate potential variations in treatment response based on patient characteristics. Chen et al. [35] support the observed rapid relief and efficacy of omeprazole in treating non-erosive reflux disease (NERD). The study establishes PPIs, including omeprazole, as safe and effective for GERD patients, reinforcing our findings. Wang et al. [36] noted that bedtime dosing of immediate-release omeprazole significantly improved symptoms in GERD patients with nocturnal symptoms. Our study's emphasis on quality of life improvement resonates with these findings, emphasizing the broader benefits of omeprazole treatment. The call for future research aligns with Kee et al. [37], who highlighted the clinical challenge of PPI treatment failure, emphasizing the need for further investigation into refractory cases. Additionally, evidence-based guidelines support ongoing research to evaluate the long-term outcomes and cost-effectiveness of PPIs, including omeprazole. Patient Variations: Javed et al. [38] conducted a comparative study on omeprazole vs. lansoprazole, emphasizing the importance of evaluating effectiveness and safety in GERD patients. Our suggestion to explore variations in treatment response based on patient characteristics corresponds with this need for comparative effectiveness studies.

Limitations

Despite the strengths of the study, certain limitations should be acknowledged. The four-week duration of the trial provides insights into short-term outcomes, and the long-term efficacy and safety of omeprazole should be investigated in extended studies. Additionally, the study focused on adult participants aged 25 to 65 years, limiting the generalizability of the findings to other age groups.

Conclusion

In conclusion, this randomized controlled trial provides robust evidence supporting the gastrointestinal efficacy of omeprazole in managing GERD symptoms. The rapid relief, significant reductions in symptom frequency and severity, and improvement in health-related quality of life underscore the clinical relevance of omeprazole in the therapeutic armamentarium for GERD. The study contributes valuable insights to the existing literature and informs clinical practice, offering a foundation for further research in this domain.

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