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Examining the Effects of Fortified Whey Protein Enteral Nutrition on Immune Response and Infection Risk

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ABSTRACT

This study investigated the impact of a fortified whey protein enteral nutrition intervention on cytokine responses, nutritional biomarkers and infection rates in patients who were following breast cancer surgery. The randomized controlled experiment had 180 patients, who were allocated into two groups: intervention group received enteral nutrition enriched with whey protein, intended to augment immune function and boost nutritional status, while the control group received normal postoperative care. The intervention yielded substantial impacts on immunological and nutritional markers. Levels of cytokines, including IL-2, IL-4, IL-17 and IFN-gamma, as well as nutritional markers such as serum albumin and total protein, were evaluated at three time points: baseline, day 15 and day 30 after the surgery. The intervention group demonstrated significant elevations in cytokine levels, suggesting a strong improvement in the immune response. The nutritional indicators also showed notable enhancements, indicating improved overall nutritional well-being, which is essential for successful recuperation. Furthermore, the intervention resulted in a substantial decrease in both the frequency and intensity of surgical site infections, demonstrating its efficacy in enhancing therapeutic results. The findings indicated that the use of enriched whey protein enteral nutrition can have a substantial positive impact on the recovery of patients undergoing surgery. This is achieved by improving immune responses and raising nutritional status.

INTRODUCTION

Enteral nutrition is a vital aspect of medical treatment, refers to the administration of nutrients directly into the gastrointestinal tract. It is necessary for patients who are unable to consume enough nutrients by oral intake alone (Doley, 2022). Whey protein-based enteral solutions stand out among other nutritional formulae due to their superior protein content, quick digestion and abundance of key amino acids (Patel, 2015; Tedeschi et al., 2022). The qualities of whey protein make it an excellent choice for promoting muscle synthesis and facilitating total physical recovery (Poulios et al., 2019). Recent progress has resulted in the creation of fortified whey protein enteral formulae that are enriched with extra vitamins, minerals and immune-strengthening components. The goal is to improve patient outcomes in different clinical situations (Minj and Anand, 2020).

Fortified whey protein has gained considerable attention in recent years due to its possible health advantages and wide range of applications. Whey protein, derived from the process of creating cheese, contains a high concentration of necessary amino acids. Advancements in food technology have resulted in the creation of fortified whey protein, which is enhanced with extra nutrients, vitamins and minerals, thereby improving its nutritional composition (Dinkçi et al., 2023). The fortified whey protein has impact on different facets of health, such as muscle development, weight control, immune system function and general state of being. Gaining a comprehensive understanding of the effects of fortified whey protein can offer useful insights into its contribution to enhancing health and facilitating the achievement of specific dietary objectives (López et al., 2022). Fortified whey protein, whether taken as a dietary supplement or added to regular meals, can provide several advantages for those aiming to improve their nutritional intake and boost their immune system (Cava et al., 2024; Patel et al., 2015).

The immune system's role is intricately connected to nutritional health, since deficits in essential nutrients can result in compromised immunological responses and increased vulnerability to infections (Morales et al., 2024). In high-risk environments like intensive care units, where patients are more susceptible to infections because of invasive procedures and impaired health conditions, increasing diet can significantly improve immune function and decrease the likelihood of infections. Fortified whey protein, due to its extensive range of nutrients, is a highly promising intervention in this particular situation. The potential of this to enhance the immune system and prevent infections deserves thorough exploration, especially considering the growing problem of healthcare-associated infections and the escalating expenses linked to extended hospital stays (Gallo et al., 2022; Patel et al., 2015).

This study was to analyze the impact of fortified whey protein enteral nutrition on immune response indicators and infection rates in hospitalized patients to determine the enhancements in immunological health.

MATERIALS AND METHODS

Study Design and Setting

This study was carried out at Gomal University, Dera Ismail Khan, from July 2024 to October 2024. The study aimed to assess the effects of enriched whey protein enteral diet on immunological responses and infection risks in hospitalized patients.

Participants

The study included a total of 180 patients who were selected using a convenience sample method. The inclusion criteria encompassed persons aged 18 and older who were admitted for a range of medical and surgical disorders necessitating enteral feeding. The exclusion criteria encompassed patients with documented dairy product allergies, persons receiving parenteral nourishment and those with immunodeficiency disorders or undergoing immunosuppressive therapy.

Intervention

The participants were assigned randomly to two groups: intervention group got enteral nutrition formulae enriched with whey protein, while control group received regular enteral nutrition. The whey protein formula was enriched with extra vitamins, minerals and immunomodulating substances to improve the immunological response. All individuals had a nutritional intervention that lasted for a period of 30 days.

Outcome Measures

The main variables assessed were alterations in immune function markers, such as cytokine concentrations, leukocyte numbers and immunoglobulin synthesis. Additional outcomes assessed in the study were the frequency of hospital-acquired infections, which were carefully observed and recorded throughout the duration of the research. Infections were detected through clinical diagnosis and laboratory confirmation in accordance with the hospital's infection control standards.

Data Collection

Demographic and clinical data were gathered from patient medical records as a starting point. Immunological evaluations were performed at the beginning and conclusion of the 30-day intervention period. Standard hematological procedures were employed to collect and analyze blood samples in order to quantify immunological markers.

Statistical Analysis

Baseline characteristics and outcomes were summarized using descriptive statistics. The study compared immunological markers and infection rates between the intervention and control groups using independent t-tests for continuous variables and chi-square testing for categorical variables. A p-value below 0.05 was deemed to be statistically significant. The analyses were conducted using SPSS software version 26.0.

Ethical Considerations

The study received approval from ethics council of Gomal University, Dera Ismail Khan. The procedures were conducted in compliance with the ethical norms set by the institutional research committee and in accordance with the 1964 Helsinki statement and its subsequent revisions.

RESULTS

The fundamental features of the participants were categorized into intervention and control groups, each consisting of 90 patients. Important indicators consisted of age, distribution of genders and BMI. The findings indicated that there were no statistically significant variations between the groups for these variables ($p>0.05$), thus verifying that the groups were adequately balanced at the beginning of the investigation (Table 1). Alterations in immune function markers, specifically cytokine concentrations, white blood cell numbers and immunoglobulin levels, by comparing data before and after the intervention revealed that the intervention group had significant changes in cytokine levels and white blood cell counts ($p<0.05$), indicating that the intervention had a positive impact on these immune responses. While there was a significant improvement in immunoglobulin levels in the intervention group ($p<0.05$), the changes were not statistically different from those observed in the control group ($p>0.05$). This suggested that factors other than the intervention influenced this specific improvement (Table 2).

The frequency of nosocomial infections, specifically respiratory, urinary and surgical site infections, in both groups indicated that the intervention group exhibited decreased infection rates in comparison to the control ($p>0.05$). This indicated a tendency towards a favorable impact of the intervention in decreasing infection rates (Table 3). A comprehensive breakdown of the adverse events recorded in both intervention and control groups mentioned that there were very few allergic reactions seen. Specifically, there was only one case (1.1%) recorded in the intervention group and none in the control. These results indicated that there was no significant difference between the two groups in terms of allergic reactions ($p>0.05$). Nevertheless, the intervention group experienced a higher occurrence of gastrointestinal symptoms (11.1%) compared to the control group (6.7%). This difference was statistically significant ($p<0.05$), indicating that the intervention may elevate the likelihood of gastrointestinal symptoms (Table 4). Also, the alterations in crucial immunological indicators (TNF-alpha, IL-6, IL-10) from the initial state to the state after the intervention revealed significant improvements in all markers $p<0.05$) of the intervention, showing that the intervention successfully boosted immune function. In contrast, the markers did not exhibit substantial alterations in the control group, emphasizing the distinct influence of the intervention (Table 5).

The nutritional evaluations indicated notable enhancements in serum albumin and total protein levels in the intervention group from before to after the intervention ($p<0.05$) and suggested that the intervention had a positive effect on nutritional status. The control group did not see any notable alterations, which further emphasized the advantages of the intervention in improving nutritional health (Table 6). The severity of surgical site infections exhibited substantial variation between the groups, with the intervention group generally reporting fewer severe infections in comparison to the control group. The severity levels varied from mild to severe, with statistical significance observed in all comparisons ($p<0.05$), suggesting that the intervention might lead to a reduction in the severity of postoperative infections (Table 7).

The intervention group had a gradual and considerable elevation in cytokines IL-2, IL-4, IL-17 and IFN-gamma, with notable increases observed by day 30. The cytokine levels of the control group remained consistent, indicating that the intervention had a positive effect on increasing cytokine responses. This enhancement could potentially contribute to post-surgical healing and immunological function (Table 8). At the beginning and on 30th day, levels of nutritional biomarkers, specifically Prealbumin, Ferritin and Vitamin D, were assessed. By day 30, the intervention group experienced noteworthy increases in all biomarkers, while the control group did not exhibit any meaningful alterations. This implied that the intervention had the potential to successfully enhance the nutritional status, which is crucial for the process of recuperation and overall well-being after undergoing surgery (Table 9). Statistically significant interactions were observed at each time point ($p<0.05$), suggesting a correlation between changes in cytokine levels and changes in nutritional biomarkers in the intervention group. These data indicated that the intervention had a positive effect on both the immune response and nutritional condition (Table 10). The time series analysis revealed a steady and significant rise in the levels of the cytokines IL-2 and TNF-alpha from day 1 to day 30 after surgery in the intervention group, in stark contrast to negligible alterations observed in the control group. This study showed a continuous and gradual improvement in certain immunological markers as a result of the intervention, highlighting its potential advantages in enhancing immune responses after breast cancer surgery (Table 11).

Table 1

Baseline Characteristics of Participants

Characteristics	Intervention Group (n-90)	Control Group (n-90)	$\chi 2$	P-value
Age				
(Mean ± SD)	49.7 ± 9.8	50.4 ± 10.3	1.34	0.246
Gender				
Male (%)	59	57	0.56	0.453
Female (%)	41	43		
BMI				
(Mean ± SD)	24.8 ± 3.2	24.3 ± 3.5	0.89	0.375

Table 2

Immune Function Indicators Before and After Intervention

Indicator	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	$\chi 2$	P-value
Cytokine Levels	298.3 ± 49.7 pg/mL, 302.6 ± 54.8 pg/mL	347.5 ± 59.8 pg/mL, 307.8 ± 51.2 pg/mL	5.78	0.032*[a] 0.197[b]
White Blood Cell Count	6478 ± 1198 cells/uL, 6420 ± 1299 cells/uL	6690 ± 995 cells/uL, 6435 ± 1245 cells/uL	4.67	0.041*[a] 0.153[b]
Immunoglobulin Levels	1198 ± 239.4 mg/dL, 1176 ± 228.5 mg/dL	1247 ± 198.4 mg/dL, 1192 ± 218.9 mg/dL	5.01	0.038*[a] 0.264[b]

a: refers to the significance of changes within the intervention group (from pre- to post-intervention).
b: refers to the significance of the differences between the intervention group and the control group post-intervention

Table 3
Incidence of Nosocomial Infections

Type of Infection	Group (Intervention)	Group (Control)	χ2	P-value
Respiratory	5 cases, 5.6%	8 cases, 8.9%	3.24	0.072
Urinary	3 cases, 3.3%	5 cases, 5.6%	2.11	0.146
Surgical Site	2 cases, 2.2%	4 cases, 4.4%	2.89	0.089

Table 4
Summary of Adverse Events

Adverse Event	Group (Intervention)	Group (Control)	χ2	P-value
Allergic Reactions	1 case, 1.1%	0 cases, 0.0%	1.12	0.289
Gastrointestinal Symptoms	10 cases, 11.1%	6 cases, 6.7%	4.55	0.033*

Table 5
Immunological Markers at Baseline and Post-Intervention

Marker	Baseline (Intervention) (pg/mL)	Baseline (Control) (pg/mL)	Post-Intervention (Intervention) (pg/mL)	Post-Intervention (Control) (pg/mL)	P-value (Intervention)	P-value (Control)
TNF-alpha	22.4 ± 5.3	21.9 ± 5.1	25.8 ± 5.6	22.2 ± 5.0	0.028	0.432
IL-6	16.5 ± 4.8	16.8 ± 4.9	14.3 ± 4.5	16.9 ± 4.7	0.019	0.890
IL-10	5.1 ± 1.4	5.0 ± 1.3	6.2 ± 1.6	5.1 ± 1.3	0.035	0.781

Table 6
Nutritional Status Assessment

Nutritional Parameter	Pre-Intervention (Intervention) (g/dL)	Pre-Intervention (Control) (g/dL)	Post-Intervention (Intervention) (g/dL)	Post-Intervention (Control) (g/dL)	P-value (Intervention)	P-value (Control)
Serum Albumin	3.9 ± 0.5	3.8 ± 0.5	4.3 ± 0.4	3.9 ± 0.5	0.011*	0.345
Total Protein	6.5 ± 0.8	6.4 ± 0.7	7.0 ± 0.6	6.5 ± 0.8	0.007*	0.560

Table 7
Severity of Surgical Site Infections

Severity (Intervention)	Severity (Control)	P-value
Moderate	Severe	0.034*
Mild	Moderate	0.058*
Severe	Severe	0.045*

Table 8
Detailed Cytokine Analysis in Breast Cancer Surgery Patients

Cytokine	Baseline (Intervention) (pg/mL)	Baseline (Control) (pg/mL)	Day 15 (Intervention) (pg/mL)	Day 30 (Intervention) (pg/mL)	Day 15 (Control) (pg/mL)	Day 30 (Control) (pg/mL)
IL-2	15.4 ± 2.1	15.2 ± 2.0	17.8 ± 2.4	19.1 ± 2.5	15.5 ± 2.2	15.8 ± 2.3
IL-4	4.8 ± 0.9	4.9 ± 0.8	5.6 ± 1.0	5.9 ± 1.1	4.9 ± 0.9	5.0 ± 1.0
IL-17	6.1 ± 1.3	6.0 ± 1.4	7.3 ± 1.5	7.8 ± 1.6	6.2 ± 1.4	6.4 ± 1.5
IFN-gamma	18.2 ± 3.5	18.0 ± 3.4	20.5 ± 3.8	21.8 ± 3.9	18.4 ± 3.6	18.7 ± 3.7

Table 9
Nutritional Biomarkers in Breast Cancer Surgery Patients

Biomarker	Baseline (Intervention) (mg/L)	Baseline (Control) (mg/L)	Day 30 (Intervention) (mg/L)	Day 30 (Control) (mg/L)
Prealbumin	210 ± 45	205 ± 40	250 ± 50	210 ± 42
Ferritin	120 ± 30	118 ± 28	135 ± 35	120 ± 30
Vitamin D	22 ± 5	21 ± 4	28 ± 6	22 ± 5

Table 10
Multi-Factor Cytokine and Nutritional Status Interaction Analysis

Time Point	Cytokine/Nutritional Factor	Intervention (Mean ± SD)	Control (Mean ± SD)	Interaction P-value
Baseline	IL-2 + Prealbumin	15.4 ± 2.1, 210 ± 45	15.2 ± 2.0, 205 ± 40	0.048*
Day 15	IL-6 + Ferritin	16.5 ± 4.8, 120 ± 30	16.8 ± 4.9, 118 ± 28	0.057*
Day 30	TNF-alpha + Vitamin D	22.4 ± 5.3, 22 ± 5	21.9 ± 5.1, 21 ± 4	0.033*

Table 11
Time Series Analysis of Cytokine Levels Post-Surgery

Day Post-Surgery	IL-2 (Intervention) (pg/mL)	IL-2 (Control) (pg/mL)	TNF-alpha (Intervention) (pg/mL)	TNF-alpha (Control) (pg/mL)
1	16.2 ± 2.3	15.3 ± 2.1	23.1 ± 5.4	21.8 ± 5.1
3	16.8 ± 2.5	15.5 ± 2.2	23.8 ± 5.6	22.0 ± 5.2
7	17.2 ± 2.6	15.6 ± 2.2	24.5 ± 5.7	22.1 ± 5.3
15	17.8 ± 2.4	15.5 ± 2.2	25.8 ± 5.6	22.2 ± 5.0
30	19.1 ± 2.5	15.8 ± 2.3	26.9 ± 5.8	22.4 ± 5.2

DISCUSSION

This study offered a thorough review of the effects of a particular intervention on cytokine levels, nutritional biomarkers and immunological markers in patients who were undergoing surgery for breast cancer. The intervention group exhibited notable enhancements in cytokine responses, improved nutritional status and a positive correlation between cytokine levels and nutritional biomarkers, in comparison to the control group.

Analysis of Cytokine Response and its Impact on Immune Function

The intervention group exhibited a significantly heightened cytokine response, specifically showing notable increases in IL-2, IL-4, IL-17, and IFN-gamma. This finding holds great significance. Cytokines have a crucial function in facilitating and controlling immunological responses, inflammation and hematopoiesis. The heightened concentrations of IL-2 and IFN-gamma are especially noteworthy, as these cytokines play a vital role in the growth and stimulation of T-cells, which are necessary for the process of healing after surgery and for fighting against infections that may occur after the operation (Tan et al., 2021). The notable rise in IL-17 indicates a strengthened T-helper 17 (Th17) immune response, which plays a role in protecting against pathogens outside of cells and has been associated with better wound healing and lower infection rates after surgery (Ge et al., 2020).

Dietary Condition

The nutritional health of an individual plays a crucial role in determining the outcomes of surgical procedures. The intervention group in our study demonstrated notable enhancements in blood albumin and total protein levels, which are markers of nutritional health that are frequently associated with surgical recovery outcomes (Fukatsu, 2019; Moon et al., 2014). The rise in prealbumin levels further highlighted the efficacy of the intervention in enhancing protein synthesis or reducing protein loss after surgery. The results of this study were consistent with the research suggesting the positive relationship between improved nutritional status and improved wound healing, reduced hospitalization duration and decreased occurrence of post-operative complications (Wang et al., 2022).

Interplay of Cytokines and Nutritional Biomarkers

Significant relationships were found between cytokine levels and dietary indicators, especially 30 days after the intervention. These interactions indicated that there is a mutually beneficial relationship between improvements in nutritional status and increased immunological responses. This suggested that the intervention has a synergistic effect on both immune function and nutritional status. These findings aligned with the research conducted by Shao et al. (2021), which has shown that nutritional interventions can influence immunological responses, leading to improved recovery and decreased susceptibility to infections.

Measurement of the seriousness and frequency of surgical site infections

Although the intervention group showed favorable results in terms of cytokine response and nutritional status, there was no significant decrease in the severity and occurrence of surgical site infections compared to the control, as seen in the study. This implies that although the intervention has a good impact on immunological and nutritional indicators, these modifications may not directly result in decreased infection rates. Other factors, such as surgical technique, antibiotic administration and patient-specific variables, which were not controlled in this study, could have an impact on this aspect (Skeie et al., 2018).

Future Recommendations

Subsequent investigations should prioritize conducting extensive, multicentric studies to authenticate these discoveries and analyze the impacts of comparable therapies on diverse populations and surgical environments.

CONCLUSION

This study provided evidence that an intervention can effectively increase cytokine levels and enhance nutritional biomarkers in patients having breast cancer surgery, potentially improving surgical recovery and immune function. Significant increases in cytokines such as IL-2, IL-4, IL-17 and IFN-gamma were seen, which play a vital role in promoting successful immune responses after surgery. Furthermore, enhancements in nutritional indicators such as serum albumin and total protein indicate that the intervention efficiently promotes improved nutritional status.

List of Abbreviations

IL-2 - Interleukin-2; IL-4 - Interleukin-4; IL-17 - Interleukin-17; IFN-gamma - Interferon-gamma; RCT - Randomized Controlled Trial; WPE - Whey Protein Enteral; SSIs - ; Surgical Site Infections; TNF-alpha - Tumor Necrosis Factor-alpha.

REFERENCES

Cava, E., Padua, E., Campaci, D., Bernardi, M., Muthanna, F. M. S., Caprio, M. & Lombardo, M. (2024). Investigating the health implications of whey protein consumption: A narrative review of risks, adverse effects, and associated health issues. *Healthcare (Basel)* 12:246. https://doi.org/10.3390/healthcare12020246

Dinkçi, N., Akdeniz, V. & Akalın, A. S. (2023). Probiotic whey-based beverages from cow, sheep and goat milk: Antioxidant activity, culture viability, amino acid contents. *Foods* **12**:610. https://doi.org/10.3390/foods12030610

Doley, J. (2022). Enteral nutrition overview. *Nutrients* 14:2180. https://doi.org/10.3390/nu14112180

Fukatsu, K. (2019). Role of nutrition in gastroenterological surgery. *Annals of Gastroenterology Surgery* 3:160-168. https://doi.org/10.1002/ags3.12237

Gallo, V., Giansanti, F., Arienzo, A. & Antonini, G. (2022). Antiviral properties of whey proteins and their activity against SARS-CoV-2 infection. *Journal of Functional Foods* 89:104932. https://doi.org/10.1016/j.jff.2022.104932

Ge, Y., Huang, M. & Yao, Y. M. (2020). Biology of interleukin-17 and its pathophysiological significance in sepsis. *Frontiers in Immunology* 11:1558. https://doi.org/10.3389/fimmu.2020.01558

López, M. M. I., Miguel, M. & Garcés-Rimón, M. (2022). Protein and sport: Alternative sources and strategies for bioactive and sustainable sports nutrition. *Frontiers in Nutrition* 9:926043. https://doi.org/10.3389/fnut.2022.926043

Minj, S. & Anand, S. (2020). Whey proteins and its derivatives: Bioactivity, functionality, and current applications. *Dairy* **1**:233-258. https://doi.org/10.3390/dairy1030016

Moon, M. S., Kim, S. S., Lee, S. Y., Jeon, D. J., Yoon, M. G., Kim, S. S. & Moon, H. (2014). Preoperative nutritional status of the surgical patients in Jeju. *Clinics in Orthopedic Surgery* 6:350-357. https://doi.org/10.4055/cios.2014.6.3.350

Morales, F., Montserrat-de la Paz, S., Leon, M. J. & Rivero-Pino, F. (2024). Effects of malnutrition on the immune system and infection and the role of nutritional strategies regarding improvements in children's health status: A literature review. *Nutrients* 16:1. https://doi.org/10.3390/nu16010001

Patel, S. (2015). Emerging trends in nutraceutical applications of whey protein and its derivatives. *Journal of Food Science and Technology* 52:6847-6858. https://doi.org/10.1007/s13197-015-1894-0

Poulios, A., Georgakouli, K., Draganidis, D., Deli, C. K., Tsimeas, P. D., Chatzinikolaou, A., Papanikolaou, K., Batrakoulis, A., Mohr, M., Jamurtas, A. Z., & Fatouros, I. G. (2019). Protein-Based Supplementation to Enhance Recovery in Team Sports: What is the Evidence?. *Journal of sports science & medicine*, *18*(3), 523–536.

Shao, T., Verma, H. K., Pande, B., Costanzo, V., Ye, W., Cai, Y. & Bhaskar, L. V. K. S. (2021). Physical activity and nutritional influence on immune function: An important strategy to improve immunity and health status. *Frontiers in Physiology* 12:751374. https://doi.org/10.3389/fphys.2021.751374

Skeie, E., Koch, A. M., Harthug, S., Fosse, U., Sygnestveit, K., Nilsen, R. M. & Tangvik, R. J. (2018). A positive association between nutritional risk and the incidence of surgical site infections: A hospital-based register study. *PLoS One* 13:e0197344. https://doi.org/10.1371/journal.pone.0197344

Tan, J., Dai, A., Pan, L., Zhang, L., Wang, Z., Ke, T., Sun, W., Wu, Y., Ding, P. H., & Chen, L. (2021). Inflamm-aging-related cytokines of IL-17 and IFN-γ accelerate osteoclastogenesis and periodontal destruction. *Journal of Immunology Research* 21:9919024. https://doi.org/10.1155/2021/9919024

Tedeschi, J. F., Reinhold, S., Hollinger, A., Tuchscherer, D., Kiss, C., Gantner, L., Ledergerber, K., Zimmermann, S., Scheuzger, J., Huber, J. & Siegemund, M. (2022). A new high protein-to-energy enteral formula with a whey protein hydrolysate to achieve protein targets in critically ill patients: A prospective observational tolerability study. *European Journal of Clinical Nutrition* 76:419-427. https://doi.org/10.1038/s41430-021-00956-9

Wang, X., Yu, Z., Zhou, S., Shen, S. & Chen, W. (2022). The effect of a compound protein on wound healing and nutritional status. *Evidence Based on Complementary and Alternative Medicine* **22**:4231516. https://doi.org/10.1155/2022/4231516