4th Indian International Conference on Industrial Engineering and Operations Management
Hyderabad, Telangana, India, November 07-09, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/IN04.20240086
Published: November 07, 2024

An Anthropometric Analysis Comparing the Effects of Very Low Protein Lactovegetarian and Omnivorous Diets along with Keto analogues

Aparna Nemalikanti
Registered Dietician
Research Scholar, BEST Innovation University Head Quarters
Gownivaripalli, Gorantla, Andhra Pradesh, India
2023wpfsc001@bestiu.edu.in

Abstract

A whole food plant-based (WFPB) diet is regarded as an optimal nutritional approach for managing patients with chronic kidney disease (CKD). The "Forks Over Knives" movement has significantly influenced healthcare professionals, promoting the benefits of nutrient-dense, minimally processed plant foods while excluding refined and heavily processed items, as well as animal products. This dietary approach aids in slowing CKD progression by addressing issues such as hypertension, volume overload, azotemia, acidosis, electrolyte imbalances, and malnutrition. The study, conducted from April 2022 to February 2024, aimed to compare the nutritional status of CKD patients following lacto-vegetarian and omnivorous very low-protein diets (VLPDs) with the aid of objective assessment tools, including weight, BMI, waist-to-hip ratio, skinfold thickness, mid-arm muscle circumference (MAMC), visceral fat, grip strength, bioelectrical impedance analysis (BIA), and skeletal muscle measurements. Patients adhering to plant-based VLPDs showed notable improvements in MAMC, grip strength, and skeletal muscle mass across the body, trunk, and legs compared to those on omnivorous diets. The study excluded patients transitioning to dialysis and included individuals based on creatinine clearance and eGFR levels.

Keywords
Chronic Kidney Disease (CKD), Very Low-Protein Diet (VLPD), Plant-Based Diet, Nutritional Status, Bioelectrical Impedance Analysis (BIA)

1. Introduction
A plant-based diet, particularly one rich in plant proteins, has significant advantages for patients with chronic kidney disease (CKD). Its benefits include lower net urinary albumin excretion (UAE), likely due to the higher glutamate content of plant proteins, an amino acid with neutral metabolites. Plant-based foods, especially those high in citrate, are metabolized into bicarbonate in the body, creating an alkaline environment that neutralizes acid, making low-potassium fruits and vegetables an essential recommendation. Additionally, the bioavailability of phosphorus in plant foods is relatively low (under 50%) due to the absence of the phytase enzyme in humans, which helps mitigate the risk of hyperphosphatemia, a common issue in CKD patients.

Plant-based diets also reduce the production of harmful compounds such as trimethylamine N-oxide (TMAO), a cardiovascular risk factor, by lowering the intake of L-carnitine, commonly found in animal-based foods. These diets are linked to improved lipid metabolism, as they lower LDL cholesterol, triglycerides, and uric acid, and replace harmful saturated fats with healthier monounsaturated fats. Elevated serum levels of threonine, histidine, and glutamic acid, which are abundant in plant foods, contribute to better blood pressure control.

The high fiber content in plant-based diets, particularly in low-protein regimens, reduces protein fermentation and increases carbohydrate fermentation, which positively influences gut microbiota. This leads to the production of short-chain fatty acids like butyrate, which are beneficial for gut health and act as a key factor in reducing systemic inflammation, improving insulin sensitivity, and supporting kidney function. This gut-kidney axis is now recognized as crucial for slowing CKD progression.

Additionally, plant-based diets reduce the dietary acid load, alleviating strain on kidney buffering mechanisms and helping to manage metabolic acidosis, a common complication in CKD. As a result, these diets aid in preserving kidney function over time. The consumption of plant-based proteins, such as soy and wheat gluten, is linked to reduced risk factors for cardiovascular disease, while the antioxidant properties of fruits and vegetables help combat oxidative stress and inflammation, both of which contribute to CKD progression.

Comparative studies of CKD patients on very low-protein lacto-vegetarian diets (VLPDs) and omnivorous diets have demonstrated that those following plant-based diets experience improvements in nutritional parameters, including mid-arm muscle circumference (MAMC), grip strength, skeletal muscle mass, and body composition. Such diets not only benefit kidney health but also reduce cardiovascular risks and manage comorbidities such as diabetes, obesity, and metabolic disorders.

Moreover, the environmental benefits of a plant-based diet further enhance its appeal. By reducing the consumption of animal products, individuals contribute to lowering the carbon footprint, fostering a more sustainable lifestyle that aligns personal health with global environmental goals. Given its wide-ranging benefits for CKD management, metabolic health, and sustainability, a whole food plant-based diet represents a holistic and effective strategy for long-term well-being.

1.1 Objectives

- To compare the nutritional status and progression of CKD patients on lacto-vegetarian and omnivorous low-protein diets supplemented with keto analogues, using objective assessment tools, among individuals not undergoing dialysis.
- To assess adherence to a low-protein, low-sodium diet among lacto-vegetarian and omnivorous CKD patients using a subjective assessment tool, specifically a questionnaire, including only participants who meet the study criteria.

2. Literature Review

2.1 Protein Intake

For individuals with chronic kidney disease (CKD), it is suggested that protein consumption should be between 0.6 and 0.8 grams per kilogram of body weight each day (Mason et al., 2019). Research has shown that low-protein diets (LPDs) can help maintain kidney health and lessen the occurrence of glomerular hyperfiltration (Kalantar-Zadeh et al., 2014). Evidence suggests that proteins derived from plants may lead to lower levels of urinary ammonia excretion, which might be attributed to their higher glutamate levels (Shah, 2021). In contrast, proteins from animal sources are associated with higher oxidative stress and an increased renal acid load (Nissenson et al., 2015).

2.2 Sodium and Blood Pressure

It is advised that sodium consumption should be maintained between 2 and 2.3 grams per day (Johnson et al., 2020). Reducing sodium intake has been found to positively impact blood pressure and extracellular fluid volume, which is essential for avoiding hyperfiltration injury (Krause, 2016). Diets rich in plant-based foods typically contain greater amounts of potassium and glutamic acid, which may further enhance the regulation of blood pressure (Patel & Hoover, 2017).

2.3 Potassium Regulation

For patients with chronic kidney disease (CKD), the recommended daily intake of potassium ranges from 750 to 1,250 mg (Ramezani et al., 2016). While potassium is crucial for proper neuromuscular function, imbalances in its levels can result in serious health issues. Plant-based foods are rich in potassium, although certain cooking techniques can diminish their potassium content (Di Iorio et al., 2012). Therefore, prioritizing low-potassium fruits and vegetables is vital for maintaining appropriate serum potassium levels in CKD patients (Koppe et al., 2018).

2.4 Phosphorus Management

Phosphorus intake is recommended at 800 to 1000 mg/day. Hyperphosphatemia can lead to secondary hyperparathyroidism, affecting bone health (Kalantar-Zadeh et al., 2010). Plant-based sources of phosphorus, primarily in the form of phytate, are less bioavailable (<50%) compared to animal-based sources (Matarese, 2021). This difference highlights the importance of monitoring phosphorus intake from various dietary sources.

2.5 Gut Microbiota and Dietary Impact

Recent research indicates that individuals with chronic kidney disease (CKD) often experience dysbiosis in their gut microbiota, characterized by reduced populations of beneficial bacteria (Ramezani & Raj, 2016). Implementing dietary changes, especially those that increase fiber intake from plant-based foods, has been found to alter the composition of gut microbiota, which may help decrease the production of harmful uremic toxins (Tang et al., 2015).

In contrast, the fermentation of animal proteins can lead to the formation of harmful metabolites that are linked to an increased risk of cardiovascular disease (Poesen et al., 2014).

2.6 Acid-Base Balance

Metabolic acidosis frequently occurs in patients with chronic kidney disease (CKD) and can have a major impact on their overall health. It is advised that individuals consume alkaline-producing foods with a negative potential renal acid load (PRAL) to help neutralize acids and enhance bicarbonate levels (Kalantar-Zadeh et al., 2004). On the other hand, diets that are rich in animal proteins may exacerbate metabolic acidosis, complicating the progression of CKD (Saxena, 2012).

2.7 Cardiovascular Disease

(CKD) significantly increases the risk of cardiovascular disease (CVD), making dietary choices crucial for managing heart health in CKD patients. Plant-based diets have been shown to improve lipid profiles, leading to lower levels of LDL cholesterol, triglycerides, and uric acid (Tirosh et al., 2022). Unlike animal-based diets, plant-based eating patterns replace saturated fats with healthier monounsaturated and polyunsaturated fats, offering protective effects for cardiovascular health. Moreover, these diets are rich in antioxidants from fruits and vegetables, which help to decrease oxidative stress and inflammation—two major contributors to cardiovascular issues in CKD patients (Mirmiran et al., 2014). Another advantage of plant-based diets is their ability to reduce the production of trimethylamine-N-oxide (TMAO), a harmful compound associated with increased cardiovascular risk. TMAO is formed by gut bacteria during the metabolism of L-carnitine, which is primarily found in animal foods. By minimizing L-carnitine intake, plant-based diets lower TMAO levels, thus reducing the likelihood of cardiovascular events (Zha & Qian, 2017).

2.8 Impact on Body Composition and Muscle Strength

Comparative research indicates that chronic kidney disease (CKD) patients adhering to very low-protein, plant-based diets show enhancements in body composition, muscle mass, and physical strength. For instance, individuals on lacto-vegetarian diets have reported improvements in mid-arm muscle circumference (MAMC), hand grip strength, and overall skeletal muscle mass when compared to those following omnivorous diets (Kalantar-Zadeh et al., 2011). These results imply that plant-based diets may aid in muscle preservation and enhance overall functional abilities, which is essential for maintaining a good quality of life for CKD patients.

3. Materials & Methods

Subjective Assessment Tool Questionnaire (Burrowes, J. D, et al., 2005).
Objective Assessment Tool (Carrero JJ, et al., 2008).
BMI (body mass index) Wt in Kg/Ht $(m)^2$ (Gelber RP, et al., 2005).
Waist / Hip ratio (Elsayed EF, et al., 2008).
SFT (skinfold thickness of all 4 regions – biceps, triceps, subscapular region & iliac crest) (MUMC+)
MAMC (Mid arm muscle circumference) (PMC4278104).
Skeletal muscle strength (SMS) – grip strength (Kg) (S. El-Katab, et al., 07 August 2015).
Skeletal muscle mass Quality by BIA – Bioelectrical impedance analysis (Visceral Fat & Skeletal Muscle) (Raíssa A. Pereira, et al., October 2015).
MAC – Mid arm circumference (PMC4278104).

In practice, midarm muscle circumference is used in preference to midarm circumference as a measurement which reflects total body protein stores. Midarm muscle circumference is derived using the following equation Mid arm muscle circumference = Mac-(3.14 x TSF)

4. Methodology

4.1 Study Design and Participant Selection

This longitudinal study included patients presenting with stage 3 chronic kidney disease (CKD) who were not yet on dialysis. Participants were recruited from a clinical setting and were screened to ensure they met the study criteria, specifically having CKD stage 3 and being free from other severe comorbidities that could influence dietary adherence or kidney function independently. Patients requiring dialysis at any point during the study were excluded from further analysis.

4.2 Grouping and Dietary Counseling

Upon recruitment, patients were grouped based on their existing dietary preferences (lacto-vegetarian or omnivorous). Each group received counseling tailored to their dietary habits, emphasizing adherence to a very low-protein diet (VLDP) with appropriate keto-analogue supplementation as per dietary guidelines for CKD management. Dietary counseling sessions were conducted at the beginning of the study and reinforced at each follow-up visit to enhance compliance and address challenges faced by participants.

4.3 Data Collection and Follow-Up
Participants underwent comprehensive assessments at baseline (initial visit) and at the 3rd, 6th, and 9th months. During each visit, anthropometric and body composition parameters were recorded. Measurements included: All measurements were performed by trained personnel using standardized techniques and calibrated equipment to ensure consistency and reliability across visits.

4.3.1 Exclusion Criteria
Any participant who transitioned to dialysis during the study period was excluded from further analysis. This ensured that the results reflected only those patients who were managed solely with dietary interventions without the impact of dialysis on their nutritional and body composition parameters.

4.3.2 Data Analysis
Data were analyzed to assess changes in anthropometric and body composition parameters over time, comparing outcomes between the lacto-vegetarian and omnivorous groups. Adherence to the very low-protein diet was monitored, and the effects of dietary patterns on muscle preservation, body composition, and kidney health progression were evaluated using statistical analysis.

5. Data Collection
Protocol Title - Prospective single center, double arm, comparative clinical study comparing the Effects of Supplemented Low Protein Lactovegetarian and Omnivorous Diets along with Keto analogues on the progression of chronic kidney disease in pre dialysis patients by using anthropometric analysis.
Clinical phase - Prospective cohort, single center, hospital based, two group, comparative clinical study.
Actual Enrolment - 27 participants in each group.
Study Duration - Start Date - April 2022, Completion Date - Feb 2024.
Study group - Lacto-vegetarian & Omnivorous diets on VLPD, Keto-analogues.
Inclusion Criteria – 20-80 yrs, all sexes with CKD stages 3 (eGFR 30-59 mL/min/1.73 m²) and 4 (eGFR 15-29 mL/min/1.73 m²), CrCl can be measured through 24-hour urine collections or estimated from serum creatinine levels, adjusting for age, sex, and body weight.
Exclusion Criteria - On dialysis.

6. Results & Discussion
6.1 Numerical Results
Table 1: it is a prospective single center, double arm, comparative clinical study with 27 patients in each group with lactovegetarian & omnivorous diets, with 22 months follow up (Table 1). It was found that patients on lactovegetarian diets had significantly improved in terms of their mid-arm muscle circumference (M(SD) 24.25 (3.59) $P < 0.001$, hand grip muscle strength (M(SD) 26.67 (11.16) $P < 0.05$, skeletal muscle whole body 29.49 (5.9) ($P < 0.05$), skeletal muscle trunk 22.64 (5.8) $P < 0.05$, skeletal muscle legs 46.01 (7.7) $P < 0.05$, skeletal muscle arms 35.17 (5.7) $P < 0.001$ when compared to omnivorous diets.

Table 1. Comparison of Anthropometric and Body Composition Parameters Between Lacto-Vegetarian and Omnivorous Diet Groups

Lacto-vegetarian Diets			P VALUE	Omnivorous Diets	
	M(SD)	RANGE		M(SD)	RANGE
Age	57.45(9.6)	38-79.2	-	54.14 (17.5)	15 – 88
Ht	162.3(9)	146-179	-	160.5 (9.3)	143 – 181
Wt	65.6 (13.4)	44.8-95	>0.05	68.2 (9.8)	46.9 – 87
BMI	24.79 (4.51)	18.3-38.4	>0.05	26.4 (4.2)	20.8 – 37.8
W/H	1.02 (0.118)	0.86-1.5	**<0.05**	0.94 (0.10)	0.78 – 1.15
MAMC	24.25 (3.59)	15 -30.2	**<0.001**	20.12 (2.9)	16 – 26.3
BICEPS	16.68 (8.02)	5 -34	>0.05	17.1 (6.8)	4.8 -34.2
TRICEPS	21.2 (8.7)	8.1 – 38.3	>0.05	25.6 (8.8)	10 – 50.2
SUBSCAPULAR	24.2 (8.6)	10 – 45	>0.05	25.5 (9.4)	6 – 38.2
SUPRAILIAC	18.45 (7.8)	8.5 – 34.1	>0.05	17.4 (6.3)	6.5 - 34.6
FAT%	34.7 (9.24)	18.8 – 59.6	>0.05	36.65 (7.5)	22.9– 49.5

HAND GRIP	26.67 (11.16)	11.3 – 65.8	**<0.05**	18.3 (8.7)	6.5 – 40
VISC FAT	12.5 (6.6)	3.8 – 30	>0.05	15.3 (8.3)	2.1 – 41.1
SM WB	29.49 (5.9)	19.3 – 47.4	**<0.05**	25.3 (6.06)	16 – 37.9
SM TRUNK	22.64 (5.8)	12 - 37.4	**<0.05**	18.2 (6.3)	9.7 – 33.2
SM LEGS	46.01 (7.7)	31.9 - 64.5	**<0.05**	39.1 (7.1)	27.9 -53.6
SM ARMS	35.17 (5.7)	19.9 - 45.2	**<0.001**	26.4 (8.6)	10.7 – 40.8

p < 0.05: Generally considered statistically significant, suggesting a less than 5% probability that the observed effect is due to chance.
p < 0.01: Indicates stronger evidence against the null hypothesis, with a less than 1% probability that the results are due to chance.
p < 0.001: Indicates very strong evidence against the null hypothesis, with a probability of less than 0.1% that the observed results are due to random variation.

6.2 Graphical Results

Graphical Results are presented in Figure 1, Figure 2, Figure 3 and Figure 4.

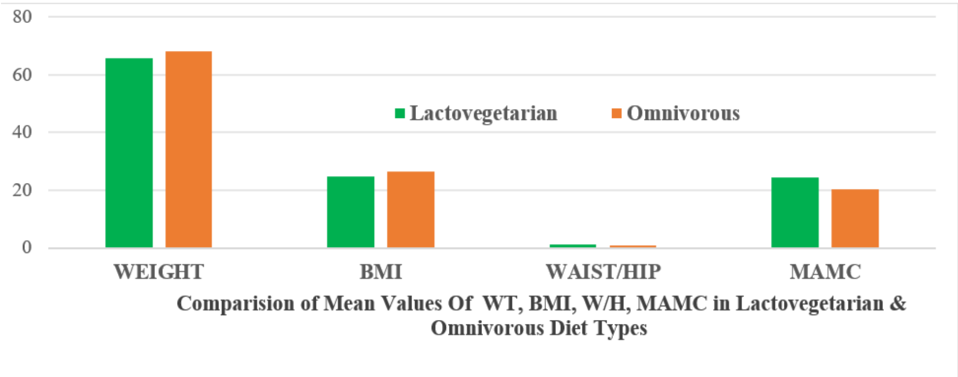

Figure 1: Comparison of Mean Values of WT, BMI, W/H, MAMC in Lactovegetarian & Omnivorous Diet Types

Mid-arm muscle circumference (MAMC) is notably greater in lacto-vegetarians than in those on an omnivorous diet, indicating a possible benefit of plant-based diets for muscle preservation, which may help slow the progression of chronic kidney disease (CKD) and delay the need for dialysis (Figure 1).

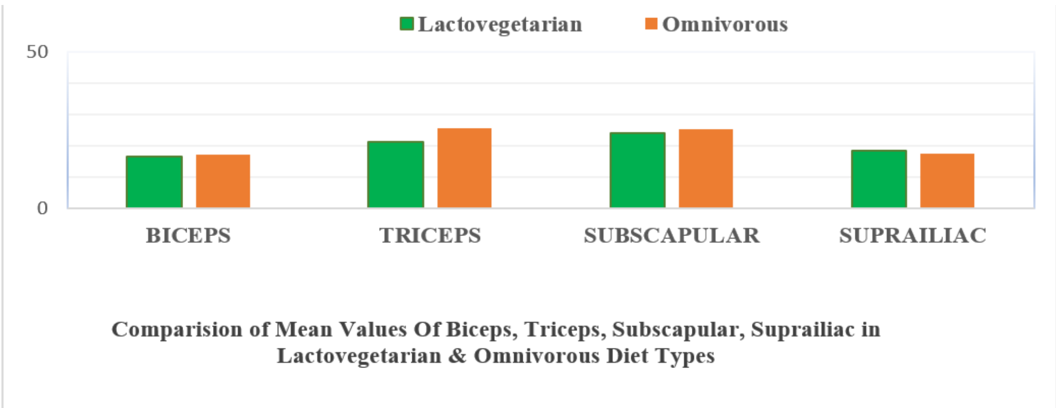

Figure 2: Comparison of Mean Values of Biceps, Triceps, Subscapular, Supraillac in Lactovegetarian & Omnivorous Diet Types

Skinfold thickness measurements are significantly lower in lacto-vegetarians compared to individuals adhering to omnivorous diets (Figure 2). This finding suggests that the lacto-vegetarian diet will contribute to reduced body fat accumulation and improved overall body composition, likely due to a higher intake of fiber-rich foods and lower levels of saturated fats.

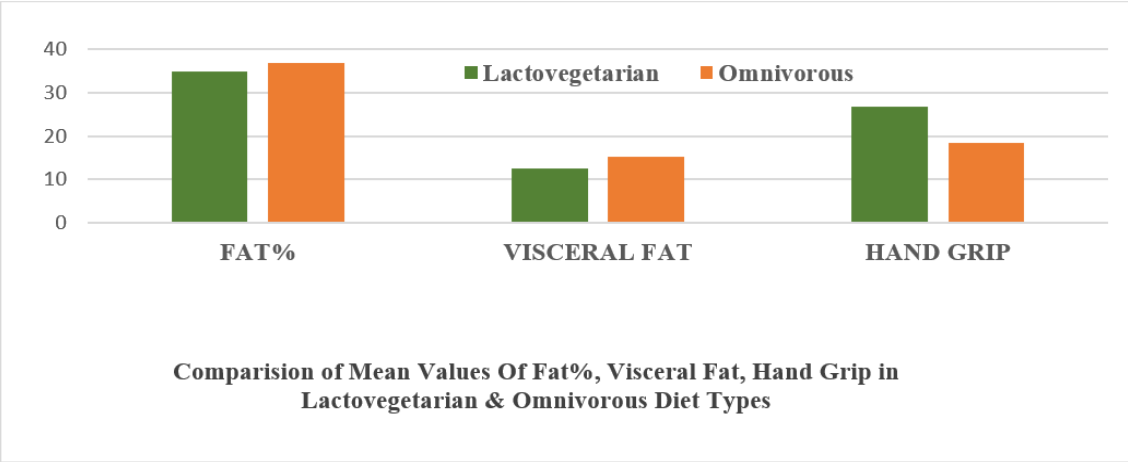

Figure 3: Comparison of Mean Values of Fat%, Visceral Fat, Hand Grip in Lactovegetarian & Omnivorous Diet Types

Lacto-vegetarians demonstrate significantly lower body fat percentage and visceral fat levels compared to individuals consuming omnivorous diets. Furthermore, lacto-vegetarians exhibit greater hand grip strength, suggesting enhanced muscular performance and overall physical fitness (Figure 3). These findings indicate that the lacto-vegetarian diet will support better body composition and muscle strength, potentially attributed to a higher intake of plant-based nutrients and lower saturated fat consumption and in turn slow the progression of chronic kidney disease (CKD) and delay the need for dialysis.

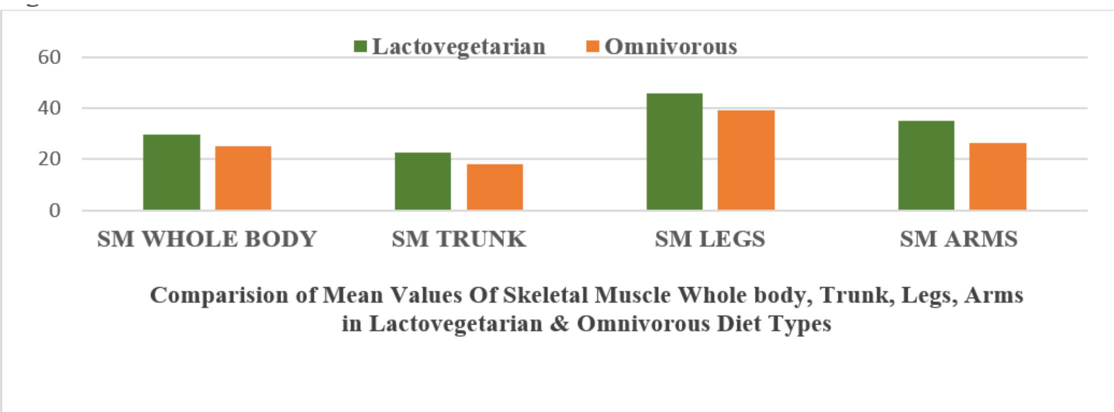

Figure 4: Comparison of Mean Values of Skeletal Muscle Whole Body, Trunk, Legs, Arms in Lactovegetarian & Omnivorous Diet Types

Lacto-vegetarians possess a higher overall skeletal muscle mass in the whole body, including the trunk, arms, and legs, compared to individuals on omnivorous diets (Figure 4). This difference will be attributed to the nutritional profile of the lacto-vegetarian diet, which includes a beneficial combination of plant-based nutrients and dairy-derived proteins that support muscle growth and retention.

6.3 Proposed Improvements

The positive outcomes observed in this study underscore the potential of plant-based diets to enhance nutritional status and functional performance in CKD patients. Given the significance of muscle health in overall well-being and quality of life, I aim to extend this research to further investigate sarcopenia by incorporating assessments of physical performance through gait speed measurements, the Medical Research Council (MRC) score, and the SARC-F questionnaire along with HMB supplementation. This additional exploration will provide deeper insights into the interplay between dietary patterns and physical function, ultimately contributing to more effective strategies for managing sarcopenia in CKD patients. By continuing this vital research, I hope to refine dietary recommendations and optimize patient outcomes in this vulnerable population.

7. Conclusion

In conclusion, this study underscores the significant role that diet adherence plays in managing chronic kidney disease (CKD) for non-dialysis patients, specifically focusing on lacto-vegetarian low-protein diets supplemented with keto analogues. Findings reveal that adherence to a low-protein, low-sodium lacto-vegetarian diets not only supports better nutritional status but also helps slow CKD progression, reduce muscle wasting, and delay or potentially avoid the need for dialysis. These positive health outcomes also highlight the importance of effective patient education and ongoing dietary counselling to achieve and maintain compliance with prescribed diets. The study provides compelling evidence that a lacto-vegetarian low-protein diet, when followed consistently, can be particularly beneficial for kidney health, improving quality of life and enhancing longevity for CKD patients. These insights lay a foundation for further research into personalized dietary interventions in CKD care, aiming to develop tailored strategies that maximize patient well-being and long-term kidney function through sustainable dietary management.

References

Burrowes, J. D., Subjective assessment of nutritional status in chronic kidney disease: a comparison of the Subjective Global Assessment and other tools. *Journal of Renal Nutrition*, pp. 5-11, 2005.

Carrero, J. J., Malnutrition in chronic kidney disease: an overview of the available assessment tools. *Journal of Renal Nutrition*, pp. 300-307, 2008.

El-Katab, S., https://doi.org/10.1111/jhn.12331, *07 August 2015*, Citations: 16.

Elsayed, E. F., Waist-to-hip ratio, body mass index, and subsequent kidney disease and death in healthy adults, *CJASN*, 2008.

Gelber, R. P., Association between body mass index and development of chronic kidney disease in men. *CJASN*, 2005.

Kalantar-Zadeh, K., Gutekunst, L., Mehrotra, R., Understanding Sources of Dietary Phosphorus in the Treatment of Patients with Chronic Kidney Disease. *Clin. J. Am. Soc. Nephrol.*, pp. 519-530, 2010.

Krause, M. Food, Nutrition & Diet Therapy. *10th Edition*, Elsevier, 2016.

Matarese, L. Contemporary Nutrition Support Practice. *First Edition*, 2021.

MUMC+. Skinfold measurements. *Maastricht University Medical Center*, Retrieved October 6, 2024, from https://nutritionalassessment.mumc.nl/en/skinfold-measurements.

Nissenson, A.R., The Role of Dietary Protein in Managing Chronic Kidney Disease: A Review. *J. Ren. Nutr.*, pp. 343-350, 2015.

Patel, K., & Hoover, K.W. Comparison of vegetarian versus animal-based low protein diets on estimated glomerular filtration rates in chronic kidney disease patients: A systematic review protocol. *JBI Database Syst. Rev. Implement. Rep.*, pp. 2861-2865, 2017.

Pereira, R. A., Nephrology Dialysis Transplantation. *Volume 30, Issue 10*, pp. 1718-1725, October 2015, https://doi.org/10.1093/ndt/gfv133.

Poesen, R., Viaene, L., Verbeke, K., Cardio vascular disease relates to intestinal uptake of p-cresol in patients with chronic kidney disease. *BMC Nephrol.*, 87, 2014.

Ramezani, A., & Raj, D.S. The Gut Microbiome, Kidney Disease, and Targeted Interventions. *J. Am. Soc. Nephrol.*, pp. 1299-1306, 2016.

Saxena, A. Nutritional problems in adult patients with chronic kidney disease. *Clin. Queries Nephrol.*, pp. 222-235, 2012. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4278104/

Biography

Aparna Nemalikanti is a seasoned Clinical Dietician with over 19 years of experience, currently serving as the Chief Dietician at Sindhu Hospitals, Hyderabad. She holds a Master's degree in Clinical Nutrition and Dietetics from Osmania University College for Women, Hyderabad, and a Bachelor's degree in Food Science and Quality Control from Osmania University. In addition, she is a Registered Dietician with the Indian Dietetic Association and is pursuing a Ph.D. in Food Science & Nutrition from BEST Innovation University Head Quarters, India. She is also certified in Nutrigenomics, emphasizing her expertise in personalized nutrition. Her clinical experience includes comprehensive patient care in both inpatient (IP) and outpatient (OP) settings. She has a strong background in designing and implementing Enteral and Parenteral Nutrition protocols based on NABH standards. Her contributions include the introduction of NUTRIC scoring for critically ill patients, revisions of diet prescriptions for various diseases, and the development of quality indicators for the hospital's food and beverage department. She has led efforts to mitigate drug-nutrient interactions, winning the Best Poster Award at the Apollo International Patient Safety Conference in 2019. She is actively involved in training, conducting interdepartmental education programs, and overseeing internship training for dietetics students. Her accolades include the Best Employee Award (2021) and recognition as a celebrity guest on ETV's *Abhiruchi* program, where she discussed micronutrient deficiencies. Aparna is a Life Member of the Indian Dietetic Association (IDA), ISPEN, and NSI, and has participated in numerous national and international nutrition conferences.