

**BJMHR**British Journal of Medical and Health Research
Journal home page: www.bjmhr.com

A Cross-Sectional Study of Nutritional Inadequacies In Patients with Rheumatoid Arthritis

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ABSTRACT

Rheumatoid arthritis (RA) is a progressive autoimmune disease characterized by joint stiffness, pain, and swelling. Along with conventional treatment, adequate nutrient intake and lifestyle habits may help decrease/manage the RA activity. This cross-sectional study aimed to evaluate dietary and nutrient intake adequacy, nutritional status, lifestyle patterns, nutritional and inflammatory biomarkers among RA patients. A total of 300 patients aged 25-75 years were selected from reputed hospitals based on inclusion criteria. Data on demographics, medical history, dietary intake through FFQ and 24-hour dietary recall, anthropometric measurements, handgrip strength, inflammatory & nutritional biomarkers were analyzed. Nutrient intake analysis showed 270 patients had inadequate daily intake of protein, essential fatty acids, calcium, phosphorus, and zinc. Among patients, 160 were overweight/obese (25.54 ± 1.98 kg/m²), 28 were undernourished (16.93 ± 1.43 kg/m²), and 93 had normal BMI (21.1 ± 1.21 kg/m²). Handgrip strength was weak in 210 patients, 85 were normal, and only 5 were strong. Nutritional biomarkers showed normal calcium (8.63 ± 0.66 mg/dl) and hemoglobin (14.01 ± 0.27 g/dl) levels in males but low calcium (7.99 ± 0.12 mg/dl) and hemoglobin (11.82 ± 0.08 g/dl) levels in females. Inflammatory markers, ESR (76.74 ± 27.26 mm/hr) and CRP (36.67 ± 20.24 mg/dl), were higher in females compared to males ESR (43 ± 17.51 mm/hr) and CRP (25.68 ± 5.20 mg/dl). Inadequate sun-exposure increase vitamin-D insufficiency and sedentary lifestyles aggravate RA complications significantly. The evidence suggests the need for nutrient-dense diet, focusing more on protective nutrients such as protein, calcium, iron, and essential fatty acids with antioxidant and anti-inflammatory potential. A holistic approach combining medical and nutrition therapy is recommended for better RA management and improved quality of life.

Keywords: Nutrient adequacy, Pro-inflammatory, Protective nutrients, Anti-oxidant, Anti-inflammatory.

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Received 28 April 2026, Accepted 07 May 2026

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic autoimmune disease that manifests as inflammatory, symmetric, and progressive polyarthritis¹. According to a study conducted by Dar *et al*, the global prevalence of RA is 0.3-1.0%, and in India it is estimated to be 0.7% population². The early symptoms of RA may initiate as pain with a gradual appearance of joint swelling or tenderness. Chronic condition may result in morning stiffness with arthralgia, swelling, tenderness of small joints of hands and feet³. If RA left untreated, it leads to deformities and impacts on quality of life. Management strategies can include drug therapy, diet therapy, physio-therapy, lifestyle modifications in severe cases surgery may be recommended. It is observed that the standard treatment guideline emphasizes on drugs but adjuvant therapies like diet is neglected⁴. The drug therapy in parallel with diet therapy is imperative as medical nutrition management strategy to alleviate the signs and symptoms of rheumatoid arthritis.

According to the traditional system, evidence has suggested that diet plays a significant role in RA management⁵. A diet rich in nutrients with potential antioxidant activity is recommended for maintaining Bone Mineral Density (BMD) and lowering inflammation⁶. It is well recognized that calcium and vitamin D rich foods play a crucial role in enhancing bone health. Diet specifically designed for RA with low pro-inflammatory index like red meat, salt, high calorie foods and diet rich in anti-inflammatory component foods such as nuts, fruits, vegetables, whole grains and Omega-3 fatty acids such as fish (like salmon and mackerel), flaxseeds, and walnuts along with antioxidant-rich foods such as berries, spinach and kale can help protect from cell damage caused by inflammation and help to reduce inflammation and ease RA symptoms⁷⁻⁸. RA specific dietary intake with foods rich in anti-inflammatory and antioxidative bioactive components may exert a positive effect on symptoms. The gut microbiota plays a key role in immune regulation and mental health, and its balance can be supported through diets rich in fibre, prebiotics, and probiotics. Disruptions in gut flora are linked to the progression of inflammatory conditions like RA⁹⁻¹⁰. The nutrient quality, adequacy depends on intrinsic factors such as drug-nutrient interaction, gut health, nutrient bioavailability and extrinsic factors such as dietary pattern, food choices, economic condition, geographical location and regional foods. The present study aims to evaluate the less explored factors such as diet quality, nutrient intake adequacy, nutritional status and lifestyle pattern among RA patients in Mysore district, Karnataka, South India.

MATERIALS AND METHOD

This cross-sectional study was conducted in outpatients recruited from a tertiary care centre in Mysuru, Karnataka. A total of 300 patients were recruited based on their willingness and after obtaining written informed consent. Aged between 25-75 years, with history of > 2

years of RA, with or without T2DM, HTN & Hypothyroidism were included in the study. RA patients with other chronic illnesses were excluded.

Assessment of Nutrient Intake:

The food consumption pattern was collected using a structured questionnaire [validated and approved by DAC (Doctoral Advisory Committee)] and the Food Frequency Questionnaire (FFQ)¹¹ which includes the pattern of different food group consumption on daily, weekly, monthly and on occasional basis. Dietary intake was recorded using 24-hour dietary recall method. Standard cups and measurements were used as tools for portion size while taking in person responses. Adequacy of nutrient intake was evaluated using the Recommended Dietary Allowance (RDA), and a percentage of an individual's daily nutrient intake to the age and sex-specific RDA was calculated.

Assessment of Nutritional Status:

The nutritional status was assessed using anthropometric measurements. The height was measured using a stadiometer, weight was recorded using digital weighing balance and the BMI was calculated using anthropometric parameters. The musculoskeletal strength of patients was assessed using the tool Hand dynamometer (Camry Digital Dynamometer (200Lbs/90kgs) and the patients were categorized as Weak, Normal and Strong based on the tool's standard ranges. The data on medical history and medications were captured through a structured questionnaire.

Biochemical Assessment:

The nutritional markers such as Haemoglobin (Hb) was assessed using SLS Haemoglobin/Photo-optical Colorimetry and serum calcium levels were evaluated using BAPTA method. The inflammatory markers namely ESR (Erythrocyte Sedimentation Rate), CRP levels (C-Reactive Protein) were analysed using Westergren's and Nephelometry methods respectively.

Ethical approval was obtained from the Institutional Ethics Committee of JSS Medical College, JSS AHER, Mysuru and approval no: JSSMC/IEC/19052022/04NCT/2022-2023. Written informed consent was obtained from all patients prior to their inclusion in the study.

Statistical Analysis

The results were **patiented to suitable** statistical analysis such as Mean, SD, t-test and One-way ANOVA using MS excel and SPSS tools. $p \leq 0.05$ was considered to be statistically significant.

RESULTS AND DISCUSSION

The study represents the data of total number of 300 patients, males n=45 and females n=255. The patients were grouped according to age: 25-60 years and >60 years. Table 1 represents

the prevalence and age-wise distribution of RA according to the sex. The prevalence showed that the incidence of RA is almost 5 times higher in females than males. Hence, the RA condition showed the sexual preponderance, as it is more prevalent in women than men, especially in the younger age group.

Table 1. Age wise distribution of RA patients (n=300)

Age (Years)	Male (n=45)	Female (n=255)
25-60	27	206
>60	18	49

Assessment of Nutrient Intake

Food Frequency Assessment:

The frequency of food consumption pattern across various food groups, was assessed among 300 participants, comprising 88 vegetarians, 189 non-vegetarians, and 23 ovo-vegetarians. Table 2 illustrates intake frequencies for cereals and millets, legumes and pulses, vegetables, fruits, non-veg, and fats. The most evident observation was the intake of cereal Rice and Fats & Oils, consumed daily by 100% of the patients (n=300). Followed by daily intake of milk as beverages (tea and coffee) and milk products 85.3% (n=256) and sugar & jaggery 83.3% (n=250). Consumption of other cereals showed high preference for Ragi (Finger millet) on daily basis 82.6% (n=248), and daily intake of wheat rate of 57% (n=171). Under cereals group consumption of rice & finger millet was significantly high ($p < 0.05$) in total participants. Notably, there appears to be a reduction in the variety of grain intake, where foods like Jowar and Millets were rarely consumed. Proteins attained from legumes were the primary source of proteins for vegetarian and most of the non-vegetarian patients. Red gram, green gram, and horse gram had higher frequencies per week, 38% (n=112) of the patients consumed green gram dal on a weekly basis, whereas 39% and 39.3% (n=117 and 118) of the patients had red gram and horse gram on a weekly basis. In contrast, soybean was not consumed by many patients. Whereas daily intake of non-vegetarian food and eggs was minimal 1.66% (n=5) and 5.66% (n=17) respectively. The consumption of vegetables and green leafy vegetables was concerned, the participants showed an intake of Green Leafy Vegetables (GLV) that occurred regularly but not on a daily basis, however the proportion of patients reporting a daily intake was only 3.6%, a huge 73% had taken GLVs 2–3 times a week. A similar trend was observed for the group of Roots, Tubers, and Other Vegetables, which were predominantly consumed 2–3 times per week the detailed numbers are given in the table (2). The data on Fruits, around 34.3% (n=103) patients were consuming fruits on a daily basis, while 25% (n=75) consume them twice or thrice a week. There is a fairly significant number of people who consume fruits either weekly or monthly. A study by He J

et al. (2016), n=968 patients showed that potato exhibited pro-inflammatory effect whereas, fruits, vegetable, mushroom and dairy products helped in relieving the inflammation and symptoms of RA¹². A trend in the consumption of Dry fruits & Nuts, were largely consumed on an "Occasionally", with 52% of the patients (n=156). The percentage of people consuming nuts every day is just 14% (n=42). Consumption frequencies for all food groups varied from daily to weekly, monthly, occasionally, or never as given in the Table 2.

Table 2. Food frequency of RA patients (n=300)

Food groups		Daily	Weekly once	Weekly 2-3 times	Monthly once	Monthly 2-3 times	Occasionally	Never
Cereals	Rice	300 ^d	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a
	Ragi(Finger millet)	248 ^d	12 ^b	17 ^b	9 ^a	5 ^a	5 ^a	4 ^a
	Wheat	171 ^{cd}	19 ^b	104 ^{cd}	0 ^a	0 ^a	3 ^a	3 ^a
	Jowar	7 ^a	3 ^a	9 ^a	13 ^b	4 ^a	77 ^c	187 ^c
	Millets	14 ^b	15 ^b	3 ^a	4 ^a	7 ^a	61 ^c	196 ^c
Dals & Pulses	Red gram	87 ^c	117	67 ^{bc}	4 ^a	18 ^b	3 ^a	4 ^a
	Green gram dal	86 ^c	112	58 ^{bc}	16 ^b	18 ^b	7 ^a	3 ^a
	Black lentil	66 ^c	84 ^c	101 ^{cd}	11 ^b	7 ^a	5 ^a	26
	Horse gram	85 ^c	118	65 ^{bc}	16 ^b	4 ^a	9 ^a	3 ^a
	Chick pea	70 ^c	72 ^c	30 ^{bc}	8 ^a	67 ^c	9 ^a	44 ^b
	Bengal gram	71 ^c	11 ^b	26 ^b	10 ^a	62 ^c	81 ^c	39 ^b
	Black eye bean	72 ^c	43 ^{bc}	33 ^{bc}	20 ^b	81 ^c	22 ^{bc}	29 ^b
	Hyacinth bean	13 ^b	6 ^a	20 ^b	24 ^{bc}	42 ^{bc}	92 ^c	103 ^{bc}
Soy bean	4 ^a	6 ^a	11 ^b	8 ^a	6 ^a	91 ^c	174 ^c	
Green leafy vegetable	11 ^b	48 ^{bc}	219 ^d	8 ^a	10 ^{bc}	1 ^a	3 ^a	
Roots & tubers	142 ^{cd}	6 ^a	132 ^{cd}	11 ^b	1 ^a	3 ^a	5 ^a	
Other vegetable	139 ^{cd}	10 ^a	140 ^{cd}	1 ^a	5 ^a	3 ^a	2 ^a	
Fruits	103 ^{cd}	49 ^{bc}	75 ^c	20 ^b	27 ^{bc}	23 ^{bc}	3 ^a	
Milk & milk products	256 ^d	4 ^a	20 ^b	4 ^a	6 ^a	4 ^a	6 ^a	
Fats & Oils	300 ^d	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	
Non-veg	5 ^a	89 ^c	34 ^b	41 ^c	25 ^{bc}	12 ^b	94 ^{bc}	
Egg	17 ^b	65 ^c	88 ^c	21 ^{bc}	16 ^b	18 ^b	75 ^{bc}	
Dry-fruits & Nuts	42 ^{bc}	20 ^b	25 ^b	19 ^b	12 ^b	156 ^d	26 ^b	
Sugar & Jaggary	250 ^d	9 ^a	4 ^a	2 ^a	13 ^b	15 ^b	7 ^a	

*Values carrying different superscripts in columns a,b... differ significantly (p<0.05)

High Fat, Salt & Sugar (HFSS) food intake pattern:

In the study population, along with determining the frequency of food group intake pattern, the data on the consumption frequency of foods high in sugar, salt and fat were assessed and the data is given in Table 3. The major observation from the data was that the Bakery food type dominates, with a large percentage 56.7% of the patients consuming daily (n=170). Data indicates high prevalence of Deep-fried foods among the patients, consuming 2-3 times in a week was 55% (n=165). The high prevalence of Packed & Processed foods and Chocolate/Ice cream/ Cool drinks was seen to be consumed by patients at a weekly 2-3 times interval with a rate of 21.6% (n=65) and 25% (n=75), respectively. The consumption of processed food and

junk foods prominently less common pattern of monthly consumption, suggesting these groups remain recurrent stressors despite not being consumed every day. The category “never” is statistically insignificant since complete avoidance of these pro-inflammatory foods is not very common; just a small percentage of participants have never eaten any form of bakery or fried foods. Overall, there is a significantly high consumption ($p < 0.05$) of sweetened beverages, bakery products, deep-fried foods rich sources of sugar, salt and fat, which can lead to high calorie intake and reduced micronutrient intake from the diet. It is imperative to check on these foods, since some of the food’s items are also identified as pro-inflammatory foods.

Table 3. High Fat, Salt, Sugar intake of RA patients (n=300)

HFSS	Daily	Weekly once	Weekly 2-3 times	Monthly	Monthly 2-3 times	Occasionally	Never
Deep fried foods	3 ^a	36 ^{ab}	165 ^b	44 ^{ab}	14 ^a	24 ^{ab}	14 ^{ab}
Chocolate/Ice creams/Cool drinks	8 ^a	65 ^b	75 ^{ab}	22 ^{ab}	48 ^{ab}	44 ^b	38 ^b
Packed & Processed foods	13 ^a	15 ^a	65 ^{ab}	84 ^b	54 ^{ab}	34 ^{ab}	35 ^b
Bakery products	170 ^b	27 ^{ab}	54 ^{ab}	7 ^a	30 ^{ab}	4 ^a	8 ^a
Chats and Junk foods	20 ^a	68 ^b	23 ^a	48 ^{ab}	75 ^b	35 ^{ab}	31 ^b

*Values carrying different superscripts in columns a,b... differ significantly ($p < 0.05$)

Dietary Intake Adequacy:

The dietary intake and nutrient adequacy of the patients are presented in Table 4. The actual nutrient intake of the patients was calculated from 24-hour dietary recall data. The macro and micro nutrient intake of both gender groups were compared with respective recommended daily allowances (RDA) as per Indian requirements. The macro and micro nutrient adequacies as excess or deficit nutrient intake is also shown in Table 4. It was observed that the calorie intake was excess, 108 kcal (5.12%) 165 kcal (10%) than the recommended levels for males and females respectively. Similar trend was observed for carbohydrates 100g (76.9%) and 73g (56%), fat 28.77g (96%) and 25.86g (103%) for males and females respectively. On contrary, there was deficit of daily protein intake (male-6.78g, female- 5.2g), calcium (male-150mg, female-438 mg), and iron (male-7.6mg, female 21.3mg). There was a significant difference ($p < 0.05$) in actual calorie intake between males-108 Kcals & females-165 Kcals, which was in excess as per RDA for both groups. between the genders in the actual intake excess of calories, less of iron and calcium, and phosphorous according to the RDA. The intake of minerals namely calcium, iron & phosphorous was less than recommended levels for all the patients, and calcium and phosphorous consumption was significantly ($p < 0.05$) low in female than male counterparts as represented in Table 4. In the present study, the dietary assessment tool, 24-hour diet recall, and food frequency assessment showed, that 270 (90%) of the patients had imbalance dietary intake as per Indian RDA. The

intake of protective nutrients such as protein, essential fatty acids, calcium, phosphorous, zinc, anti-inflammatory and antioxidant sources were low hence are at risk of nutrient deficiency. Inadequate diet influences RA onset and progression, and pro-inflammation can be an indirect outcome. Research studies also show anti-inflammatory rich foods such as nuts, oil seeds, essential fatty acids, fruit (berries) and others reduce inflammation⁹, the possible link between dietary anti-inflammatory components and additional lifestyle factors can reduce the risk of RA helping improve nutritional status, effective management of RA, improving overall QOL of patients with RA. In all the patient's micronutrient intake was less than the RDA, hence the patients are vulnerable to RA-related complications and require immediate dietary intervention. The results also showed that there is a high intake of simple sugar and fat, this is in parallel with other clinical studies which show alterations in gut microbiota and body composition modifications¹³. Studies have shown that, the protective efficacy of vitamin C in the management of RA and a positive relation between high consumption of red meat and aggravation of symptoms, and there were no association between protein, iron and corresponding food sources with RA risk, hence they are safe¹⁴⁻¹⁵. Hence, we can reduce those specific dietary choices such as red meat, salt, and excessive caloric intake.

Table 4. Daily Actual Intake and Nutrient Adequacy of the patients (n=300)

Nutrients	RDA		Actual Intake (AI)		Nutrient Adequacy (NA)	
	Male	Female	Male (n=45)	Female (n=255)	Male	Female
Energy (kcal)	2110	1660	2218.29 ^b ± 85.75	1824.93 ^a ± 186.6	+108 ^x	+165 ^y
CHO (g)	130	130	229.51 ^a ± 34.21	203.72 ^a ± 46.61	+100 ^x	+73 ^x
Proteins (g)	54	46	47.02 ^a ± 12.18	40.82 ^a ± 14.30	-6.98 ^x	-5.2 ^x
Total fat (g)	30	25	58.77 ^a ± 20.0	50.86 ^a ± 30.31	+28.77 ^x	+25.86 ^x
Total fibre (g)	40	30	39.78 ^a ± 6.77	26.36 ^a ± 8.76	-0.22 ^x	-3.64 ^x
Calcium (mg)	1000	1000	848.99 ^b ± 252.45	561.66 ^a ± 229.40	-150 ^x	-438 ^y
Iron (mg)	19	29	11.40 ^a ± 5.57	7.68 ^a ± 1.96	-7.6 ^x	-21.3 ^y
Phosphorous (mg)	1000	1000	1005.50 ^a ± 346.84	664.14 ^b ± 172.93	100 ^x	-336 ^y

*AI-Values carrying different superscripts in rows a,b... differ significantly (p<0.05)

*NA- Values carrying different superscripts in rows x,y... differ significantly (p<0.05)

Anthropometric Measurements

The mean anthropometric measurements of the patients according to age groups are shown in Figure 1. As per the WHO-Asian classification of BMI, 3 male patients and 25 females were falling in the under-weight category with BMI 17.90±0.16 kg/m² and 16.80±1.48 kg/m² respectively. Normal BMI was found in 12 Males (20.97±1.24 kg/m²) and 81 females (31%). The mean BMI for overweight was 23.59±0.60 kg/m² and 23.67±0.71 kg/m² for males and females respectively, around 65 males had BMI under obese category i.e., (26.57±1.33 kg/m²) and females had BMI of 27.02±1.37 kg/m². Grade I obesity was found in 4 and 24

male and females with BMI of $30.95 \pm 1.23 \text{ kg/m}^2$ and $33.05 \pm 2.60 \text{ kg/m}^2$ respectively. There is a significant difference between age groups between both gender ($p < 0.05$). Due to disease activity in RA condition, the patients had low physical activity contributing to the risk of developing overweight/obesity. The results showed that the physical activity level is sedentary leading to overweight/Obesity (53.4 %) this may be due to lower physical activity as well as high consumption of simple Carbohydrates and fats. On the contrary, 24 (8.15%) patients had a BMI less than normal, which can be attributed to low calorie and protein intake leading to undernutrition. The features of RA also include reduced mobility, muscle strength, and low physical activity caused by joint pain and stiffness resulting in decreased physical fitness¹⁶.

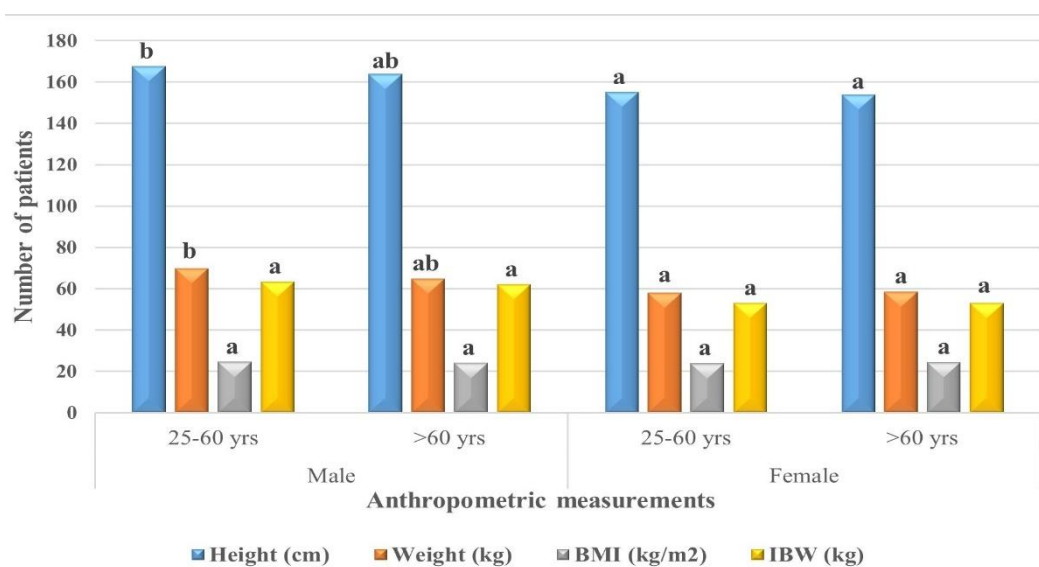


Figure 1. Mean Anthropometric measurements of RA Patients (n= 300)

*Values carrying different superscripts a,b for each anthropometric measurement differ significantly ($p < 0.05$)

Musculoskeletal (Handgrip) Strength

The impact of RA condition on musculoskeletal strength was assessed through the hand grip strength (Table 5). Hand grip strength plays an essential role in facilitating the performance of prehensile and precision hand functions within the human body, and it is used as one of the main indicators for testing muscle and bone strength¹⁷. From the table, the hand grip strength of patients was given according to age. There is a significant difference between age groups between both gender ($p < 0.05$). Overall, 37 (82%) and 173 (68%) were categorized as weak, 8 (18%) and 77 (30%) patients were normal for males & females respectively. Only 5 (2%) of female patients showed hand grip strength under the strong category, and none for males. Around 210 (70%) of patients diagnosed with RA show reduced musculoskeletal handgrip strength and performance in hand function assessments. Handgrip strength is a useful method

for assessing functional impairments of individuals with RA and influenced by active inflammation and joint damage.

Table 5. Hand Grip Strength (kg) Classification of RA patients (n=300)

Age (year)	Male (n=45)			Female (n=255)		
	Weak (n=37)	Normal (n=8)	Strong (n=0)	Weak (n=173)	Normal (n=77)	Strong (n=5)
25-29	2 ^b	1 ^b	0 ^a	8 ^c	5 ^{bc}	0 ^a
30-34	2 ^b	1 ^b	0 ^a	9 ^c	9 ^c	0 ^a
35-39	3 ^b	0 ^a	0 ^a	14 ^c	8 ^c	0 ^a
40-44	3 ^b	0 ^a	0 ^a	30 ^d	8 ^c	2 ^b
45-49	3 ^b	3 ^b	0 ^a	16 ^c	10 ^c	0 ^a
50-54	3 ^b	1 ^b	0 ^a	22 ^d	19 ^{cd}	2 ^b
55-59	6 ^c	1 ^b	0 ^a	32 ^d	9 ^c	0 ^a
60-64	7 ^c	0 ^a	0 ^a	21 ^d	3 ^b	0 ^a
65-69	6 ^c	0 ^a	0 ^a	14 ^c	4 ^b	0 ^a
70-99	2 ^b	1 ^b	0 ^a	7 ^c	2 ^b	1 ^b

*Values carrying for superscript a.b.c.... for male and female differ significantly (p<0.05)

Biochemical Parameters

The biochemical parameters of patients with RA are shown in Figure 2. The inflammatory markers such as ESR, CRP and nutritional biomarkers like Hb and Calcium were analysed. The normal ranges for men and women for ESR are 0-22 mm/hr and 0-29 mm/hr¹⁸ respectively, CRP value >3 mg/L is considered normal for both genders¹⁹. The normal range of Calcium is 8.5-10.2 mg/dl²⁰, and Hemoglobin levels for male is 13.8 to 17.2 g/dL and for female 12.1 to 15.1 g/dL²¹. In RA disease, inflammation increases the concentration of fibrinogen in the blood, which causes red blood cells to clump together and settle faster, thus raising ESR levels²². Similarly, chronic inflammation stimulates the liver to produce more CRP, a protein that helps fight infections, resulting in higher CRP levels in the blood²³.

The ESR level of male patients aged between 25-60 years was 43.33±8.61 mm/hr and >60 years was 48.33±7.55 mm/hr. The CRP level of male patients aged between 25-60 years was 21.64±1.10 mg/L and >60 years was 15.9±1.16 mg/L. The ESR level of female patients aged between 25-60 years was 71.33±5.88 mm/hr and >60 years was 102.77±2.66 mm/hr. CRP level of female patients aged between 25-60 years was 27.02±2.80 mg/L and >60 years was 25.13±4.45 mg/L. The serum ESR & CRP levels were high in both age groups of females, but the group >60 years had a significantly increased value of ESR. There was a significant difference in ESR and CRP levels between the age group of 25-60 years and >60 years in both male and female groups (p<0.05). The Hb level of male patients aged between 25-60 years was 14.21±1.51 g/dL and >60 years was 13.82±3.11 g/dL. The calcium level of male patients aged between 25-60 years was 9.10±1.81 mg/dl and >60 years was 8.16±1.24 mg/dl. The Hb level of female patients aged between 25-60 years was 11.88±2.48 g/dL and >60

years was 11.76 ± 0.50 g/dL. Calcium level of female patients aged between 25-60 years was 8.08 ± 2.48 mg/dl and >60 years was 7.9 ± 1.66 mg/dl. There was no significant difference between Hb and Calcium levels in both age groups of males & females ($p < 0.05$) The Hb and Calcium levels were shown lower than the normal range in both age female groups. The reason for increased level of inflammatory markers and decreased level of serum Hb and Calcium may be because of the inadequate intake of iron and calcium foods in the diet, hormonal changes due to the TAH (Total Abdominal Hysterectomy), Early menopause or menopause²⁴, physical activity and other metabolic changes. Clinical/inflammation biomarkers such as ESR and CRP levels provide the extent of disease activity progression.

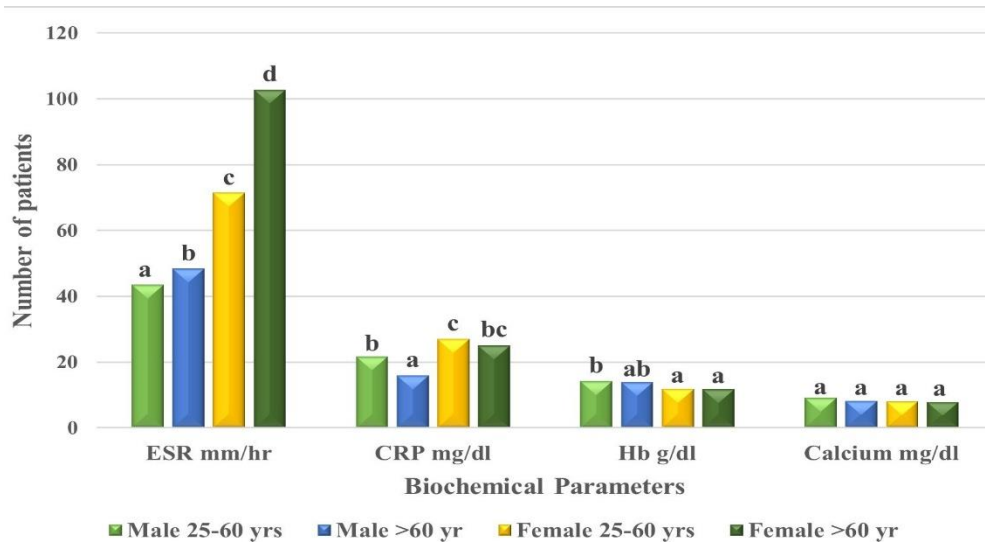


Figure 2. Mean Biochemical parameters of RA patients (n= 300)

*Values carrying different superscripts a,b... for each biochemical parameter between gender differ significantly ($p < 0.05$)

Effect of drugs on GI health

The long-term management of RA pharmacological intervention, the common drug classes include NSAIDs, corticosteroids, conventional DMARDs which can significantly impact gastrointestinal (GI) health. Understanding these effects is essential for optimizing nutritional status while minimizing complications. RA medications are essential, but has increased risk of mucosal damage, altered immunity and microbiota changes. The prescribed drugs, its mechanism of action and adverse effects on GI health is presented in Table 6. The patients expressed complaints of gastritis, nausea, vomiting, low appetite, bloating and constipation/ loose motion. All the symptoms have impact on food intake and nutrient metabolism, which may lead to inadequate nutrient status. A multidisciplinary approach involving medical management and nutritional support is critical to minimize complications and improve patient outcomes.

Table 6: RA drugs Dosage, Mechanism of action and Adverse Effect on GI health

Drugs	Mechanism of action	Side effects on GI Health	No. of patients with GI disturbance
Tab. Methotrexate (Dosage: 5mg – 25mg)	<ul style="list-style-type: none"> • Inhibition of Pro-inflammatory Cytokines. • Alteration of Immune Cell Function. • Folate Antagonism. • Adenosine Signaling. 	Nausea, vomiting, & diarrhoea	Nausea & Vomiting- 17 • Bloating- 112 • Constipation/Loose motion- 97
Tab. Folic acid (Dosage: 5mg – 15mg)	<ul style="list-style-type: none"> • Supplementation with folic acid ensures sufficient availability of tetrahydrofolate, thereby supporting normal cell function and development. 	Nausea, bloating, & gastritis.	• Gastritis- 218 • Low appetite- 199
Tab. Hydroxychloroquine (Dosage: 100mg – 500mg)	<ul style="list-style-type: none"> • Inhibition of Cytokine Production Suppression of Toll-like Receptors (TLRs). • Alteration of Lysosomal Activity Inhibition of Antigen Processing. 	Nausea, vomiting, abdominal cramps, & diarrhoea	
Tab Leflunomide (Dosage: 5mg – 25mg)	<ul style="list-style-type: none"> • Reduces inflammatory cytokine production, leading to decreased joint inflammation and damage. 	Diarrhoea	
Inj. Rituximab (Dosage: 500mg – 1000mg)	<ul style="list-style-type: none"> • Depletion of B cells through targeting CD20, leading to reduced disease activity and improved patient outcomes 	Nausea, vomiting, Diarrhoea, & abdominal pain	

Comorbidities Data

Table 7 shows the comorbidities data of patients diagnosed with RA. Co-morbidity refers to the presence of one or more additional medical conditions or diseases combined with Rheumatoid Arthritis. According to the inclusion criteria three co-morbid conditions presented, Hypertension (HTN), Type 2 Diabetes (T2DM), and Thyroid conditions. Patients above 60 years old, both male and female, had HTN and T2DM. Thyroid was predominantly high in females, may be because of age, hormonal changes, menopause and history of hysterectomy²⁵.

Table 7. Comorbidities data of patients with RA

Comorbidities	Male (n=45)		Female (n=255)		Total
	25-60 years	>60 year	25-60 years	>60 year	
Co-morbidity HTN	06	07	33	16	62
T2DM	02	04	17	10	33
Thyroid	-	01	33	03	37

Physical Activity Data

In the physical activity data presented in Table 8, out of total 300 patients, only 40.3% of patients (n=121) reported being physically active in comparison to 59.7% of patients (n=179), who were not doing any physical activity on daily basis, hence showing at risk of

joint stiffness and possibilities of developing comorbidities. Among male patients 71.1% of were active in comparison to 34.9% of females. Around 45.5% of patients (n=55) reported doing exercises 1-2 days in a week, and only 3% were physically active every day (n=9). About 90% (n=110) of patient's mode of exercise was walking on regular basis. Physical activities like Yoga/stretching, gardening were preferred by very few participants. The data reveals the physical inactivity seen among individuals with RA, particularly females and those who are aged above 60. The fact that individuals depend too much on just walking exercises and have low physical activity frequency is an indicator of the need to provide physiotherapy interventions. Reduced physical activity may lead to positive energy balance, increasing the risk of high visceral fat deposition, overweight, and other metabolic conditions such as T2DM, and HTN.

Table 8. Physical activity of the patients (n=300)

Physical activity		Male (n=45)		Female (n=255)		Total
		25-60 years	>60 year	25-60 years	>60 year	
Regular physical activity	Yes	21	11	77	12	121
	No	6	7	129	37	179
No of days of physical activity	Never	6	7	129	37	179
	1-2 days	9	5	35	6	55
	3-4 days	6	3	25	3	37
	5-6 days	4	2	12	2	20
	Everyday	2	1	5	1	9
Type of physical activity	Walking	17	9	74	10	110
	Yoga/stretching	0	0	1	0	1
	Gardening	3	2	0	2	7
	Exercise	1	0	2	0	3

Sun Exposure Time

Study shows the sunlight exposure pattern among RA patients indicates major deficiencies with respect to Vitamin-D synthesis chances, which is an important aspect in musculoskeletal condition in patients with Rheumatoid Arthritis. Table 9 shows that the patients were having insufficient exposure and frequency is relatively high, < 8% of patients (n=24) expose to daily sunlight, while 50.4% were getting exposure "Occasionally" (n=151), and– 24.7% were exposing once a week. The timing of the exposure, a strong preference shown exposing to sunlight in the early morning, with 81% (n=243) of patients were exposed before 10 AM. Less than 12.7% patients were exposing themselves (n=38) from 10 AM - 1 PM. Avoiding the mid- day sunlight, the optimal peak angle of the sun may not be achieved within this timeframe due to seasonal and geographical factors. The 13% of patients exposed only face to the sunlight, while 72% patients exposed face and arm (n=216), less than 14% (n=41) of

patients include legs in this list, and nobody exposed whole body. The predisposition is evident within female group, with the majority of female having inconsistent exposure frequency. The less sun exposure rate may contribute to higher vitamin D deficiency among RA patients, which can lead to increased disease activity and low bone mineral density. As RA patients are under medication requires sun protection as they have photosensitivity, limited exposure rate and surface area suggest a high dependence on supplements for maintaining the adequate vitamin D level. From the study, sunlight exposure highlights inconsistency between environment and behaviour that can adversely affect the outcome of Rheumatoid Arthritis. Approximately 75% of the sample population gets sunlight infrequently or weekly. Moreover, there was a trend towards early morning sun exposure and inadequate skin exposure, which is not an efficient synthesis of Vitamin D.

Table 9. Sun exposure of the patients (n=300)

Sun exposure		Male (n=45)		Female (n=255)		Total
		25-60 years	>60 year	25-60 years	>60 year	
No of days exposed to sunlight	Everyday	5	3	12	4	24
	4 – 6 days/week	6	4	22	5	37
	2 – 3 days/week	7	4	38	9	58
	Once a week	4	3	55	12	74
	Occasionally	3	2	59	13	77
	Rarely / Never	2	2	20	6	30
Time of exposure	Morning (before 10 AM)	14	15	171	43	243
	Midday (10AM – 1PM)	11	1	23	3	38
	Evening (after 4 PM)	2	2	12	3	19
Exposed areas	Only face	1	2	33	16	52
	Face and arms	16	14	157	29	216
	Face, arms & legs	10	1	26	4	41
	Whole body	0	0	0	0	0

In recent years, there has been an increase in the prevalence of RA. It is observed that usually the dietary intervention is given less importance in the RA treatment regimen. Adequate diet, nutrients, and lifestyle patterns play a pivotal role in the prevention and management of RA apart from standard treatment and medication.

Practical implication of the study

Reveals the food consumption pattern, extent of change in food intake pattern, nutrition transition and its impact on the nutritional status of RA patients. Helps in identifying risk of triple burden of malnutrition and disease progression. Gives insights for better understanding the underlying nutritional risks, implementing strategies to improve food choices, nutrient intake and adequacy combating nutritional deficiencies. Improved nutritional status will enable good response for RA treatment process by delaying disease progression and also alleviating the RA activity, hence improving the overall quality of life of patients with RA.

Limitations of the study

The study is limited to selected urban and rural locations of Mysuru region, Karnataka. Patient recruitment is age specific and with selected co-morbidities. This study includes representative group of patients with RA condition; however, the extent of RA activity and nutrition adequacy need to be established in larger population for planning and implementing strategies for sustainable RA management.

CONCLUSION

The impact of diet on RA disease activity, pathogenesis, and beneficial effects of nutrients on inflammation and immunity can be established through clinical and biochemical parameters. In our study, according to the dietary intake adequacy, there was a high consumption of macronutrients such as carbohydrates, fat and a low consumption of proteins, and micronutrients such as calcium, iron, potassium, and zinc might alleviate the inflammation. High CHO & fat intake may interfere with micronutrient bioavailability and metabolism. The patients had known clinical symptoms, which can be managed/reduced effectively through proper dietary and lifestyle interventions. Consumption of protective nutrients, physical activity, and weight management may represent helpful tools for disease management, aid in the reduction of inflammation, symptoms, and disability. Adequate dietary and lifestyle intervention as a preventive therapy may help in delaying/reversing the disease progression. The future scope of this study is to design and evaluate the efficacy of functional food formulation, with no/fewer side effects using anti-inflammatory foods & low-cost unconventional greens which may be advocated as adjunct therapy or as preventive therapy, relieving pain and delaying disease progression.

Funding –JSS AHER Student Research Grant, JSSAHER/REG/RES/URG/54/2011-12/7541, Dated 29.09.2022.

Conflict of interest- All authors declare no conflict of interest.

ABBREVIATIONS:

RA	Rheumatoid Arthritis
BMD	Bone Mineral Density
T2DM	Type 2 Diabetes Mellitus
HTN	Hypertension
FFQ	Food Frequency Questionnaire
RDA	Recommended Daily Allowance
Hb	Haemoglobin
ESR	Erythrocyte Sediment Rate
CRP	C – Reactive Protein
WHO	World Health Organisation
BMI	Body Mass Index
NSAID's	Nonsteroidal Anti-Inflammatory Drugs
DMARD's	Disease-Modifying Antirheumatic Drugs
TLRs	Toll-like Receptors
CD20	Cluster of Differentiation 20
QOL	Quality Of Life

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