IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Assessment Of Dietary Protein Intake In Apparently Healthy Adults Aged 41-60 Years Across High And Low Socioeconomic Strata In Mumbai

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Abstract: Sarcopenia, characterized by the gradual decline in skeletal muscle mass and strength, can start as early as the fourth decade of life. While protein intake has been linked to skeletal muscle mass and strength in older adults, there is a gap in understanding similar connections in middle-aged individuals. The aim of the study is to assess the dietary protein intake in an apparently healthy population aged 41-60 years across high and low economic strata in the Mumbai suburbs. The study included 100 community-dwelling adults, aged 41-60 years, from both low and high socioeconomic strata. Participants completed a 24-hour dietary recall for three days. Demographic and socioeconomic details were collected via a self-administered questionnaire and the Modified Kuppuswamy Scale 2023. Body composition and handgrip strength were measured, and physical activity was assessed in MET-minutes/week. The mean protein intake aligns with the Estimated Average Requirement (EAR) but falls short of the Recommended Dietary Allowance (RDA), highlighting the need for interventions to improve protein adequacy in this population. Protein intake from plant sources was seen on a more frequent basis than protein intake from animal sources. It was observed that high protein intake was directly associated with greater muscle mass and strength.

Index Terms - Protein intake, sarcopenia, body composition, handgrip strength

I. INTRODUCTION

1.1 Background

In order to maintain optimal health, growth, and development across the lifespan, it is essential to ensure an adequate intake of dietary protein. Throughout adulthood, the requisites for protein are significantly influenced by factors such as body mass, lean body mass, net energy balance, and engagement in physical activity (Baum & Wolfe, 2015). A noteworthy demographic shift is observed in India, where the population aged 60 years and older is anticipated to surge from 101.5 million in 2011 to 227.4 million by 2036, primarily attributed to increased longevity (Ministry of Statistics and Programme Implementation, 2022). The substantial size of this aging cohort underscores the critical need for the implementation of dietary guidance to enhance their health and well-being, thereby fostering a trajectory of healthy aging. Significantly, ensuring an adequate intake of protein emerges as a pivotal nutritional factor in preserving independence, notably by preventing the onset of conditions like sarcopenia, frailty, and associated comorbidities in later life (Lonnie et al., 2018).

As age advances, there is a loss of skeletal muscle strength and function, affecting physical performance and activities of daily living. Sarcopenia, a progressive muscle disorder that results in loss of skeletal muscle mass and strength, increases the risk of impairment in the ability to perform daily activities, falls, fractures, and mortality. Although sarcopenia becomes increasingly visible with age, it can be detected in certain adults as early as their forties. (Jun et al., 2021). Muscle loss may begin as early as 30 years of age at a rate of 3–8% per decade in certain cases (Paddon-Jones & Rasmussen, 2009). As a result, from the standpoint of primary prevention, middle age may be a vital moment to implement preventive treatments to lower the incidence of sarcopenia.

1.2 Recommended Dietary Allowance for Protein

The recommended daily allowance (RDA) for protein is based in most jurisdictions on the "safe" requirement to maintain body nitrogen balance (WHO/UNU/FAO, 2007) and is given as 0.80 g protein/kg body weight for adults of all ages (Institute of Medicine, 2005).

In 2020, new protein intake recommendations were established for adults in India. These guidelines suggest that the Recommended Dietary Allowance (RDA) for protein should be 0.83 grams per kilogram of body weight per day, which is slightly lower than the previously recommended 1 gram per kilogram per day in 2010. The Estimated Average Requirement (EAR) for protein intake is advised to be 0.66 grams per kilogram of body weight per day. For individuals who primarily consume diets rich in cereals and low-quality protein, the recommended protein intake remains at 1 gram per kilogram of body weight per day, as per the 2020 guidelines from the Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN).

1.3 Dietary Protein Intake in Indian population

Indians adhering to a predominantly vegetarian diet may not meet the recommended daily allowance of protein. It has been estimated that 60% of the protein Indians consume in their diet comes from cereals, which have low digestibility and are an incomplete protein source. As cereals are deficient in lysine, they do not provide all essential amino acids (Swaminathan S, et al., 2012). Indians consume a diet that is both low in quality and low in quantity (Kurien et al., 2020). In India, while there's been a shift towards more expensive animal-based protein sources like milk, meat, and eggs, the risk of protein deficiency remains high as cereals still dominate the diet, with high-quality protein sources like, milk, eggs, fish, and meat being consumed in smaller quantities (Minocha et al., 2019).

Across different sectors and social groups in India, cereals dominate protein intake, especially in rural areas. Urban areas consume more pulses and animal-derived foods like milk, meat, eggs, and fish due to greater dietary diversity. This shift is driven by increased accessibility to a variety of food supplies, evolving tastes and preferences, and changes in the relative prices of different food items (Priya Rampal, 2018). Dietary choices in India are shaped by various socioeconomic factors such as rural or urban residence, income, education, social group, and religion (Athare, Pradhan, & Kropp, 2020). Notably, households with lower incomes allocate a larger portion of their budget to staple food products, rendering them more responsive to fluctuations in food prices and income (Priya Rampal, 2018).

1.4 Protein intake and muscle mass

Insufficient intake of dietary protein poses a challenge to both muscle and whole-body protein balance, disrupting the equilibrium between protein synthesis and breakdown. This imbalance has adverse effects on muscle mass, function, exercise adaptations, bone health, calcium homeostasis, immune response, fluid-electrolyte balance, enzyme activity, and hormone synthesis. When dietary protein is inadequate, muscles undergo catabolism to supply amino acids, sustaining ongoing endogenous protein synthesis in vital physiological tissues and organs (Carbone & Pasiakos, 2019)

There is a growing global population of individuals aged 65 and older, leading to an increased need for strategies to combat age-related skeletal muscle deterioration. Research shows muscle mass begins to decline from the third decade of life, with a 30-50% decrease between ages 40 and 80, and muscle strength drops rapidly after 50 (Lonnie et al., 2018). Therefore, the early stages of one's fourth decade of life are seen as a critical period when the aging process of muscles begins. This stage presents an optimal opportunity for implementing dietary changes to prevent or delay the onset of sarcopenia.

As such, there is a clear need for further research to assess the role of dietary protein intake among middle-aged adults to inform early interventions aimed at preserving muscle health and preventing sarcopenia. This study aims to assess the quantity and quality of dietary protein intake in adults aged 41-60 across different economic strata in Mumbai and to explore its relationship with body composition, handgrip strength, and physical activity.

II. METHODOLOGY

2.1 Study design and population

The present study was a cross-sectional study. 110 participants were screened using a purposive convenience sampling method and 100 were selected for the study based on the screening criteria. Adults aged 41 to 60, residing in Mumbai suburbs were selected for the study after obtaining informed consent.

2.2 Data Collection

The study participants completed a detailed questionnaire covering sociodemographic details, including sex, age, education, and socioeconomic status using the modified Kuppuswamy SES scale (2023). Anthropometric assessments were conducted, with height determined through self-reported information and weight measured using a weighing scale. Skeletal muscle mass and body composition were assessed using a Tanita BC-541 Body Fat Analyzer. Handgrip strength was evaluated with a handgrip dynamometer. Dietary protein intake was assessed through a 24-hour dietary recall over three non-consecutive days, and a food frequency questionnaire (FFQ) focusing on 22 protein-rich food items was administered. Physical activity was assessed with the Global Physical Activity Questionnaire (GPAQ), and metabolic equivalent scores (MetS) were calculated for each participant.

2.3 Statistical analysis

Data analysis was performed using SPSS (Statistical Package for Social Sciences) software. Data was generated in the form of tables and figures. Descriptive statistics such as mean, frequency, median, and standard deviation were used to analyze socio-demographic variables and anthropometric measurements. Inferential statistics such as the chi-square test, levene's test and independent t sample test was performed to determine the association between two variables. One way ANOVA test was performed to determine the association between three variables.

III. RESULTS

110 participants were screened and assessed for eligibility, out of which 4 participants were excluded due to incomplete data, 8 participants did not meet the inclusion criteria and 2 participants declined to participate. Hence, the data was analyzed for 100 participants (n=100). The data presents a comprehensive overview of various parameters across different protein intake categories within the study population.

Table 3.1: General characteristics, Macronutrient intake, Body Composition, Handgrip Strength, and Physical Activity across the Tertiles of Protein Intake.

	(Mean ± SD) or proportions (n)	**T1 (<44.5g/day)**	**T2 (44.5-56.04g/day)**	**T3 (>56.04 g/day)**	**P value**
N	100	25	49	26	
Age (years)	50.5±5.03	50.6±3.64	51.45±6.05	49.56± 5.42	0.04
Gender					
Males (n)	35	5	19	11	0.03
Females (n)	65	20	30	15	
Socioeconomic class					
Lower Class n (%)	62 (100%)	17 (68)	31 (63.3)	14 (53.8)	0.56

Upper class n (%)	38 (100%)	8 (32)	18 (36.7)	12 (46.2)	
Macronutrient Intake					
Energy (Kcal)	1584±164.99	1338.32±199.48	1620.29±152.39	1793.55 ±143.1	< 0.00001
Carbohydrates (g)	228.89±31.38	195.11±33.94	236.48±32.72	255.08±27.48	< 0.00001
Protein (g)	49.9±3.55	38.5±3.84	50.3±2.68	60.92 ± 4.14	< 0.00001
Fat (g)	52.9±9.42	45.36±8.98	53.44±10.09	60.18±9.21	< 0 .0001
Body composition					
Fat (%)	34.43±8.74	35.6±10.48	33.58±7.63	34.11±8.11	0.61
Muscle mass (kg)	44.09±9.97	39.7±6.58	42.87±10.98	49.7±12.37	0.003
Basal metabolic rate (kcal)	1326±231.4	1236.9±179.2	1262.8±223.5	1478.3±291.5	< 0.0001
Bone mass (kg)	2.51±0.45	2.39±0.41	2.39±0.47	2.77±0.47	0.001
Visceral Fat (kg)	10.4±3.75	8.36 ± 3.26	10.4± 4.01	12.48±3.99	< 0.0001
Handgrip Strength					
Handgrip strength(kg)	24.1±17.42	20.5± 4.55	25.7 ± 6.56	26.1±6.31	0.0004
Physical Activity					
Physical activity in MetS-min/week	1455.4±1530	895±625.2	2193±2421.9	1278.4±154 2.9	0.01

Significance level is p <0.05; SD = Standard Deviation

Participants were categorized into Tertiles based on daily protein intake: T1 (<44.5g/day), T2 (44.5-56.04g/day), and T3 (>56.04g/day). Age varied slightly across groups, with T2 (moderate protein) having a higher average age compared to T1 and T3. Gender distribution differed significantly (p=0.03), with T2 having a higher proportion of males. Socioeconomic class, based on the Modified Kuppuswamy Scale (2023), showed no significant differences among groups (p=0.56). Lower class representation was high in all Tertiles, with the highest in T1 (68%) and the lowest in T3 (53.8%).

Macronutrient analysis showed significant differences across protein intake Tertiles (all p < 0.00001). Higher protein intake was associated with increased energy, carbohydrate, and fat consumption. Energy intake increased from T1 (1338.32 ± 199.48 kcal) to T3 (1793.55 ± 143.1 kcal), and carbohydrate intake increased from 195.11 ± 33.94 g in T1 to 255.08 ± 27.48 g in T3. Protein intake ranged from 29.6 to 70.2 g/day, with T3 having the highest intake (60.92 ± 4.14 g). Fat intake also increased from T1 (45.36 ± 8.98 g) to T3 (60.18 ± 9.21 g). The mean protein intake was found to be 0.75g/kg/day.

Participants in T3 had significantly higher muscle mass (49.7 ± 12.37 kg) and basal metabolic rate (1478.3 ± 291.5 kcal) compared to T1 (muscle mass: 39.7 ± 6.58 kg; BMR: 1236.9 ± 179.2 kcal) and T2 (muscle mass: 42.87 ± 10.98 kg; BMR: 1262.8 ± 223.5 kcal) (muscle mass p = 0.003; BMR p < 0.0001). Visceral fat levels were highest in T3 (12.48 ± 3.99 kg), followed by T2 (10.4 ± 4.01 kg) and T1 (8.36 ± 3.26 kg) (p < 0.0001). Handgrip strength was significantly higher in T2 (25.7 ± 6.56 kg) and T3 (26.1 ± 6.31 kg) compared to T1 (20.5 ± 4.55 kg) (p = 0.0004). Physical activity levels were highest in T2 (2193 ± 2421.9

MetS-min/week), followed by T3 (1278.4 ± 1542.9 MetS-min/week), and lowest in T1 (895 ± 625.2 MetS-min/week) (p = 0.01).

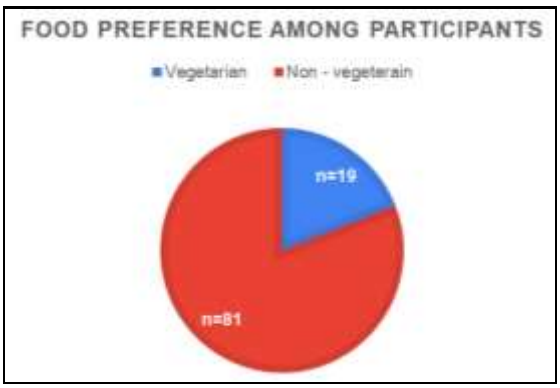

Figure 3.1: Dietary preferences among participants

Figure 3.1 shows the food preferences of participants in a study. It was observed that the majority, specifically 81% of the participants, had a non-vegetarian dietary preference.

Table 3.2: Mean protein intake in grams per day among participants with vegetarian and non-vegetarian dietary preference

Dietary preference (Mean ± SD)		**Mean protein intake, g/day**	**P-value**
Vegetarian	n=19	44.1 ± 7.3	<0.005
Non - vegetarian	n=81	51.5 ± 8.5	

Significance level is p <0.05; SD = Standard Deviation

Among vegetarians and non-vegetarians, the results indicate a statistically significant difference (p=<0.005) in mean protein intake. On average, non-vegetarians exhibit a significantly higher mean protein intake in grams per day compared to vegetarians (refer table 2)

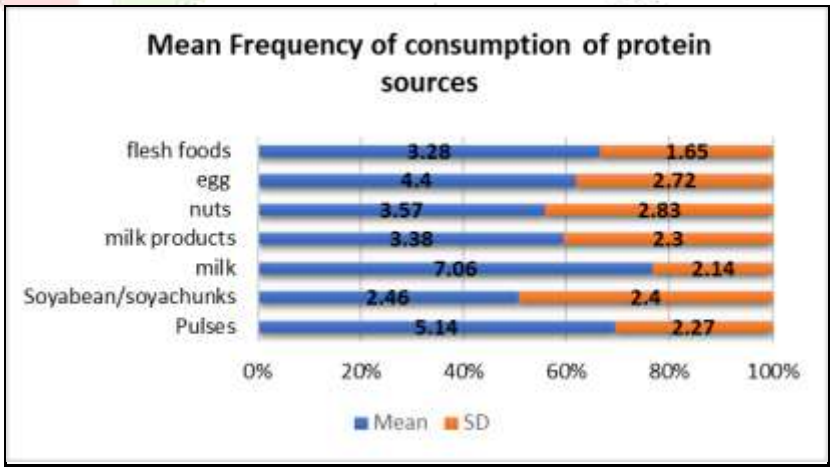

Figure 3.2: Average Consumption Frequencies of Animal and Plant Protein Sources

Once a week=7; Twice a week=6; > 2 times a week=5; Once in 15 days=4; Once a month =3; Once in 6 months=2; Rarely=1; Never=0

Figure 3.2 shows average consumption frequencies of various protein sources on a scale from 0 (Never) to 7 (Once a week). Pulses are the most frequently consumed, with a mean frequency of 5.14 ± 2.27, indicating they are eaten more than twice a week. Milk follows, with a mean frequency of 7.06 ± 2.14,

suggesting it is consumed weekly. Eggs are consumed with a mean frequency of 4.4 ± 2.72, roughly every 15 days. Nuts and milk products have mean frequencies of 3.57 ± 2.83 and 3.38 ± 2.30, respectively, indicating monthly intake. Flesh foods are consumed slightly more than once a month, with a mean frequency of 3.28 ± 1.65. Soybean has the lowest mean frequency at 2.46 ± 2.40, indicating infrequent consumption, approximately every six months to once a month. Pulses and milk are dietary staples, while soybean and flesh foods are consumed less frequently.

The study also compared the mean consumption of various food items between lower class (62 participants) and upper class (38 participants), revealing notable differences in dietary preferences. The frequency of consumption of specific pulses like Rajma/Chickpeas/Chana, soybean/soya chunks was significantly higher in the lower class compared to the upper class. While cow's milk consumption frequency was slightly higher in the upper class and buffalo's milk consumption frequency was significantly higher in the lower class. Consumption frequency of walnuts and pistachios was notably higher in the upper class. There was no significant difference in egg consumption frequency between the two classes. Chicken consumption frequency showed a slight but non-significant difference. Fish and red meat consumption frequency exhibited no significant difference.

Table 3.3: Mean Body composition, handgrip strength, physical activity MET-minutes/week among male and female participants

Variable	Male (Mean ± SD)	Female (Mean ± SD)	P-value
Fat %	26.2033 ± 6.506	38.1274 ± 8.165	< 0.001
Total Body Water (%)	55.16 ± 20.59	44.45 ± 7.91	< 0.001
Muscle Mass, kg	51.5 ± 8.931	40.3 ± 11.711	< 0.001
Basal Metabolic Rate (kcal)	1481.26 ± 1481.2	1230.84 ± 246.34	< 0.001
Bone mass (kg)	2.79 ± 0.538	2.31 ± 0.559	< 0.001
Visceral Fat (kg)	13.74 ± 3.860	8.68 ± 2.878	< 0.001
Hand grip (Kg)	31.03 ± 6.43	20.52 ± 4.704	< 0.001
Total physical activity MET-minutes/week	2480.11 ± 2842.85	1173.54 ± 1021.08	0.001

Significance level is $p < 0.05$; SD = Standard Deviation

Males exhibited lower percentages of body fat, higher muscle mass, and higher basal metabolic rates compared to females. Additionally, males tend to have higher bone mass and hand grip strength. Visceral fat and total physical activity in MET-minutes per week are also notably higher in males compared to females (refer table 3.3)

Table 3.4: Association between protein intake and physical activity level with Body composition and handgrip strength

Protein intake and Physiological parameters (Mean ± SD)	Low physical activity level	Moderate physical activity level	High physical activity level.	P-value
	n= 24	n= 59	n= 17	
Protein intake, g/kg	0.76 ± 0.22	0.7758 ± 0.20	0.75 ± 0.172	0.369
Fat %	33.50 ± 9.14	36.80 ± 7.63	27.36 ± 7.07	0.930
Total body water, %	48.65 ± 6.71	48.36 ± 16.04	53.14 ± 5.22	0.783
Muscle mass, kg	45.59 ± 11.65	41.84 ± 10.71	45.48 ± 6.48	0.642
Basal Metabolic Rate, kcal	1425.04± 335.51	1260.40 ± 195.27	1330.58 ± 172.72	0.185
Bone mass, kg	2.56 ± 0.99	2.41 ± 0.42	2.61 ± 0.27	0.02
Visceral Fat, kg	12 ± 4.53	9.50 ± 3.28	11.70 ± 4.46	0.017
Handgrip strength, kg	25.54 ± 7.51	23.14 ± 5.64	28.84 ± 6.10	0.06

MET-minutes/week > 3000 = high activity level,
MET-minutes/week > 600 and < 3000 = moderate activity level.
MET-minutes/week < 600 = low activity level.
Significance level is p <0.05; SD = Standard Deviation

Table 3.4 presents the association between Protein intake and physical level with body composition and handgrip strength. The mean protein intake was 0.75g/kg/day. Fat percentage, total body water, muscle mass, and basal metabolic rate do not show significant differences among the groups, with p-values ranging from 0.369 to 0.930. However, there are notable differences in bone mass and visceral fat. The higher activity group exhibits higher bone mass and he low physical activity group exhibits higher levels of visceral fat compared to moderate and high activity groups. Handgrip strength shows a borderline significance level (p = 0.06), suggesting a potential difference that warrants further investigation.

IV. DISCUSSION

This study found that among individuals aged 41-60 in suburban Mumbai, the mean protein intake was 0.75g/kg/day, close to the estimated average of 0.66g/kg/day but below the Recommended Dietary Allowance (RDA) of 0.83g/kg/day. While the RDA for protein is 0.83g/kg/day, evidence suggests that higher intake, between 1.0–1.2g/kg/day, is linked to better physical performance, muscle mass maintenance, and reduced risk of physical impairment, particularly in older adults (Gaytán-González et al., 2020). Both (Bauer 2013) and (Taylor 2024) emphasize the importance of increased protein consumption among older adults to enhance their health and functionality, suggesting that this may also apply to middle-aged adults. The findings of this study indicate variations in the frequency of consumption of different protein sources among the participants, with plant-based sources being consumed more frequently than animal-based ones. A 24-hour dietary recall of the participants indicated that cereals constitute a major part of the population's diet and serve as a significant source of protein. Studies propose that heightened plant protein consumption correlates with reduced decline in physical performance among older females (Famularo. 2023). Nonetheless, the consumption of plant protein-rich foods remains generally insufficient among adults, impacting the overall dietary quality (Suey, S.Y., Yeung., Jean, Woo. 2022). Elevated levels of animal protein intake are linked to a higher probability of fulfilling the protein intake recommendations among adults (M., Katherine, et.al, 2022). As a result, it is essential to adopt a comprehensive approach that includes a variety of both plant and animal protein sources to maximize nutrient intake and promote overall well-being in adults.

The outcomes suggest that dietary preferences and consumption patterns differ across socioeconomic strata, potentially influenced by economic circumstances, cultural inclinations, and food accessibility. The correlation between protein intake and socioeconomic status is intricate, with some studies indicating a connection while others find no substantial correlation. (Khattak 2012) did not discover a direct link between protein intake and socioeconomic status. Conversely, (Kwon 2019) and (Park 2020) identified that higher socioeconomic status was related to increased animal protein consumption, particularly among the elderly population in Korea.

Across the protein intake Tertiles, higher protein intake was associated with greater muscle mass. Several studies have established a positive correlation between protein intake and lean body mass in adults. For instance, (Parker 2010) observed greater lean mass in men with higher protein intake. Preserving and increasing muscle mass is crucial for preventing health risks like metabolic syndrome, diabetes, and sarcopenia (Takae Shinto et al., 2022). Long-term observational studies, including the Health, Aging and Body Composition (Health ABC) cohort study, have consistently demonstrated a positive association between protein intake and the preservation of lean mass in older adults (Deer & Volpi, 2015). Physical activity, particularly muscle-strengthening exercises, plays a crucial role in increasing muscle mass, especially when combined with adequate dietary protein intake, as highlighted in the study (Morris & Jacques, 2012; Wu, 2016)

Significant differences were noted in mean hand grip strength across the three protein intake groups, with participants in the high protein intake category demonstrating greater mean handgrip strength compared to those in other protein groups. This finding is consistent with previous research indicating a positive association between protein intake and hand grip strength in various populations. For instance, a study by Jun et al. (2021) associated protein intake with appendicular lean mass and hand grip strength in middle-aged adults, while Putri et al. (2021) found a similar relationship in elderly women. Additionally, a pooled analysis of individual participant data from four longitudinal aging cohorts, conducted by (Nuno Mendonça et al., 2022), revealed that higher protein intake above Recommended Dietary Allowance (RDA) levels is not linked to handgrip strength in older adults.

Our findings revealed that Individuals with moderate protein intake levels tend to exhibit greater activity levels. While the relationship between protein intake and physical activity is complex, with some studies indicating a positive correlation and others finding no clear association. Research in older adults suggests a protective effect of higher protein intake on physical function decline. Studies by (Mendonça 2021), (Lourida 2021), and (Coelho-Júnior 2018) support this notion, emphasizing the beneficial impact of higher protein intake on physical performance in older adults. Findings of this study also revealed that individuals with higher physical activity had higher bone mass density and lower visceral fat. Our findings showed borderline significance between physical activity and handgrip strength, with higher handgrip strength observed in participants with a high level of physical activity. (Labott 2019) conducted a meta-analytical review and found that exercise training had small but significant effects on handgrip strength in healthy older adults.

In conclusion, this study underscores the importance of adequate dietary protein intake in middle-aged adults for preserving muscle health and physical function. The findings indicate that the mean protein intake among the study participants aligns closely with the estimated average but falls below the Recommended Dietary Allowance. High protein intake was significantly associated with high muscle mass and high handgrip strength, indicating the importance of protein adequacy for maintaining muscle mass and physical performance. Future research with larger sample sizes should explore these associations further, including intervention studies to determine optimal protein intake levels and their impact on long-term health outcomes.

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