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ORIGINAL ARTICLE

Vitamin B12 status and skeletal muscle function among elderly: A literature review and pilot study on the effect of oral vitamin B12 supplementation in improving muscle function

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Abstract

Objectives: The objective of this study is to understand the role of vitamin B12 supplementation in improving skeletal muscle function among the elderly.

Methods: A literature review in the Medline database was conducted to understand the association between vitamin B12 and muscle function in Section A. In Section B, 28 healthy elderly participants aged ≥60 years were recruited in a cross-sectional design for estimation of plasma vitamin B12 status and assessment of upper limb muscle strength Maximal voluntary contraction (MVC) and muscle quality (expressed as MVC/total muscle mass). Participants were grouped based on vitamin B12 status into vitamin B12-depleted (<148 pmol/L) and replete (≥148 pmol/L) groups. In a quasi-experimental study design, the vitamin B12-depleted group ($n = 14$) received daily oral vitamin B12 supplementation of 100 μg for 3 months. All the study measures were repeated post-supplementation.

Results: Vitamin B12 deficiency was identified to contribute adversely to muscle strength, quality, and physical performance among older people in the extensive literature review. The pilot intervention study showed significant improvement in MVC and muscle quality ($p < 0.050$) post-vitamin B12 supplementation, comparable to the vitamin B12-replete group.

Conclusions: Vitamin B12 may have a crucial role in the maintenance of muscle function. 3-month oral vitamin B12 supplementation among subclinical vitamin B12 deficient elderly improved muscle strength and quality and reached levels similar to the vitamin B12 replete group.

KEYWORDS
elderly, muscle function, muscle quality, subclinical, supplementation, vitamin B12

1 | INTRODUCTION

The increase in the elderly population worldwide has brought the focus on new challenges faced both at an individual and policy level. Aging leads to increased susceptibility to multimorbidity and reduced quality of life, thus increasing the economic burden on the health care system.[1,2] This is a concern, especially in developing countries like India, where older people constitute 8%

of the population, which is significant considering the country's population.[3] Progressive muscle mass and strength loss are also associated with aging.[4,5] Among the elderly, the decline in muscle strength is accelerated at a higher rate than the decline in muscle mass.[6,7]

Additionally, muscle strength, but not muscle mass, is independently associated with physical performance and mortality,[8] suggesting muscle strength is a better sensitive indicator of functional limitation. Therefore, exploring muscle mass might not provide an overall picture of functional changes and mobility status in the elderly population. It is essential to study muscle strength, particularly "muscle quality" (muscle strength by muscle mass, i.e., relative strength), to unravel functional incapacity, thus preventing the increased risk of falling or fractures.

As per the International Clinical Practice Guidelines for Sarcopenia (ICFSR), treatment of sarcopenia includes resistance-based physical activity and protein supplementation/protein-rich diet.[9] However, there is no recommendation for any other micronutrient supplementation. One of the reasons is the need for robust evidence supporting the utility of micronutrient supplementation as a treatment option. Micronutrient deficiency, including vitamin D, vitamin B12, Iron, etc., among the Indian population across the age strata (especially among children and the elderly) is high.[10,11] Vitamin B12 is among the most prevalent micronutrient deficiencies, especially among elderly Indians.[12] Dietary insufficiency may be a significant cause as the Indian diet is predominantly lacto-vegetarian due to socio-cultural factors. Consumption of meat, even among self-reported non-vegetarians, is relatively infrequent.[13] Other factors like parasitic infestations, Helicobacter pylori infection, and tropical sprue are common among elderly Indians and can result in limited absorption of vitamin B12, enhancing the problem of vitamin B12 deficiency.[12] The role of vitamin B12 on skeletal muscle is underestimated, especially in the context of the Asian Indian population. In addition, the impact of tissue metabolites of vitamin B12, namely, Hcy and MMA, on skeletal muscle needs further exploration. This article reviewed the available evidence from different populations to explore the association of vitamin B12 and its metabolites with skeletal muscle health among the elderly. This extensive literature review formed the basis of the pilot intervention subsequently presented in this article. Thus, the objectives of this study were to explore the effect of vitamin B12 and its metabolites on skeletal muscle strength and quality among the elderly and evaluate the impact of vitamin B12 supplementation on muscle function/quality among vitamin B12 deficient elderly.

This article is divided into two sections:

Section A: An extensive literature review to gather state-of-the-art evidence on the effects of vitamin B12 status on skeletal muscle.

Section B: Presents data from a pilot study on the role of vitamin B12 supplementation among subclinical vitamin B12-deficient, otherwise healthy elderly Indians for the first time.

1.1 | Section A: A literature review on the relationship between vitamin B12 and skeletal muscle

An extensive literature search was conducted on Pubmed and Google Scholar databases using combinations of the following keywords and MeSH terms: "vitamin B12", "muscle", "elderly", "aging", "physical performance", "B12 supplementation", and "frailty" without applying any time limit. Cross-references of the identified articles were checked to obtain additional relevant articles. Articles were selected in two steps: (i) screening based on title and abstract and (ii) evaluating the full text of the selected abstracts based on the inclusion criteria. The studies were included if they met the following criteria: (i) Available in English. (ii) They were conducted on human subjects of the elderly age group. (iii) The association of serum vitamin B12 concentration or its markers with muscle strength, mass, and physical performance was evaluated. (iv) They assessed the role of vitamin B12 supplementation on muscle function or performance indices. Based on this strategy, a total of 23 relevant articles were identified. Articles were removed if results were not available (study protocol, $n=2$), articles otherwise irrelevant to the literature search ($n=3$), and review articles ($n=1$). Seventeen articles were identified and included in this review (Table S1).

1.2 | Population-based studies

(i) MacArthur Studies of Successful Aging: One of the earliest evidence on serum homocysteine (Hcy) (a metabolite of vitamin B12) and decline in physical function came from this cohort conducted among 499 highly functioning elderly (age: 70 to 79 years, 270 women and 229 men). The elderly with elevated Hcy levels over 3 years had a higher risk of declining physical function. A 1.6-fold increased odds of decline in physical function was reported in the study with each SD increase in Hcy level after adjusting for age and baseline physical function.[14]

(ii) National Health and Nutrition Examination Survey (NHANES): Cross-sectional analysis of NHANES 1999–2002 data on 1677 elderly participants demonstrated an inverse association between Hcy with quadriceps strength and gait speed.[15] Another publication from the same cohort by Oberlin et al. ($n=3105$ participants aged 60 years) reported a higher prevalence of B12 deficiency with increasing age ($P<0.005$). Deficiency of vitamin B12 (<200 pmol/L) and elevated Hcy (>20 μmol/L) were associated with higher total disability, particularly in lower extremity mobility. Participants with low serum B12 level (<258 pmol/L) or high serum MMA (>0.21 μmol/L) had higher odds of developing total disability [OR = 1.600 (1.090, 2.340), $P=0.020$].[16] NHANES 2011–2012 and 2013–2014 included 9645 adult participants (mean age 49 years ± 17), both genders from several ethnicities, and observed lower muscle strength and physical functioning in the vitamin B12 deficient group. Muscle strength and physical functioning were significantly lower in participants with elevated MMA (>300 nmol/L) concentration compared with normal serum MMA.[17]

(iii) Singapore Longitudinal Aging Studies: A cross-sectional analysis of 796 participants (aged above 55 years) showed a negative association between Hcy and mobility, gait, and activity of daily living.[18] Elderly adults categorized based on Fried criteria for frailty in the robust ($n=62$), pre-frail ($n=86$), and frail groups ($n=60$) showed 2-fold higher b12 deficiency in the frail elderly compared with robust and 1.7-fold higher compared with pre-frail elderly. Vitamin B12 deficiency was notably 4.8-fold higher in the robust elderly than in young controls.[19]

(iv) The Baltimore Longitudinal Study of Aging: During 5.4 ± 2.0 years of mean follow-up (participants age 50 years or above, $n=774$), it was observed that increased Hcy concentration was associated with a decline in gait speed.[20] A significant decrease in grip strength with increasing Hcy over time was observed during 4.7 ± 3.1 years mean follow-up (ranging from 0 to 10.1 years) among women. There was an inverse association between Hcy and grip strength among men. However, the association was not statistically significant ($n=1101$).[21]

(v) Longitudinal Aging Study Amsterdam (LASA): In the cross-sectional analysis, there was a significant decline in physical performance, lower among women in the highest quartile of Hcy than women in the lowest quartile. In the longitudinal analysis, the association was observed to be borderline significant. Higher Hcy was associated with decreased handgrip strength and functional capacity at baseline among males, whereas among females, Hcy was related to functional limitation after 3 years.[22]

(vi) Korean Frailty and Aging Cohort Study: Cross-sectional analysis of 2325 participants (1112 men and 1213 women, aged 70–84 years) could not find any significant relationship between serum B12 levels with handgrip strength, physical performance and the severity of sarcopenia.[23] However, a previous publication from a cohort including 2938 participants (1400 men and 1538 women) showed that the elderly with serum-sufficient vitamin B12 had better physical performance, and frailty was widely prevailing in the B12 deficient group. However, the statistical association attenuated after adjusting for confounding.[24]

1.3 | Other observational studies

A cross-sectional study on 86 institutionalized elderly (majority women (84.4%)) observed a significantly lower handgrip strength with an increase in Hcy.[25] Another cross-sectional analysis of 403 elderly patients attending geriatric outpatient clinics reported 59.5% of vitamin B12 deficiency. Vitamin B12 deficient participants had a higher prevalence of sarcopenia and dynapenia (loss of muscle strength).[26] In a case–control comparison of community-dwelling sarcopenic and non-sarcopenic elderly adults ($n=66$ in each group), it was observed that vitamin B12 was a single vitamin significantly lower in the sarcopenic group than non-sarcopenic; the serum concentration of other vitamins was similar in both the groups.[27]

1.4 | Intervention studies

B-vitamins in the prevention of osteoporotic fractures (B-PROOF) study: This Randomized Controlled Trial aimed to evaluate the combined effect of 2-year vitamin B12 and folic acid supplementation on measures of physical performance, strength, and falling among the elderly. The intervention did not affect the age-related decline of physical function, handgrip strength, or fall prevention. However, a positive effect on gait and physical performance among compliant participants above 80 was reported.[28]

Discussion: Results from population-based cohorts and cross-sectional studies so far are indicative of the crucial role of vitamin B12 in maintaining muscle strength, quality, and physical performance, evidenced by the significant association of vitamin B12 deficiency with low muscle strength, decreased gait speed, sarcopenia, and frailty as observed in multiple studies. Multiple pathological mechanisms primarily regulated by the metabolites of vitamin B12, i.e., MMA and Hcy, could explain this association (Figure 1). Deficiency of vitamin B12 may result in elevated MMA and Hcy. Increased Hcy may stimulate reactive oxygen species (ROS) production, inducing inflammation and altering gene expression associated with muscle regeneration.[29] Hcy may further regulate skeletal muscle blood flow as increased levels are associated with decreased nitric oxide bioavailability. Hyperhomocysteinemia can also result in DNA methylation and affect skeletal muscle remodeling and repair.[29] Increased concentration of MMA is known to inhibit fatty acid oxidation in the mitochondria, resulting in decreased cellular oxidation and accumulation of ectopic fat.[30] These findings are validated in a murine model where mutations in methyl malonyl CoA mutase activity have shown decreased energy production, cellular respiration, and muscle weakness.[31,32]

One intervention trial was identified that evaluated the effect of combined vitamin B12, folic acid, and vitamin D supplementation on muscle strength, physical performance, and fall risk among elderly Dutch participants.[28] This trial did not observe a significant improvement in markers of muscle functionality. However, the positive effect on gait and physical performance in the subpopulation that is compliant with the intervention is promising. It should also be noted that the study mentioned above was prospective and involved 2 years of intervention. Thus, the effect of confounding, such as the occurrence of new-onset diseases, could not be ruled out.

1.5 | Section B: Pilot data to study the role of vitamin B12 supplementation on muscle function

The literature review in Section A provided the rationale for the pilot intervention study. This section of the article describes the

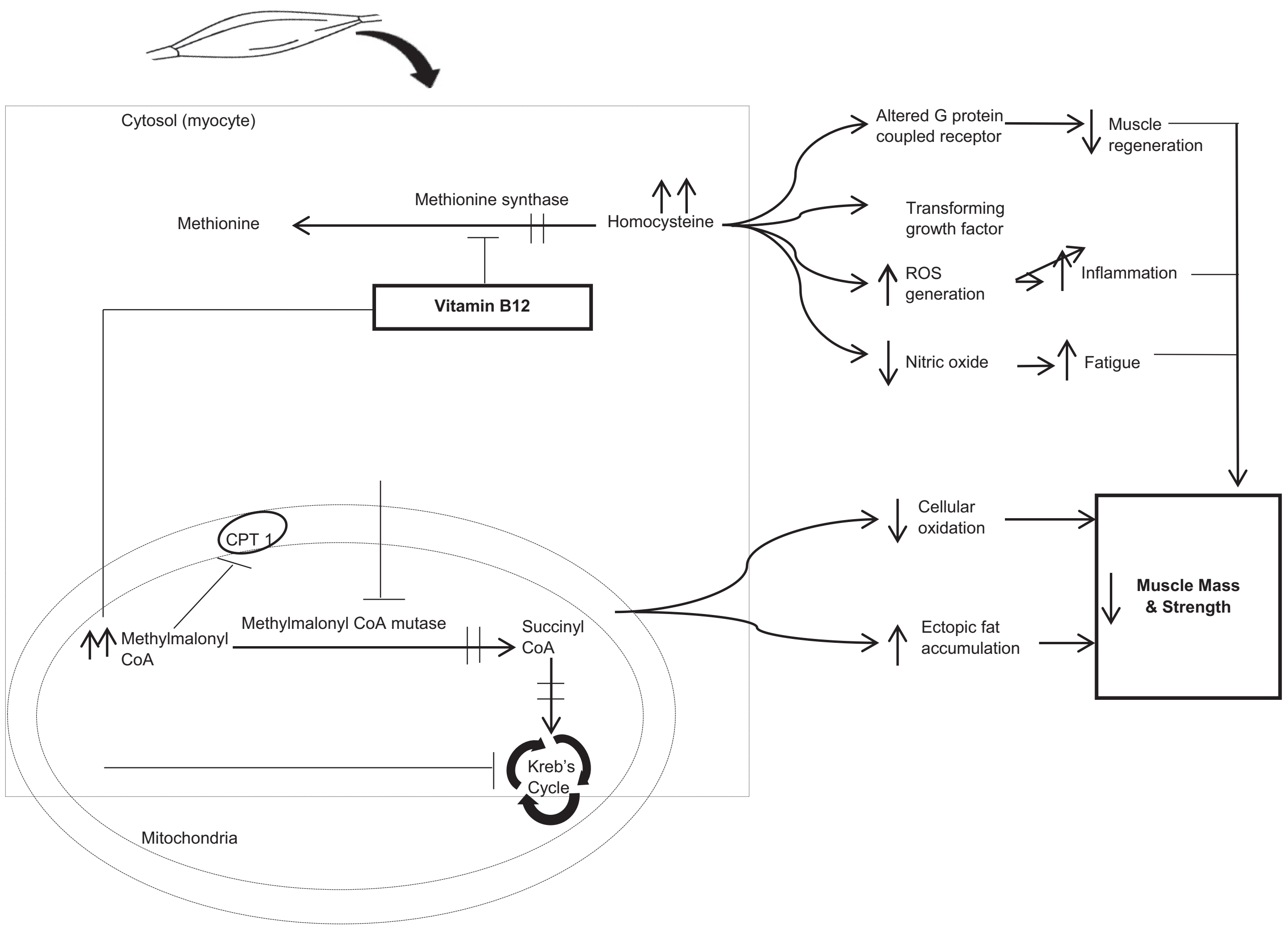

FIGURE 1 Potential mechanisms affecting skeletal muscle strength due to B12 deficiency.

intervention study that explored the effect of 100 µg oral vitamin B12 supplementation for 3 months on muscle strength and quality among the elderly.

2 | METHODOLOGY

2.1 | Participants

Using a cross-sectional study design, twenty-eight elderly volunteers (both genders) aged ≥60 years were recruited after reviewing for inclusion and exclusion criteria (any history of type 1 or 2 diabetes, hypertension, cancer, musculoskeletal disorders, on any supplementation or medication, or any respiratory disorders) between the period 2009 to 2011. Vitamin B12 and study parameters were collected in all subjects. The quasi-experimental study design was used for Vitamin B12 supplementation in Vitamin B12-depleted study subjects. The Institutional Ethics Comittee (IEC), St John's Medical College & Hospital, Bengaluru, India (reference number IERB/1/44/07) approved the study protocol. The study was conducted on humans following the Helsinki Declaration. Participants were recruited for the study after written informed consent.

2.2 | Sample size estimation

The prevalence of Vitamin B12 deficiency has varied from 60% to 81% among urban Indian populations.[12,33] Considering the prevalence of vitamin B12 deficiency in the elderly as 60% with 30% relative precision and 95% confidence interval, the number of elderly subjects needed was 28. Hence, we have studied 28 elderly populations aged >60 years.

The pilot intervention included all participants who had subclinical vitamin B12 deficiency and were willing to undergo vitamin B12 supplementation.

2.3 | Data collection

Anthropometric measurements were collected from all participants. Bodyweight was recorded in minimal clothing using a digital scale (Alfoset, Model HW-100KA1, Mumbai, India) to the nearest 0.1 kg. Height was recorded using a vertically mobile scale (Holtain, Crymych, UK) to the ~0.1 cm. Body mass index was calculated as body weight in kgs adjusted for height squared in meters. Skinfold measurements were taken using Holtain calipers (Crymych, UK). Three measurements were taken at three sites (biceps, triceps, and subscapular) and were used to calculate per cent fat and fat-free mass using the age and gender-specific equation of Durnin and Womersley (1974). Muscle strength was assessed using a handgrip dynamometer (Takei, Japan) in the nondominant hand. The participants were explained about the assessment protocol before the procedure. Tests were performed standing, arms at their side, not touching their bodies. Subjects were asked to hold the dynamometer in the nondominant hand, grip it comfortably, and squeeze the dynamometer with the maximum possible force. Three trials were performed. A gap of 10–20 s was maintained as a rest period between each trial to avoid the effects of muscle fatigue. Specific instruction was given to squeeze only once for each measurement. The results of each trial were recorded using the nearest kilogram. An average of three was taken as a maximum voluntary contraction (MVC) to assess muscle strength. Muscle quality index was calculated as a ratio of MVC to the total fat-free mass.

2.4 | Oral Vitamin B12 supplementation

Twenty participants were deficient in vitamin B12 (plasma vitamin B12 < 148 pmol/L), out of which 14 participants agreed to enroll for vitamin B12 supplementation. Six participants did not participate as they could not commit to daily consumption due to work or were not interested in participating. The study was registered under the Clinical Trials Registry-India CTRI/2009/091/000493. Each participant received 100 μg of daily cyanocobalamin tablets (one tablet/day) for 3 months. A log was maintained to document any side effects during the intervention period. None of the subjects reported any side effects. At random time intervals, tablet counts were performed at home by a research assistant to monitor compliance with treatment. Based on the tablet count, compliance with supplementation was between 97% and 100%.

2.5 | Biochemical analysis

Blood samples were collected to assess vitamin B12, MMA, Hcy, and complete hemogram. The samples were separated into aliquots, labeled, and stored at −80°C until analysis. Plasma vitamin B12 was determined using a Chemiluminescent immunoassay (Unicel DxI 600, California, USA), with an inter-assay CV of 6.6%–8.5% and intra-assay CV of 4.8%–6.9%. Serum MMA and homocysteine levels were determined using GCMS (Varian CP-3800 GC with Saturn 2000 MS). Two levels of in-house quality control samples prepared from pooled plasma were injected daily; the intra-assay CV was <4%, and the inter-assay CV was <7.2% for both levels.

2.6 | Statistical analysis

The normality of the data was checked using the Kolmogorov–Smirnov test. All the quantitative variables were reported as mean with standard deviation. Categorical variables were reported as numbers and percentages. The study subjects were divided into replete and depleted vitamin B12 groups based on the standard serum cut-off of 148 pmol/L. Anthropometric and biochemical parameters between depleted and replete groups were compared using an independent *t*-test or Mann–Whitney U test as appropriate. Pearson correlation coefficient was used to find the correlation between muscle parameters and vitamin B12 status. The impact of aging and vitamin B12 status on muscle parameters was assessed using multiple linear regression. Following vitamin B12 supplementation, the changes before and after supplementation were evaluated using a paired *t*-test. Results were considered significant if $P < 0.050$. All statistical analyses were performed using SPSS (v25, SPSS, Chicago, IL).

3 | RESULTS

Among the 28 participants studied, eight subjects were categorized as replete and 20 as deplete (71 percent). The anthropometric, biochemical, and hematological data in both replete and depleted groups are represented in Table 1. The mean age of the participants in the deplete group was significantly higher ($P < 0.050$) compared with the replete group. MMA and homocysteine levels were significantly higher in the deplete group ($P < 0.050$). At baseline, Vitamin B12 level was significantly and positively associated with muscle quality index ($R = 0.510$, $P = 0.007$). Multiple linear regression analysis adjusting for age and BMI showed a significant association between vitamin B12 and muscle quality index ($\beta = 0.570$, $P = 0.010$).

Among the 20 deplete subjects, 14 agreed to vitamin B12 supplementation and underwent 3 months of oral B12 supplementation. Following supplementation, serum MMA and homocysteine significantly decreased, and plasma Vitamin B12 levels significantly improved (Table 1). Figure 2 represents the vitamin B12, muscle strength, and muscle quality in the deplete group before and after supplementation and in the replete group. There was a significant improvement in muscle quality index and MVC following supplementation ($P < 0.050$). Post-supplement muscle quality index and MVC measures were comparable with the replete group.

4 | DISCUSSION

The present study showed significant muscle strength and quality improvement in the vitamin B12-deplete group following supplementation, reaching levels comparable to the vitamin B12-replete group. A significant and positive correlation existed between plasma vitamin B12 and muscle quality. 71% of the study participants had plasma vitamin B12 levels lower than usual based on the WHO cut-off of 148 pmol/L. Previous studies, specifically among the elderly,

TABLE 1 Descriptive characteristics of study subjects.

Subject characteristics	Deplete group before supplementation (Mean ± SD) *n* = 14	Deplete group after supplementation (Mean ± SD) *n* = 14	Replete group (Mean ± SD) *n* = 8
Age (years)	65.7 ± 6.4		62 ± 3.6#
Gender (M:F)	7:7		3:5
Height (m)	1.57 ± 0.1		1.52 ± 0.9
Weight (kg)	57.5 ± 6.9	57.9 ± 7.1	50.4 ± 9
BMI (kg/m^2)	23.3 ± 2.9	23.7 ± 2.9	21.8 ± 2.8
Systolic blood pressure (mm Hg)	125.9 ± 19.4	124.8 ± 13.8	127.0 ± 24.8
Diastolic blood pressure (mm Hg)	78.4 ± 9.2	74.8 ± 6.4	76.7 ± 15.7
Heart rate (bpm)	69.9 ± 10.3	69.6 ± 9.9	73.5 ± 8.6
Fat mass (Kg)	17.6 ± 4.9	17.8 ± 5.0	15.9 ± 4.1
Lean mass (Kg)	39.9 ± 5.3	40.1 ± 5.9	34.4 ± 6.0
% Fat	30.3 ± 7.3	30.6 ± 7.8	31.5 ± 4.7
Vitamin B12 (pmol/L)	96.7 ± 40.1	247.3 ± 104.4*	234.7 ± 65.1#
MMA (µmol/L)	0.96 ± 0.5	0.50 ± 0.2*	0.46 ± 0.1#
Homocysteine (µmol/L)	21.3 ± 16.2	14.5 ± 11.4*	9.5 ± 5.2#
Hemoglobin (g/dL)	12.8 ± 1.9	12.9 ± 1.8	12.4 ± 2.2
MCV (fL)	86.4 ± 8.5	83.1 ± 7.9*	79.6 ± 7.4
MCH (pg)	28.7 ± 3.8	29.4 ± 2.2	26.9 ± 3.0
MCHC (%)	33.2 ± 2.2	31.9 ± 1.9	33.9 ± 1.3

Abbreviations: BMI, body mass index; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; MMA methyl malonic acid.

*$P < 0.05$ on paired *t*-test before and after supplementation.

#$P < 0.05$ on independent *t*-test between the replete and deplete group.

have shown that less than 20% of people with confirmed vitamin B12 deficiency may exhibit symptoms like macrocytic anemia or any typical neurological manifestations.[34] Hence, vitamin B12 deficiency may remain subclinical and undiagnosed, as evident from the findings of this study. As a result, alterations in physiological functions often may not be attributed to decreased vitamin B12 levels in the body.

Aging is associated with skeletal muscle changes characterized by loss of muscle strength and quality. It is supported by histological data using needle biopsy sampling that have shown preferential type II myofiber atrophy, muscle fiber necrosis, increased intramyocellular lipids, and increased collagen among the older population.[35,36] Impaired neural control of muscle contraction, mitochondrial function, biogenesis, and satellite cell function and increased production of reactive oxygen species have also been associated with aging.[35] As a result, there is gross deterioration in the skeletal muscle quality referred to as sarcopenia which can present as a significant challenge, particularly in the aging population due to its detrimental effects on overall health and quality of life.[37] When aging alone is the only apparent reason, sarcopenia is classified as "primary," but sarcopenia is classified as "secondary" when one or more additional factors (i.e., disease-related, malnutrition, and physical activity-related) are apparent.[38] Its holistic management encompasses multifaceted approaches aimed at not only mitigating muscle loss but also promoting overall well-being. Nutrition plays a pivotal role, with emphasis on adequate protein intake to support muscle synthesis and maintenance, alongside essential vitamins and minerals.[39] Regular physical activity, encompassing both resistance and aerobic exercises, is crucial in preserving muscle mass and function while improving balance and mobility.[40] Multiple studies have recognized the effect of resistance exercise training as a form of an intervention strategy to improve muscle mass and strength.[41–43] However, a substantial proportion of elderly adults may either be incapable or unwilling to carry out strenuous exercise training programs and often prescribed "low dose" resistance exercise regimes may not be physiologically adequate.[44] Other interventions in the form of hormonal and nutritional supplementation for at-risk patients have been proposed. However, much of this evidence is observational, and the mechanisms are not fully understood. Low intakes of nutrients like protein, vitamins, and antioxidants have been linked to impaired

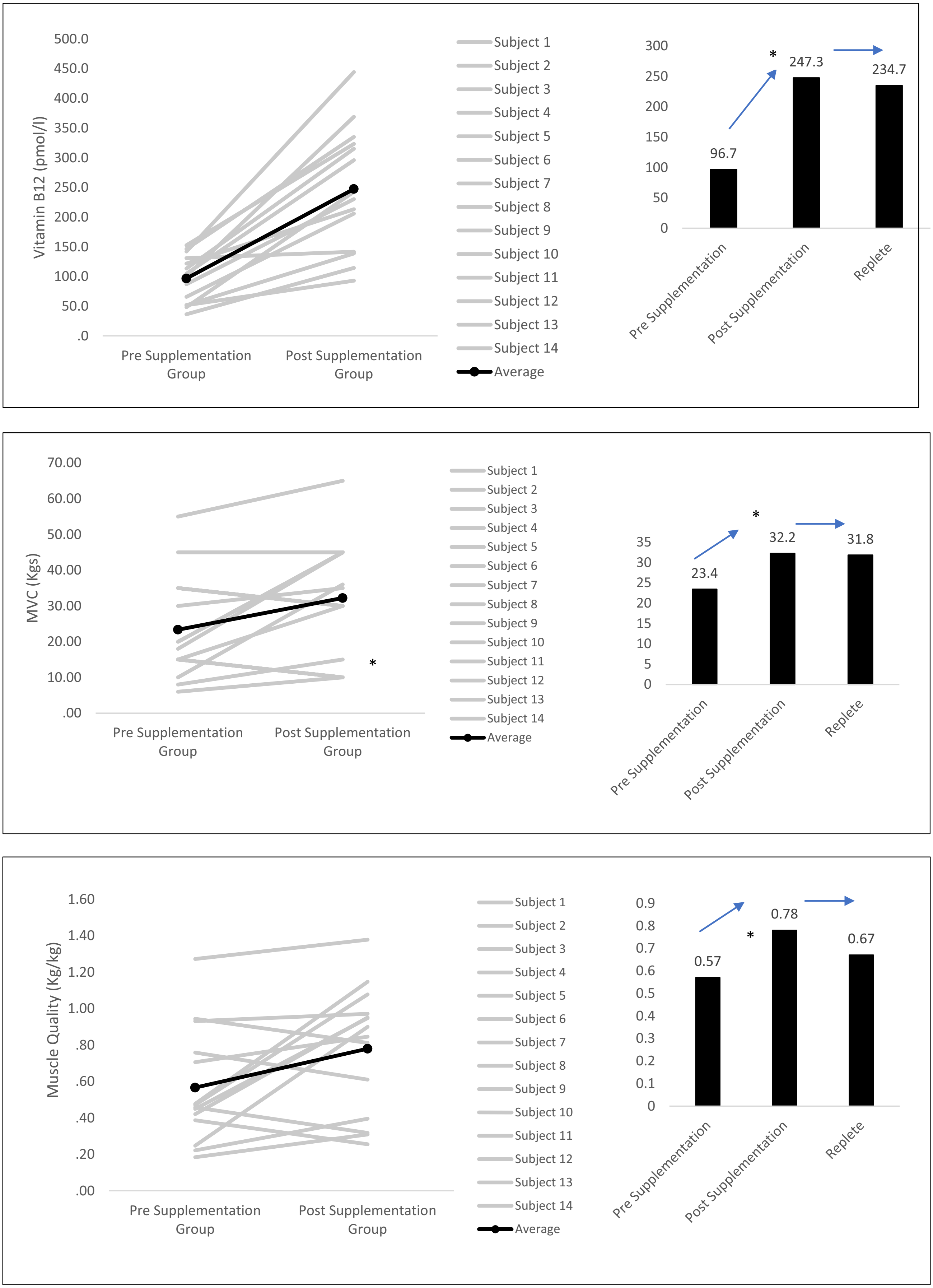

FIGURE 2 Representation of vitamin B12, muscle strength, and muscle quality between the deplete group before and after supplementation and the replete group. *$P < 0.05$ on paired *t*-test comparing before and after supplementation.

muscle function among older adults.[45,46] Several micronutrient deficiencies have been linked with sarcopenia, including vitamin B complex, vitamin D, calcium, iron and trace elements like magnesium, selenium, and zinc.[39] A plethora of research has evaluated the combined effect of protein and resistance exercise on muscle health of the elderly and found favorable outcomes indicating protein supplementation as an effective intervention that can complement the effect of resistance exercise.[47,48] The extent to which pharmacological and other nutritional interventions can improve muscle function and decrease disability in the elderly is yet to be established.

Among the micronutrients, vitamin B12 deficiency is highly prevalent among the elderly. This is evident from the data of the present study as well. Primary reasons for vitamin B12 deficiency among the elderly could be insufficient dietary intake or malabsorption.[49] This could lead to impairment in vitamin B12-dependent biochemical pathways, resulting in the building up of metabolites, namely, homocysteine and methylmalonic acid (MMA), known as functional markers of vitamin B12 deficiency.[50] Despite proof linking metabolites of vitamin B12 with altered muscle mass and muscle function14-28,51,52, as evident from the literature search, there is a lack of direct evidence linking vitamin B12 deficiency states with muscle function. Long-term supplementation of vitamin B12 among the elderly has shown mixed results.

In the present study, there was a strong association between muscle quality, a measure of relative muscle strength derived as a ratio of muscle strength and lean mass, and baseline vitamin B12 levels, even after controlling for confounders like age and BMI. Plasma vitamin B12 levels in this study significantly improved after 3 months of supplementation and were comparable to those seen among the depleted population. The effectiveness of supplementation was further corroborated by the reduction in the levels of functional markers like MMA and homocysteine, which are tissue biomarkers of vitamin B12 deficiency. This is one of the significant strengths of the study. One of the limitations of the present study is the small sample size. However, the study demonstrated significant improvement in muscle function and quality post-supplementation and plasma vitamin B12 levels. Therefore, the study emphasized the crucial role of vitamin b12 in preventing and managing sarcopenia.[39]

5 | CONCLUSION

From the literature review, it is evident that a deficiency of vitamin B12 among the elderly can negatively affect the skeletal muscle function. Supplementation of vitamin B12 among elderly suffering from subclinical deficiency can significantly improve their muscle function and quality. This provides evidence for proof of concept that there could be a role of vitamin B12 in remodeling skeletal muscle, especially among the elderly. This could also form the basis of future extensive randomized control studies among the elderly. Currently, there is no recommendation for screening for vitamin B12, including assessment of muscle strength among the elderly population. Considering that vitamin B12 deficiency is highly prevalent among the elderly and supplementation of vitamin B12 is not associated with any toxic side effects and is safe, it is worthwhile to screen for vitamin B12 deficiency even among asymptomatic and plan supplementation programs to improve muscle function as a component of physical well-being among the elderly.

AUTHOR CONTRIBUTIONS

Sowmya Sharma (SSh), and Sucharita Sambashivaiah (SSa) conceptualised the idea and design of the work. Rohini Bhadra (RB) conducted and summarised the literature review. SSa facilitated the data collection and data handling. Sumithra Selvam (SS) and SSh conducted the data analysis and interpretation. SSh and RB wrote the first draft of the article. All authors critically reviewed and revised the subsequent drafts and approved the final draft.

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CONFLICT OF INTEREST STATEMENT

None.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The Institutional Ethics Comittee (IEC), St John's Medical College & Hospital, Bengaluru, India (reference number IERB/1/44/07) approved the study protocol. No animals were used in this study, which was conducted on humans following the Helsinki Declaration. Participants were recruited after written informed consent.

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