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# NUTRITIONAL STATUS BUT NOT VITAMIN DEFICIENCIES ARE ASSOCIATED WITH LOW FUNCTIONAL SCORES

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**Abstract:** *Objectives:* To investigate relationships between selected vitamins, nutritional status and functional outcomes. *Design:* Cross-sectional study. *Setting:* Sub-acute geriatric rehabilitation hospital. *Participants:* 146 newly admitted rehabilitation patients. *Measurements:* Nutritional assessment using the Mini Nutritional Assessment (MNA) tool, vitamins B12, D and folate concentrations. Length of stay and Functional Independence Measure data were collected from discharge medical records. *Results:* Age was 83 ± 7 (mean ± sd) years and BMI 25 ± 6 kg/m$^2$. The majority (80%) of subjects were malnourished or at risk of malnutrition and 20% of them had 2 or more vitamin concentrations below the reference range. Vitamin D < 50 nmol/L was found in 55%, vitamin B12 < 221 pmol/L in 34% and serum folate < 6.8 nmol/L in 6% of subjects. Function was related to nutritional status determined by the MNA tool but not related to vitamin concentrations. The assessment component of the MNA score predicted 10% of admission function ($\beta = 0.36$, $p<0.0005$), and subjects with poorer functional scores (< 95) had lower mean MNA scores (19 versus 21, p=0.028). *Conclusion:* Nutritional status was associated with low functional scores. Low concentrations of vitamins D and B12 were common but were not related to function. More research is needed to investigate the relationship between nutritional status and function.

**Key words:** Nutrition assessment, avitaminosis, activities of daily living, rehabilitation assessment, geriatric assessment.

## Introduction

Geriatric rehabilitation patients are at high risk of malnutrition (1-3), muscle wasting and difficulties with activities of daily living (3-5). Undernourished geriatric hospital patients have poor function on admission (3, 4, 6, 7), increased functional decline (4, 6, 7), delayed functional recovery (3) and require greater support (3, 5). One of the most widely used functional assessment tools is the Functional Independence Measure (FIM) (8).

Undernutrition is related to inadequate energy and vitamin intake and can result in subclinical deficiencies (1). Deficiencies of B vitamins may affect cellular and disease processes (9), with vitamins B12 and folate essential for one-carbon metabolism, DNA methylation and nucleotide synthesis. Low vitamin B12 status is linked to mitochondrial dysfunction and inflammation (9, 10). Frailty and disability are associated with poor B vitamin status (11) and hyperhomocysteinaemia, a marker of inadequate status is linked to poorer physical function (12). Vitamin D is required for cellular growth and for central nervous system and muscle function (13). Little, however, is known of effects of subclinical vitamin deficiencies and whether specific nutrient inadequacies affect function and health.

This study explores the relationship between the selected nutrients, vitamins D, B12 and folate, nutritional status and the functional capacity of elderly rehabilitation patients as measured by FIM.

## Methods

The study was conducted in a 48 bed sub-acute geriatric rehabilitation unit. Newly admitted subjects were recruited in 2, six week periods in August and September of 2005 and 2006.

Patients with inadequate English or diagnosed dementia without a carer were excluded. The study protocol was approved by the Calvary Health Care Sydney Ethics Committee, and patients or caregivers provided consent. Potential confounders assessed included medical history, cognitive status, serum albumin, creatinine and urea. Subjects who returned to an acute hospital or those with missing FIM data were removed from analysis. The Charlson co-morbidity index was calculated (14).

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### *Assessment of nutritional status, cognitive score and vitamin deficiencies*

Trained personnel assessed cognitive status using the Mini Mental State Examination Score (MMSE) (15) or the Rowland Universal Dementia Assessment Scale (RUDAS) if English was the patients' second language . The RUDAS assesses multiple cognitive domains and is comparable to the MMSE (linear regression, r =0.83 (P < 0.05) (16). Nutritional status was determined using the Mini-Nutritional Assessment (MNA) with classifications of malnutrition (score <17), at risk of malnutrition (score 17-23.5) or well-nourished (score ≥ 24) (1) The MNA is comprised of two components, a screening and an assessment segment (1). These were analysed for associations with vitamin status and FIM score. Only medically-charted vitamin supplement usage was collected.

Vitamin D deficiency was defined as < 50 nmol/L (13); vitamin B12 deficiency as serum vitamin B12 < 221 pmol/L (17) and folate deficiency as serum folate < 6.8 nmol/L (18).

### *Functional assessment*

Function was assessed by FIM within 3 days of admission or discharge. The FIM is an 18 point validated instrument (19) assessing independence in activities of daily living and providing motor and cognition sub-scores. A higher score indicates greater independence with a maximum of 126. The FIM efficiency score (20) measures the amount of functional improvement over the course of rehabilitation (discharge FIM - admission FIM/length of stay). A higher score indicates greater improvement over the admission. The FIM was not normally distributed and the median FIM score was used as a cut-point.

### *Blood collection and laboratory analyses*

Fasting blood samples were collected within 2 days of admission, between 0600hrs and 0830hrs, processed according to standard procedures at accredited hospital pathology laboratories and are described elsewhere (21). Serum 25(OH) vitamin D was analysed by a competitive chemiluminescence immunoassay (LIAISON, DiaSorin, Saluggia, Italy).

### *Statistical Analysis*

Non-normally distributed variables are reported as median and inter-quartile values, otherwise, mean and standard deviation are reported. For evaluating group differences, independent sample t-tests, ANOVA or the Mann-Whitney and Kruskal-Wallis Tests were used. The FIM score had a non-normal distribution and was dichotomised by its median and the MNA score was analysed by nutritional status categories. Relationships between categorical variables were determined using the chi-squared test.

Associations between continuous variables were investigated using Pearson's or Spearman's correlation coefficients. Variables that correlated with the dependent variable (admission FIM) were modelled using linear regression and step-wise selection. For nutritional status, the full MNA and the MNA screening and assessment scores were investigated in separate regression models, but only the MNA assessment score was a significant predictor of admission FIM. Admission reason was a nominal variable and was transformed into dummy variables. Variables significant in the regression model were MNA assessment score and being admitted with a fracture. The residuals from the analysis were normally distributed. Data analyses were conducted using SPSS for Windows, version 19.0 (SPSS Inc, Chicago, Illinois, USA).

## Results

There were 198 admissions and 146 subjects (74%) participated. Sixteen were excluded from analysis of change in FIM score; twelve were returned to an acute hospital during the admission and four had missing scores.

Subjects were predominately community-dwelling females (68%) admitted from an acute hospital (n=127, 87%). Admissions were for fractures due to falls (41%), a medical diagnosis e.g. CVD or infection (31%), post joint replacement rehabilitation (13%), other post-surgery rehabilitation (11%) and falls without fracture (4%). The most common co-morbidities (14) were congestive heart failure (17%), previous cerebrovascular accident (17%), cancer (16%), ischaemic heart disease (14%), renal disease (14%) and diabetes (14%). There was no variation in co-morbidities with admission FIM or MNA score. Median number of medications per day was 10 (range 2-22). Twenty eight subjects (19%) were malnourished as determined by the MNA, 89 (61%) were at risk of malnutrition and 29 subjects (20%) were well-nourished.

The majority of subjects had at least one low vitamin concentration with vitamin D deficiency found in 55% (80 of 134), vitamin B12 deficiency in 34% (49 of 138) and folate deficiency in 6% (8 of 138). Insufficient concentrations of two or more vitamins were found in 18% (n=26) of subjects, one low vitamin concentration in 45% (n=66) with 20% (n=29) of subjects replete in vitamins tested.

Table 1 provides subject characteristics dichotomised around the median FIM score of 95. Subjects with lower admission FIM scores had comparable anthropometry, co-morbidity index and vitamin levels but lower

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cognition and MNA scores (19 versus 21, p=0.028) and longer lengths of stay. The mean levels of serum albumin was low at 29 g/L (reference range 33 to 48 g/L), but were not related to FIM scores.

**Table 1**
Subject characteristics

| Characteristic | All subjects | Admission FIM [a] < 95 (n=70) | Admission FIM [a] ≥ 95 (n=70) |
|---|---|---|---|
| FIM on discharge [a, b] | 110(101,116) | 103(90,111) | 114(110,117)** |
| Length of stay (d) [c, d] | 17(13,17) | 21(14,31) | 15(11,19)** |
| Age (y) [e] | 83(7) | 83(8) | 82(6) |
| Medications (number/day)[a] | 10(7,11) | 10(9,12) | 9(7,10) |
| Charlson co-morbidity Index [a] | 2(1,3) | 2(1,3) | 1(1,2) |
| Cognition score [a] | 26(24,28) | 25(23,28) | 27(25,28)* |
| BMI (kg.m $^{-2}$) [e] | 25(6) | 25(6) | 25(6) |
| MNA score [e,f] | 20(4) | 19(4) | 21(3)* |
| MAMC [a] | 27(24,31) | 27(23,30) | 28(24,31) |
| Calf circumference [e] | 34(5) | 34(4) | 34(5) |
| Serum albumin (g/L) [e] | 29(4) | 29(4) | 29(4) |
| Creatinine (μmol/L) [a] | 92(68,110) | 97(68,102) | 87(68,109) |
| Urea (mmol/L) [a] | 6.6(4.4,9.0) | 6.6(4.5,10.0) | 6.7(4.1,8.5) |
| Serum folate (nmol/L) [a] | 13.8(10.3,21.1) | 12.8(10.6,21.7) | 13.8(9.6,20.5) |
| Serum vitamin B12 (pmol/L) [a] | 280(189,402) | 299(189,403) | 266(187,393) |
| Vitamin D (nmol/L) [a] | 42(30,61) | 43(32,74) | 41(28,61) |
| Number of subjects with: | | | |
| < 2 vitamin deficiencies [g] | 90 | 46 | 44 |
| ≥ 2 vitamin deficiencies [g] | 26 | 13 | 13 |

a. Median (inter-quartile values), Mann-Whitney Test; b. n=128; c. n=140; d. n=123; e. Mean (SD); f. MNA <17 indicates malnutrition; g. Vitamin deficiency defined as plasma vitamin D < 50 nmol/L, serum vitamin B12 < 221 pmol/L and serum folate < 6.8 nmol/L, *p<0.05, **p<0.01. MNA: Mini Nutritional Assessment; MAMC: mid arm muscle circumference; FIM: Functional Independence Measure.

Multiple regression analysis showed that the assessment component of the MNA score predicted 10% of the admission FIM (standardised β = 0.36, p<0.0005) with admission reason being for fracture predicting an additional 11% (standardised β = -0.34, p<0.0005). No other potential confounders were significant in the model, and other reasons for admission such as falls, surgery or medical were not predictive of the admission FIM score. Vitamin B12 was weakly correlated with the FIM cognition sub-score (Spearman r = −0.18, p< 0.05), but not with motor or admission FIM score. No other nutritional indices were associated with functional scores.

Subjects with 2 or more vitamin deficiencies had similar MNA and FIM scores to those with less than 2 vitamin deficiencies (Table 2), but were younger, with higher BMI, mid arm muscle circumference (MAMC) and calf circumference (CC).

Malnourished subjects had poorer admission functional scores (p trend 0.014), due to poorer scores for cognition and motor FIM sub-scores (p trend 0.003 and 0.033, respectively) and higher serum vitamin B12 concentrations (p trend 0.01) (Table 3).

Subjects with malnutrition had similar improvement in functional scores (FIM score change) compared to well-nourished subjects, but still had lower discharge FIM motor sub-score (p trend < 0.05). The FIM efficiency score, indicating improvement in function related to length of stay was non-significantly lower in malnourished subjects.

**Table 2**
Vitamin deficiencies and subject characteristics [a]

| Characteristic | < 2 vitamin deficiencies | ≥ 2 vitamin deficiencies |
|---|---|---|
| Age | 83(7) | 81(5)* |
| Comorbidity index [b] | 2(1,3) | 1(1,2) |
| BMI | 24(6) | 28(6)** |
| MAMC [b] | 27(23,30) | 30(27,34)** |
| Calf circumference | 33(5) | 36(5)** |
| MNA screening | 8(2) | 9(2) |
| MNA assessment | 12(2) | 12(2) |
| Admission FIM [b] | 96(85,105) | 95(84,104) |
| Discharge FIM [b] | 110(97,116) | 112(103,116) |
| Change in FIM score [c] | 11(13) | 14(15) |
| FIM efficiency score [c] | 0.6(0.8) | 0.6(0.6) |

a. Vitamin deficiency defined as plasma vitamin D < 50 nmol/L, serum vitamin B12 <221 pmol/L and serum folate <6.8 nmol/L, Data are shown as mean (SD); b. Median (inter-quartile values) Mann-Whitney Test; c. data for n=104, *p<0.05, **p<0.01. MAMC: mid arm muscle circumference; MNA: Mini Nutritional Assessment; FIM: Functional Independence Measure.

**Table 3**
Vitamin levels and selected plasma biochemical concentrations and FIM by malnutrition score

| | Well nourished (n=29) | At risk (n=89) | Malnourished (n=28) |
|---|---|---|---|
| Age | 82(6) | 83(7) | 83(7) |
| MMSE [a] | 27(26,28) | 26(24,28) | 25(22,28) |
| Length of stay [a] | 18(11,33) | 16(13,24) | 22(12,29) |
| Creatinine [a] | 79(66,108) | 97(70,111) | 90(68,117) |
| Urea [a] | 5.4(3.8,7.4) | 6.8(4.6,9.1) | 6.8(4.2,9.2) |
| Albumin | 30(3) | 29(3) | 29(4) |
| Vitamin B12 [a] | 223(172,383) | 266(188,370) | 392(230,638)* |
| Serum folate [a] | 14.5(11.8,19.5) | 13.8(10.2,21.3) | 12.5(8.7,24.7) |
| Vitamin D [t] | 47(33,78) | 40(29,57) | 45(30,89) |
| No. of vitamin deficiencies [b] | 1.0(0.7) | 1.1(0.7) | 0.8(0.8) |
| Admission FIM [a] | 98(89,105) | 96(87,108) | 85(79,98)* |
| Cognition sub-score[a] admission FIM | 33(31,34) | 33(30,34) | 30(26,32)** |
| Motor sub-score admission FIM [a] | 65(56,73) | 65(58,76) | 58(48,67)* |
| Discharge FIM [a] | 114(108,117) | 112(104,116) | 104(83,112)** |
| Cognition sub-score discharge FIM [a] | 33(31,34) | 32(30,34) | 30(26,32)* |
| Motor sub-score discharge FIM [a] | 81(76,83) | 79(73,82) | 73(54,80)* |
| FIM score change [c] | 11(12) | 12(17) | 13(17) |
| FIM efficiency score[a] | 0.60(0.75) | 0.68(0.69) | 0.45(0.92) |

Data shown as mean (SD), a. Median (inter-quartile values) Kruskal-Wallis Test; b. Based on vitamin D < 50 nmol/L, vitamin B12 < 221 pmol/L and folate < 6.8 nmol/L; c. Discharge FIM score – admission FIM; d. Discharge FIM - admission FIM/length of stay; *p trend <0.05, **p for trend <0.01. FIM: Functional Independence Measure; MMSE: Mini Mental State Examination.

## Discussion

This study found the assessment component of the MNA score predicted 10% of admission FIM, but vitamin status was not related to FIM score. Inadequate concentrations of vitamins D, B12 and folate were found in 55%, 34% and 6% of subjects respectively. Contrary to expectations, vitamin B12 concentrations were negatively associated with the cognition FIM sub-score and were higher in malnourished subjects. No other associations with vitamin concentrations were found.

The vitamin D, B12 and folate deficiency rates detected are similar to other studies (13, 20, 22). Vitamin D status is related to falls and muscle strength (23, 24) and some studies show associations with composite functional measures (23-25), but more studies are needed (23). We found no association between vitamin B12 or folate concentrations and total FIM score, consistent with one study (26). However, other studies have found associations with measures of functional decline (11, 27), frailty (27) and increased length of stay (21, 28).

We found a trend to increased serum vitamin B12 concentrations with lower cognition FIM sub-scores and a malnutrition categorisation, also found by Coin et al (29), but this is opposite to the postulated protective effect of vitamin B12 on cognition (30). This may be due to subjects taking non-prescribed supplements or due to increases in vitamin B12 levels found in some diseases (31).

The MNA did not detect vitamin deficiencies. Subjects with two or more vitamin deficiencies were younger with higher BMI, MAMC and CC and not classified as malnourished. The MNA is validated to assess protein energy malnutrition (1), however, as serum vitamin concentrations are linked to function and frailty (11, 13, 23, 28) they should be considered when assessing malnourished, functionally impaired subjects.

Subjects with malnutrition had lower functional scores on admission and discharge, but similar functional gain over the admission compared to well nourished subjects. This indicates that malnourished subjects gained function over the admission, but were unable to reach the higher functional scores and therefore the greater independence of those who were well nourished. This continuing functional deficit may place additional difficulties on an individual's self-care, including nutritional intake, and continue the cycle of poor nutrition and functional status. A Cochrane Systematic review shows oral nutrition supplements improve nutritional status but the evidence regarding improvements in functional status is weak and more research is needed (32).

This study was limited by its cross sectional design and the recruitment of subjects from only one hospital limiting generalisability. Co-morbidities were assessed but disease severity, estimates of lean body mass and estimation of sensitive biomarkers of vitamin status were not able to be determined.

In conclusion, low concentrations of vitamins D and B12 were common but were not related to function. Nutritional status, as indicated by the MNA score, did not detect vitamin deficiencies but was associated with low functional scores. Greater understanding of the relationship between current nutrition assessment tools and function, as well as the development of tools sensitive and specific to measuring functional improvements related to nutrition in older people are needed.

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*Authorship:* FO'L was involved in the design of the study, data collection and analysis, and drafting the manuscript. PP was involved in analysis of the data and commented on drafts of the manuscript. MA-F contributed to study interpretation and manuscript preparation. SS was involved in the design of the study, drafting the manuscript, and provided significant advice and consultation.

## References

1. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature-What does it tell us? J Nutr Health Aging 2006;10:466-85.
2. Charlton KE, Nichols C, Bowden S, et al. Older rehabilitation patients are at high risk of malnutrition: evidence from a large Australian database. J Nutr Health Aging 2010;14:622-8.
3. Neumann SA, Miller MD, Daniels L, Crotty M. Nutritional status and clinical outcomes of older patients in rehabilitation. J Hum Nutr Diet 2005;18:129-36.
4. Salvi F, Giorgi R, Grilli A, et al. Mini Nutritional Assessment (short form) and functional decline in older patients admitted to an acute medical ward. Aging Clin Exp Res 2008;20:322-8.
5. Visvanathan R, Macintosh C, Callary M, et al. The nutritional status of 250 older Australian recipients of domiciliary care services and its association with outcomes at 12 months. J Am Geriatr Soc 2003;51:1007-11.
6. Oliveira MRM, Fogaca KCP, Leandro-Merhi VA. Nutritional status and functional capacity of hospitalized elderly. Nutr J 2009;8:54-62.
7. Feldblum I, German L, Castel H, et al. Characteristics of undernourished older medical patients and the identification of predictors for undernutrition status. Nutr J 2007;6:37-46.
8. Uniform Data System for Medical Rehabilitation. Guide for the unform data set for medical rehabilitation. Buffalo, NY: State University of New York; 1996.
9. Depeint F, Bruce WR, Shangari N, Mehta R, O'Brien PJ. Mitochondrial function and toxicity: role of B vitamins on the one-carbon transfer pathways. Chem Biol Interact 2006;163:113-32.
10. O'Leary F, Samman S. Vitamin B12 in Health and Disease. Nutrients 2010;2:299-316.
11. Bartali B, Semba RD, Frongillo EA, et al. Low micronutrient levels as a predictor of incident disability in older women. Arch Intern Med 2006;166:2335-40.
12. van Schoor NM, Swart KMA, Pluijm SMF, et al. Cross-sectional and longitudinal association between homocysteine, vitamin B12 and physical performance in older persons. Eur J Clin Nutr 2012;66:174-81.
13. IOM (Institute of Medicine). Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: The National Academies Press; 2011.
14. Charlson M, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. Journal of Chronic Disease 1987;40: 373-83.
15. Folstein MF, Folstein SE, McHugh PR. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-98.
16. Pang J, Yu H, Pearson K, Lynch P, Fong C. Comparison of the MMSE and RUDAS cognitive screening tools in an elderly inpatient population in everyday clinical use. Intern Med J 2009;39:411-4.
17. Green R, Kinsella LJ. Current concepts in the diagnosis of cobalamin deficiency. Neurology 1995;45:1435-40.
18. Herbert V. The 1986 Herman award lecture. Nutrition science as a continually unfolding story: the folate and vitamin B-12 paradigm. Am J Clin Nutr 1987;46:387-402.
19. Ottenbacher KJ, Hsu Y, Granger CV, Fiedler RC. The reliability of the functional independence measure: a quantitative review. Arch Phys Med Rehabil 1996;77:1226-32.
20. Kiebzak GM, Moore NL, Margolis S, Hollis B, Kevorkian CG. Vitamin D status of patients admitted to a hospital rehabilitation unit: relationship to function and progress. Am J Phys Med Rehabil 2007;86:435-45.
21. O'Leary F, Flood VM, Petocz P, Allman-Farinelli M, Samman S. B vitamin status, dietary intake and length of stay in a sample of elderly rehabilitation patients. J Nutr Health Aging 2011;15:485-9.
22. Flood VM, Smith WT, Webb KL, et al. Prevalence of low serum folate and vitamin B12 in an older Australian population. Aust N Z J Public Health 2006;30:38-41.
23. Murad MH, Elamin KB, Abu Elnour NO, et al. Clinical review: The effect of vitamin D on falls: a systematic review and meta-analysis. J Clin Endocrinol

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Metab 2011;96:2997-3006.
24. Peterson A, Mattek N, Clemons A, et al. Serum vitamin D concentrations are associated with falling and cognitive function in older adults. J Nutr Health Aging 2012:1-4.
25. Corless D, Dawson E, Fraser F, et al. Do vitamin D supplements improve the physical capabilities of elderly hospital patients? Age Ageing 1985;14:76-84.
26. Grieger JA, Nowson CA, Ackland LM. Nutritional and functional status indicators in residents of a long-term care facility. J Nutr Elder 2009;28:47-60.
27. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci Med Sci 2004;59:255-63.
28. Matteini AM, Walston JD, Fallin MD, et al. Markers of B-vitamin deficiency and frailty in older women. J Nutr Health Aging 2008;12:303-8.
29. Coin A, Veronese N, De Rui M, et al. Nutritional predictors of cognitive impairment severity in demented elderly patients: The key role of BMI. The Journal of Nutrition, Health & Aging 2012;16:553-6.
30. O'Leary F, Allman-Farinelli M, Samman S. Vitamin B12 status, cognitive decline and dementia: a systematic review of prospective cohort studies. Br J Nutr 2012;108:1948-61.
31. Ermens AAM, Vlasveld LT, Lindemans J. Significance of elevated cobalamin (vitamin B12) levels in blood. Clin Biochem 2003;36:585-90.
32. Baldwin C, Weekes CE. Dietary advice with or without oral nutritional supplements for disease-related malnutrition in adults. Cochrane Database Syst Rev 2011;9:CD002008.