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ORIGINAL ARTICLE

Is undernutrition risk associated with an adverse clinical outcome in spinal cord-injured patients admitted to a spinal centre?

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BACKGROUND/OBJECTIVES: To evaluate whether undernutrition risk measured using the Spinal Nutrition Screening Tool (SNST) and the Malnutrition Universal Screening Tool (MUST) is associated with worse clinical outcomes in respect of length of in-patient hospital stay (LOS) and mortality in the 12 months after admission to a spinal cord injuries (SCIs) centre.
METHODS: A multicentre, prospective, cross-sectional observational study was conducted in four UK SCI centres (SCICs). A total of 150 SCI patients (aged 18–88 years (median: 44 years), 30.7% females) were studied between July 2009 and March 2010. LOS and mortality 12 months after admission to the SCIC was monitored. Multivariate regression analysis was used to identify unique predictors of the variance of LOS.
RESULTS: The patients initially undernourished or at risk of undernutrition (44.6%) had a significantly longer LOS (median (days): 129 vs 85, $P = 0.012$) and greater 12-month mortality (% deceased: 9.2% vs 1.4%, $P = 0.036$). In addition, serum albumin and new admission to an SCIC were identified as independent predictors for long LOS.
CONCLUSION: The present study suggests that undernutrition risk, as identified by the SNST, is associated with adverse clinical outcomes. Nutritional screening should be helpful in improving clinical outcomes if it promotes more appropriate and effective nutritional intervention.

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INTRODUCTION

Undernutrition is a common problem in patients with recent spinal cord injury (SCI).[1,2] It is an independent risk factor for nosocomial infection,[3] pressure ulcers[4,5] and adverse clinical outcomes, such as increased hospital length of stay (LOS) and mortality.[6,7] National standards[7,8] recommend the use of validated nutrition screening tools to identify those at risk and those who should be referred for further nutritional assessment and intervention. The Malnutrition Universal Screening Tool (MUST)[9] and the Short Nutritional Assessment Questionnaire (SNAQ)[10] are well-validated examples, but they are not widely used in the SCI community, and not all tools are suitable for all patients.[11] A disease-specific nutrition screening tool, the Spinal Nutrition Screening Tool (SNST), was developed and validated by SCI dietitians to screen patients with SCI[12] (Figure 1).

Our previous work has indicated that the SNST is an acceptable and reliable nutrition screening tool with reasonable reproducibility and validity when compared with other validated nutrition screening tool and full dietetic assessment, but its predictive validity—the ability to predict clinical outcomes in SCI patients—needs further investigation.[12]

We used the dataset from a recent UK multicentre study[1] to investigate the nutritional risk factors associated with longer LOS and first year mortality after admission to an SCI centre (SCIC).

MATERIALS AND METHODS

All patients admitted to four UK SCI centres from July 2009 to March 2010 were considered for inclusion in the study, unless they were admitted for day care procedures, unable to give informed consent due to cognitive impairment or had acute stroke. A total of 150 adult SCI patients were studied prospectively for 1 year.

LOS and 1 year-mortality data were obtained from the hospital records. Each study centre was coded for identification and after local data collection, each patient was coded before anonymous data transfer to the data handling centre.

Nutritional risk screening

Patients' nutrition risk was evaluated by the local investigator within 96 h of admission.

Nutrition risk was assessed by the SNST[12] and a generic nutrition screening tool, the MUST.[9] Patients were considered at risk of undernutrition on the basis of the SNST. The SNST assesses eight criteria, of which the majority were recognised predictors or symptoms of undernutrition: history of recent weight loss, body mass index (BMI), age, level of SCI, presence of co-morbidity, skin condition, appetite and ability to eat. Each step of screening has a score of up to 5 and the total score reflects the patient's degree of risk.

Patients who had an SNST score $\leqslant 10$ or a MUST score of 0 were considered at low risk, and those with an SNST $\geqslant 11$ or MUST $\geqslant 1$ were considered at risk.

Statistical analysis

The principal endpoints of the study were the LOS and the 1 year mortality after an SCIC admission.

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Patient name _____ Hospital number _____

Est. Pre-injury Height_____**Weight**_____ **Body Mass Index** _____ **(See ready reckoner chart)**
Date completed_____

			Score		
Weight History	**0** No weight loss	**1** Some unintentional weight loss. BMI 19-21	**3** Moderate unintentional weight loss. BMI 16-18	**4** Marked unintentional weight loss. BMI <16	
Age	**1** 18-30yrs	**2** 31-60yrs	**3** over 60yrs	**4** under18yrs	
Level of SCI	**1** S1-S5	**2** L1-L5	**3** T1-T12	**5** C1-C8	
Other medical conditions	**0** None **1** Chronic condition E.g. diabetes/substance abuse	**2** Acute Trauma Fractures/Head Injury **3** Infection/Post surgery	**4** Requires ventilation	**5** On ventilatory support with tracheostomy	
Skin Condition	**0** Intact **1** Red mark or Grade 1	**2** Superficial skin damage or Grade 2	**3** Full thickness skin damage or Grade 3	**5** Deep multiple pressure ulcers or Grade 4/5	
Diet	**0** Normal diet and fluids	**1** Parenteral or enteral nutrition	**2** Modified texture diet +/-nutritional supplements	**3** Nil by Mouth	
Appetite	**0** Good, eating all meals	**1** Poor, > ½ left	**2** Not accepting food & drink or unable to eat	**3*** Vomiting and diarrhoea	
Ability to eat	**1** Able to eat independently	**2** Requires some help	**3** Needs to be fed		

TOTAL=

Score each risk factor, using highest score if more than one is relevant.	**Total these row scores to obtain Initial total Score and record risk level**	**Risk level** 0-10 = **Low** 11-15 = **Moderate** >15 = **High**

* Investigate cause and treat.

Figure 1. Spinal Nutrition Screening Tool.

In order to establish the association between nutrition risk and adverse clinical outcomes, the following variables were dichotomised/categorised using the following parameters which were selected on pragmatic grounds as being of probable clinical relevance.

Age	$\geqslant$60 years (1) vs $<$60 years (0)
Level of SCI	Tetraplegic (1) vs paraplegic (0)
Completeness of lesion	American Spinal Injury Association Impairment Scale (AIS): A (1) vs AIS: B, C and D (0)
Previous intensive therapy unit care	Yes (1) or no (0)
Use of mechanical ventilator	Yes (1) or no (0)
Type of admission	New admission to SCIC (1) Re-admission to SCIC (0)
Presence of pressure ulcers	Yes (1) or no (0)
C-reactive protein level	$>$5 mg/l (1) vs $\leqslant$5 mg/l (0)
Total protein level	$\leqslant$64 g/l (1) vs $>$64 g/l (0)
Serum albumin level	$<$35 g/l (1) vs $\geqslant$35 g/l (0)
Body mass index	$<$20 kg/m^2 (1) vs $\geqslant$20 kg/m^2 (0)
Previous weight loss	$\leqslant$10% (1) vs $>$10% (0)

It should be noted that a patient was considered to be a 'new admission' if this occurred within 6 months of the time of the injury, and that this was the first admission to an SCIC.

For the purpose of statistical analyses, patients were divided into two groups: low-risk and at risk groups.

Differences in dichotomous variables were compared using χ^2 or Fisher's exact test and continuous variables were analysed by Student's *t*-test or the Mann–Whitney *U*-test as appropriate.

Univariate linear regression analysis of the LOS data was then undertaken. Those which were significant ($P<0.05$) were entered into a multivariate analysis to determine which made a significant unique contribution. As only a small number of patients died during the follow-up period, this form of analysis was inappropriate for the mortality data.

Approximately 15% of the routine data were lost in the current study (predominantly simple biochemical and haematological variables). To reduce the bias implicit in utilizing only complete cases, multiple imputation procedures were implemented using the SPSS Markov Chain Monte Carlo multiple imputation function to produce five imputed datasets. These were each analysed as normal; thereafter standard multiple imputation procedures were used to combine the multiple scalar and multivariate estimates quantities. There were no missing data in respect of the primary endpoints of the study.

Ethical consideration

This study received an ethical approval from the National Research Ethics Committee (ref: 08/H0605/83) and each centre received approval from its local research and development department. Written informed consent was obtained from patients prior to the data collection.

RESULTS

A total of 150 patients (64% new admissions, age:18–88 years (median: 44), 30.7% females) with SCI was studied in four SCI centres (Table 1).

Of the 96 new admissions, the median age at onset of SCI was 47 years (inter-quartile range 33–61 years), and it took a median of 36 days (range 1–183 days) for patients to be transferred to an SCIC. The median duration of SCI for re-admissions was 4 years, with a range of 6.5 months to 46 years.

The causes of SCI varied and included both traumatic (71.2%) and non-traumatic causes (28.8%) (Figure 2).

Prevalence of undernutrition

The prevalence of risk for undernutrition was 44.6% ($n=62$) at the time of admission to an SCIC. (46.8% in new patients, 37.7% in re-admissions).

The highest prevalence of nutritional risk was found in groups who needed a prior ICU treatment (57.4%), mechanical ventilation (68.8%) and artificial nutrition support (100%) (Table 2). Nutritional risk showed no significant difference with admission

type (46.8% vs 37.7%, $P=0.282$); increased age (50% vs 42.2%, $P=0.405$), a traumatic SCI (48.6% vs 34.9%, $P=0.127$) and although use of mechanical ventilation was commonly associated with a nutritional risk, this did not differentiate these patients from those who had not been ventilated (68.8% vs 48.6%, $P=0.133$).

Compared with patients having SNST scores <11, those with higher scores were found to have significantly lower concentrations of total protein, albumin, haemoglobin, creatinine and magnesium, with a lower BMI and less appetite. In addition, 'at-risk' patients were found to have significantly higher C-reactive protein and white cell counts, and to be receiving more prescribed medications (Table 3).

Table 1. Patient's demographic

		Level of spinal cord injury				
		Cervical	*Thoracic*	*Lumbar*	*Sacral*	*Total*
AIS	A	23	40	7	0	70 (50.4%)
AIS	B	4	3	3	0	10 (7.2%)
AIS	C	14	8	6	0	28 (20.1%)
AIS	D	16	8	6	1	31 (22.3%)
Total		57 (41.1%)	59 (42.4%)	22 (15.8%)	1 (0.7%)	139

Abbreviation: AIS, American Spinal Injury Association (ASIA) Impairment Scale. 41.1%: Tetraplegia; 58.9% Paraplegia; 50.4% complete SCI; 49.6% incomplete SCI.

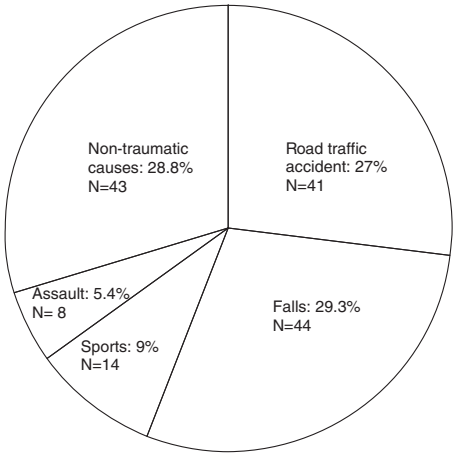

Figure 2. Causes of spinal cord injuries.

Length of stay

Overall LOS was significantly shorter in nutritionally low-risk patients (85 days vs 129 days, $P=0.012$). No statistically significant difference was observed between patients with a complete SCI and an incomplete SCI (Table 4).

Higher 'MUST' score (LOS median: 136 vs 83, $P=0.013$), 'SNST' score (LOS median: 129 vs 85, $P=0.012$), new admission (LOS median: 156 vs 31, $P<0.01$), history of previous ITU stay (LOS median: 155 vs 86, $P<0.01$), hypoalbuminaemia (LOS median: 153 vs 76, $P<0.01$), hypoproteinemia (158 vs 95, $P=0.022$) and weight loss $>10\%$ (142 vs 74, $P<0.01$) were associated with increased LOS.

The SNST score, 'MUST' score, new admission, use of ventilatory support, previous history of intensive care unit stay, serum albumin level, level of SCI and total protein level were risk factors for increased LOS on univariate analysis (Table 5). Multivariate regression reconfirmed only type of admission ($P<0.01$) and serum albumin level ($P=0.013$) as predictors of unique variance in LOS. The adjusted multiple correlation coefficient squared (R^2) for the model indicates that the model explains 35.2% of the variance in LOS (Table 6).

1 year mortality

At-risk patients were found to have a higher mortality rate at 1 year after admission to the SCIC than low-risk patients (10.2% vs 1.4%, $P=0.036$, χ^2: 4.41) (Table 4).

Re-admission (365 days mortality: 8.0 vs 3.1%, $P=0.018$), Age greater than 60 years old (365 days mortality: 13.1 vs 1.8%, $P<0.01$), presence of pressure ulcers (365 days mortality:

Table 2. Nutrition risk according to patient's demographic data and cause of SCI

	Number of patients	*At risk patients ('SNST' score ⩾11)*	*Low-risk patients ('SNST' score ⩽10)*	P-*value*
Admission type (n = *149)*				
New admission	96	45 (46.8%)	51 (53.2%)	0.282
Readmission	53	20 (37.7%)	33 (62.7%)	
Age (n = *147)*				
<60 years old	109	46 (42.2%)	63 (57.8%)	0.405
⩾60 years old	38	19 (50.0%)	19 (50.0%)	
Cause of injury (n = *150)*				
Traumatic SCI	107	52 (48.6%)	55 (51.4%)	0.127
Non-traumatic	43	15 (34.9%)	28 (65.1%)	
Disease severity				
Mechanical ventilated ($n=147$)	16	11 (68.8%)	5 (31.3%)	0.133
Non ventilated	111	54 (48.6%)	57 (51.4%)	
History of ICU stay ($n=146$)*	47	27 (57.4%)	20 (42.6%)	0.016
No history of ICU stay	99	36 (36.4%)	63 (63.6%)	
Presence of pressure ulcers ($n=147$)†	44	26 (59.1%)	18 (40.9%)	0.003
No pressure ulcers	103	34 (33.0%)	69 (67%)	
Artificial nutrition support ($n=145$)†	10	10 (100%)	0 (0%)	<0.001
Non-artificial nutrition support	135	46 (34.1%)	89 (65.9%)	

Abbreviations: ICU, intensive care unit; RTA, road traffic accident; SNST, Spinal Nutrition Screening Tool. *$P<0.05$; †$P<0.01$.

Table 3. Comparison of nutritional indices with traumatic vs non-traumatic SCI by SNST

	Overall			*Traumatic SCI*			*Non-traumatic SCI*		
	SNST < 11 mean	*SNST ⩾ 11 mean*	P	*SNST < 11 mean*	*SNST ⩾ 11 mean*	P	*SNST < 11 mean*	*SNST ⩾ 11 mean*	P
Age (years)	46.44	47.42	0.738	42.27	46.93	0.276	52.59	53.00	0.950
Protein (g/l)	66.60	63.49	0.030	64.08	63.08	0.630	67.29	61.08	0.012
Albumin (g/l)	34.62	30.46	0.001	32.67	30.36	0.153	33.86	29.25	0.069
CRP (mg/l)	27.95	55.52	0.007	36.39	58.65	0.198	22.33	49.75	0.130
Hb (g/l)	12.85	11.60	0.000	12.57	11.72	0.044	12.57	11.10	0.028
WCC	8.76	11.05	0.020	9.28	11.87	0.074	7.24	10.32	0.267
Mg (mmol/l)	0.84	0.76	0.004	0.82	0.75	0.084	0.84	0.76	0.081
Calcium (mmol/l)	2.40	2.42	0.543	2.45	2.44	0.834	2.47	2.44	0.461
Sodium (mmol/l)	138.32	137.02	0.065	138.08	136.53	0.183	138.79	138.00	0.423
Potassium (mmol/l)	4.36	4.29	0.402	4.36	4.39	0.810	4.21	4.04	0.312
Urea (mmol/l)	4.94	5.01	0.859	4.85	5.19	0.566	4.50	4.62	0.907
Creatinine (mmol/l)	66.65	60.85	0.109	60.58	60.71	0.976	68.14	64.08	0.565
Number. of drugs	8.15	10.03	0.001	8.90	9.93	0.200	8.41	10.75	0.067
BMI (kg/m^2)	25.98	23.78	0.014	26.01	24.04	0.093	25.08	22.50	0.111
Appetite	86.36	65.25	0.000	86.21	67.68	0.011	90.00	60.42	0.008

Table 4. Patients' clinical outcome according to level of SCI

	(A) Length of stay (median, day)					
	Tetraplegia		*Paraplegia*		*Total*	
Nutrition risk	*No-risk*	*At risk*	*No risk*	*At risk*	*No risk*	*At-risk*
Complete SCI	218	198	113.5	109.5	135	129
Incomplete SCI	63	141	71	100	73.5	141
Total	95	149	99	126.5	85	129*

	(B) 365 days mortality (%)					
	Tetraplegia		*Paraplegia*		*Total*	
	No-risk	*At risk*	*No risk*	*At risk*	*No risk*	*At-risk*
Total	1 (5.6%)	4 (12.1%)	0 (0%)	2 (7.1%)	1 (1.4%)	6 (10.2%)*

Abbreviation: SCI, spinal cord injury. Tetraplegia (cervical SCI); Paraplegia (Thoracic SCI, Lumbar SCI, Sacral SCI); Complete SCI (AIS: A); Incomplete SCI (AIS: B, C or D); AIS: American Spinal Injury Association (ASIA) Impairment Scale; No risk: SNST ⩽ 10; At-risk: SNST > 10. *$P < 0.05$.

10.2 vs 2.0%, $P = 0.028$), use of mechanical ventilation (365 days mortality: 18.7 vs 3.1%, $P = 0.025$) were associated with higher first-year mortality rate after an SCIC admission.

DISCUSSION

This study is the first multicentre study to examine the association between nutritional risk and clinical outcomes in an uncommon medical condition—spinal cord injury. We provide new information regarding disease-related malnutrition in SCI. This study found that being nutritionally 'at risk', as identified by the SNST, is associated with unfavourable clinical outcomes.

We noted patients with complete SCI who are at undernutrition risk tend to have a shorter LOS than low-risk patients (Table 4A). This finding was not statistically significant. We could not find any specific reason to explain this, but this could be due to the small sample size (sub-analysis of 72 patients). This will require a larger scale study with a bigger sample size to answer whether undernutrition risk affects a specific sub group of SCI patients (for example, complete vs incomplete, tetraplegia vs paraplegia). It is, however, important to note that overall, SCI patients who are at undernutrition risk had a significantly longer LOS (Table 4A) and this is in agreement with other literature that suboptimal nutritional status is associated with poorer clinical outcomes.[13]

Indeed, LOS depends on many factors—clinical,[3] nutritional,[4,6,7,14] psychological and social.[15] This study highlights, however, that a focus placed upon recognition of identifying and treating undernutrition may accelerate SCI rehabilitation and shorten LOS, at least in those with incomplete injuries.

The interpretation of nutritional marker predictor values is difficult. The desire to establish predictive measurements associated with nutritional status is not new, the association between nutritional status and increased morbidity or mortality in at risk patients has been studied for years.[3–7,13–18] Daverat and colleagues identified age, initial consciousness level and need for respiratory support as independent predictors of death in the first 3 months after SCI.[15] The present study did not examine the effect of consciousness levels but we found a higher 365-day

Table 5. Univariate analyses of predictors of LOS

Variable	*Un-standardised coefficient* (B)	*Standard error*	P-*value*
Risk of undernutrition (SNST)	49.44	16.39	0.003
Risk of undernutrition (MUST)	48.53	16.36	0.003
Type of admission	100.83	14.87	<0.001
Age	0.692	0.477	0.147
Presence of pressure ulcer	22.02	16.91	0.193
Use of ventilatory support	73.5	24.58	0.003
Previous ITU stay	64.77	16.54	<0.001
Serum albumin	−5.51	1.11	<0.001
Level of SCI	−35.88	16.23	0.027
Complete/Incomplete SCI	16.02	16.09	0.319
Serum total protein	−3.23	1.03	0.002
C-reactive protein	0.299	0.173	0.087
BMI	1.308	1.533	0.394
Weight loss	0.412	0.458	0.368
Appetite	10.03	28.19	0.722

Abbreviations: AIS, American Spinal Injury Association (ASIA) Impairment Scale; BMI, body mass index; ITU, Intensive therapy unit; LOS, Length of stay; MUST, Malnutrition Universal Screening Tool; SNST, Spinal Nutrition Screening Tool; SCI, spinal cord injury. Complete SCI (AIS: A); Incomplete SCI (AIS: B, C or D). The unstandardised coefficient (*B*) indicates the average change in LOS associated with 1 unit change in the predictor variable.

Table 6. Multivariate regression to identify predictors of unique variance in LOS

Variable	*Un-standardised coefficient* (B)	*Standard error*	P-*value*
Constant	197.41	72.42	-
Risk of undernutrition (SNST)	1.15	20.66	0.956
Risk of undernutrition (MSUT)	14.27	20.11	0.478
Type of admission	81.23	15.39	<0.001
Use of ventilatory support	37.01	26.56	0.163
Previous ITU stay	25.35	17.41	0.145
Serum albumin	−3.62	1.461	0.013
Level of SCI	−18.31	14.91	0.219
Serum total protein	0.08	1.287	0.951

Abbreviations: ITU, intensive therapy unit; LOS, length of stay; MUST, Malnutrition Universal Screening Tool; SNST, Spinal Nutrition Screening Tool; SCI, spinal cord injury. Adjusted multiple correlation coefficient R^2: 0.352. The unstandardised coefficient (*B*) indicates the average change in LOS associated with 1 unit change in the predictor variable controlling for effects of other predictors.

mortality rate in those who are at risk of undernutrition (10.2% vs 1.4%), age > 60 years (13.1% vs 1.8%) and those who required artificial ventilator support (18.7% vs 3.1%). The present study showed no statistically significant increase in undernutrition risk in older SCI patients (> 60 years old), although the risk was numerically higher (50% vs 42.2%), and the absence of significance may be due to the small sample size (sub-analysis of 38 patients).

We employed multivariate analysis to identify the new admission and serum albumin level as independent predictors of adverse clinical outcomes. Our findings were comparable with previous studies in SCI patients,[16] and other medical conditions such as preoperative hypoalbuminaemia being independent risk factors for development of surgical site infections.[18]

The association between nutritional status and LOS is not necessarily a causal one. The severity of the underlying disease is reflected by, for example, the presence of pressure ulcers, hypoalbuminaemia and hypoproteinaemia. Indeed, hypoalbuminaemia is a proven indicator of poor prognosis and mortality, marking it an index of illness rather than nutritional state.[19] It is worth noting that in our study, we did not find any significant difference in LOS or 365 days mortality in tetra- and paraplegic patients and this is comparable with literature.[12] However, the patients who report weight loss within 3 months of their SCI were hospitalised significantly longer than patients who reported no weight loss ($P < 0.01$) (Table 5).

Limitations

Our study may have limitations due to some of the exclusion criteria. Patients admitted to an intensive care unit were also not included. The present study only investigated mortality over 1 year after initial data collection. Due to small numbers of patients who died during the follow-up period, further study with a larger sample size would permit the identification of potential factors contributing to early mortality.

Furthermore, the nutrition risk was identified in new admissions, and therefore it did not take into account the change in nutritional status over time. We reported previously that 74.6% of nutritionally at-risk patients received nutritional support and 52.4% 'at risk' patients were referred for nutritional assessment by dietitian,[1] so some positive outcomes may result as clinical intervention has been initiated.

The present study only evaluated patients admitted to the SCIC, characterised by standardised SCI treatment.[20] This may be a limitation in extending our result to more severely affected patients (such as non-traumatic SCI or older SCI patients), where even stronger correlation between undernutrition and disease activity may only be hypothesized, nevertheless, our study results encourage the use of routine nutritional screening with concomitant action in SCI patients.

SCI patients are expected to have a longer hospital stay than general able-bodied patients as their needs are more complex.[20] Positive nutrition-risk screening does not imply undernutrition,[12] it highlights the clinical importance of access to nutritional advice from a dietitian[7,21] and repeated nutrition screening in SCI patients, as this allows a re-evaluation of a patient's nutritional status.

CONCLUSION

The present study indicates that undernutrition is associated with, but not proven to be a cause of, poorer clinical outcomes in SCI patients with serum albumin concentration as a unique predictor of adverse clinical outcome. The use of SNST could help to utilize the dietetic resources more effectively among patients with nutritional risk. Therefore, we propose that all SCI patients admitted to an SCIC should be routinely screened by the SNST and repeated at regular intervals to reduce nutrition related complications. In order to clarify the effects of nutritional status on patient outcomes, further larger studies with a less heterogeneous group (for example, new admission only) of patients are warrented.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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in the study design, data collection, analysis and interpretation, writing of the paper or in the decision to submit the paper for publications.

AUTHOR CONTRIBUTIONS

SW contributed to protocol development, data collection, data analysis, manuscript preparation. FD helped in clinical supervision, manuscript revision. AJ provided clinical supervision, manuscript revision. SPH contributed to statistical supervision, manuscript revision. SPH helped in statistical supervision, manuscript revision. AF contributed to academic supervision, manuscript revision and guarantor. All authors have read and approved the final version submitted for publication.

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