JAN JOURNAL OF ADVANCED NURSING

ORIGINAL RESEARCH

Functional recovery of older people with hip fracture: does malnutrition make a difference?

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Accepted for publication 8 September 2012

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LI H.-J., CHENG H.-S., LIANG J., WU C.-C. & SHYU Y.-I.L. (2013) Functional recovery of older people with hip fracture: Does malnutrition make a difference?. *Journal of Advanced Nursing* **69**(8), 1691–1703. **doi: 10.1111/jan.12027**

Abstract

Aim. To report a study of the effects of protein-energy malnutrition on the functional recovery of older people with hip fracture who participated in an interdisciplinary intervention.

Background. It is not clear whether protein-energy malnutrition is associated with worse functional outcomes or it affects the interdisciplinary intervention program on the functional recovery of older people with hip fracture.

Design. A randomized experimental design.

Methods. Data were collected between 2002–2006 from older people with hip fracture (N = 162) in Taiwan. The generalized estimating equations approach was used to evaluate the effect of malnutrition on the functional recovery of older people with hip fracture.

Results. The majority of older patients with hip fracture were malnourished (48/80, 60% in the experimental group vs. 55/82, 67% in the control group) prior to hospital discharge. The results of the generalized estimating equations analysis demonstrated that subjects suffering from protein-energy malnutrition prior to hospital discharge appeared to have significantly worse performance trajectories for their activities of daily living, instrumental activities of daily living, and recovery of walking ability compared with those without protein-energy malnutrition. In addition, it was found that the intervention is more effective on the performance of activities of daily living and recovery of walking ability in malnourished patients than in non-malnourished patients.

Conclusion. Healthcare providers should develop a nutritional assessment/management system in their interdisciplinary intervention program to improve the functional recovery of older people with hip fracture.

Keywords: functional recovery, hip fracture, interdisciplinary intervention, malnutrition, nursing, older people

Introduction

Improvements in nutrition, medicine and sanitation have led to an increase in human life expectancy. As a result, higher ageing population levels have become a global phenomenon. In Taiwan, the percentage of people aged 65 or older has quadrupled over the past 60 years, from 2·5% in 1951 to 10·7% in 2010 (Department of Statistics, Ministry of the Interior, ROC 2010) and is projected to quadruple again to 41·6% in 2060 (Council for Economic Planning & Development, Executive Yuan, ROC 2010). As in many other countries with an increasing ageing population, in Taiwan hip fractures among older people have become a serious healthcare issue (Hung *et al.* 2005). As several studies have indicated that most patients cannot resume their pre-fracture functional status (Magaziner *et al.* 1990, 2000, Zuckerman *et al.* 2000), it is worth investigating the issue of functional recovery for older people with hip fracture.

Malnutrition among older people is another serious and growing global health problem. It is associated with higher morbidity and mortality, and a lower quality of life. The increased prevalence of a poor nutritional status among older people with hip fracture as compared with the general population of older people has been well-documented (Delmi *et al.* 1990, Hanger *et al.* 1999). However, the influence of malnutrition on functional recovery following hip fracture has seldom been explored.

Background

Hip fracture among older people is associated with higher morbidity and a higher mortality for all fractures (Bruyere *et al.* 2008). In addition, the economic burden to society of treating hip fractures cannot be ignored (Hung *et al.* 2005). As a result, hip fractures are an important health issue, especially in the older population of Taiwan. One of the more devastating effects following a hip fracture is the loss of functionality, including the loss of physical and instrumental function. Functional recovery following hip fracture is a noticeable health issue, because 25·8–62·1% of older people with a hip fracture cannot resume their pre-fracture functional status at 12 months following hospital discharge (Shyu *et al.* 2004). Studies have shown that the predictive factors of functional recovery following hip fracture include gender difference, age of patient, pre-fracture motor, fracture type, cognitive function, depression, coexisting disease, and length of hospital stay (Shyu *et al.* 2004, 2008b, Givens *et al.* 2009, Samuelsson *et al.* 2009, Jamal Sepah *et al.* 2010, Kristensen *et al.* 2010). However, little is known about the relationship between nutritional status and functional recovery among older people who suffered a hip fracture.

Malnutrition is prevalent in patients with varied medical condition, such as stroke, chronic respiratory failure, peptic ulcers, and surgical patients (Visvanathan *et al.* 2004, Kaur *et al.* 2008, Lelovics 2009, Charlton *et al.* 2010, Nip *et al.* 2011, Pison *et al.* 2011). These studies found that malnutrition was associated with longer hospital stay, more complications, poorer health outcomes, and higher mortality. Therefore, malnutrition has been recognized as an important health issue. Malnutrition is also a common problem in older people because ageing produces physiological, psychological, and social changes. However, malnutrition is a broad term and difficult to investigate, because there is no universally accepted definition of malnutrition and varies depending on the institution, discipline, and/or culture. The terms, malnutrition and undernutrition are used interchangeably in many literatures (Chen *et al.* 2001). Undernutrition can be defined as a state of energy, protein, or their specific nutrient deficiency (Allison 2000). Protein is an important structural component. Low protein intake may compromise the structure and strength of bone mass and therefore increase the incidence of hip fracture (Dawson-Hughes 2003, Bonjour 2005). Energy and protein needs may be elevated with the trauma of a fracture and the subsequent surgical repair and as a result, nutritional deficits may quickly become exacerbated (Jallut *et al.* 1990, Neumann *et al.* 2004). Thus, protein-energy malnutrition (PEM) is also a common phenomenon in older people patients with hip fracture.

Although malnutrition in older people may be correlated with decreased functionality in a broad range of patients (Sieber 2006) and produces a measurable change in body function and results in a worse outcome from an illness (Allison 2000), it is not clear whether PEM is associated with a worse functional outcome for hip fractured older people. Malnutrition in older people is an alarming sign. Without intervention, it presents a downward trajectory in health outcomes (Chen *et al.* 2001). Older people who are ill and malnourished may be expected to benefit more from an intervention. Although oral protein and energy supplementation has been shown to have a beneficial effect on several complications, there is little evidence that it is of benefit to functional outcomes (Milne *et al.* 2009). Our previous study showed that the interdisciplinary intervention program, composed of geriatric consultation, continuous rehabilitation, and discharge-planning, can improve the health and functional outcomes of older people with hip fracture in Taiwan within 3 months after hospital discharge (Shyu *et al.* 2005). Its effects can last for 1–2 years following discharge (Shyu *et al.* 2008a, 2010). However, it is not clear whether the effect of this interdisciplinary intervention program on the functional recovery of older people with hip fracture is different between those with and without PEM.

Due to its possible negative effect, this study explored the relationship between PEM and functional recovery among hip fractured older people. Obesity and other forms of malnutrition were not evaluated in this study. Although nutritional status has been shown to decline due to a lack of adequate nutritional intake during hospitalization (Sullivan *et al.* 1999), it is not clear if the protein-energy nutritional status prior to hospital discharge has an influence on the functional recovery following hospital discharge. Thus, this study focused on protein-energy nutritional status prior to hospital discharge. In addition, this study focused on whether intervention had a different effect on the functional recovery of older people with and without PEM following hip fracture.

The study

Aim

The aim of this study was to explore the effects of PEM prior to hospital discharge on the functional recovery of those older people with hip fracture who participated in an interdisciplinary intervention program 1 year after hospital discharge. Our aim was to evaluate the following two hypotheses:

- First, baseline PEM is associated with worse functional outcomes in older people with hip fracture.
- Second, the intervention has a greater impact on functional recovery of malnourished older patients with hip fracture than on non-malnourished older hip fracture patients.

Design

A randomized experimental design with an in-hospital and 3-month postdischarge interdisciplinary intervention was conducted to explore whether baseline PEM is associated with a worse functional outcome and the baseline nutritional status is a statistically significant independent covariate that could potentially influence the impact of the intervention on the functional outcome 1 year after hospital discharge.

Participants

Participants were recruited from the trauma wards of a 3,700-bed medical centre in northern Taiwan. The sample recruitment process is shown in Figure 1. Of the participants 75·31% completed the 1-year follow-up. The inclusion criteria for the participants were: (1) age 60 years or older; (2) admitted to hospital for a non-pathologic, accidental single-side hip fracture; (3) having received hip arthroplasty or internal fixation; (4) able to perform a full range of motion (ROM) against gravity and against some (or full) resistance prior to the hip fracture; (5) Chinese Barthel Index [CBI] score >70 before the hip fracture; and (6) living in northern Taiwan. Patients with severe cognitive impairment (score <10 on the Chinese Mini-Mental State Examination [CMMSE]) (Yip *et al.* 1992) or those with terminally ill were excluded. These exclusion criteria were established to exclude subjects who were completely unable to follow orders and complete a 1-year follow-up.

Data collection

Data were collected between 2002–2006 from older people with hip fracture in Taiwan. Research nurses identified and recruited subjects who met the inclusion criteria in 36 hours postsurgery. Written consent was obtained from the patient at the beginning of the initial visit in the hospital. The 162 patients who met the study criteria and agreed to participate were randomly assigned to either the experimental or the control group. The participants in the experimental group received our interdisciplinary intervention program and routine care from the hospital, while subjects in the control group received only routine care from the hospital. Data were collected before hospital discharge and then at 1, 3, 6, 12 months following hospital discharge respectively.

A step-by-step manual, training sessions, supervised visits, and case-conferences were given for the research nurses to ensure consistency in delivering interventions and enhance the rigour of this study. Each of the five research nurses received 8 hours of training before this study and was supervised at beginning of this study by a senior gerontological nurse. Moreover, problems raised in the data collection were discussed and resolved during regular case-conferences.

Nutritional status

In this study, the Mini Nutritional Assessment (MNA) tool (Guigoz *et al.* 1996) was used to grade the baseline nutritional status of older people with hip fracture. The MNA

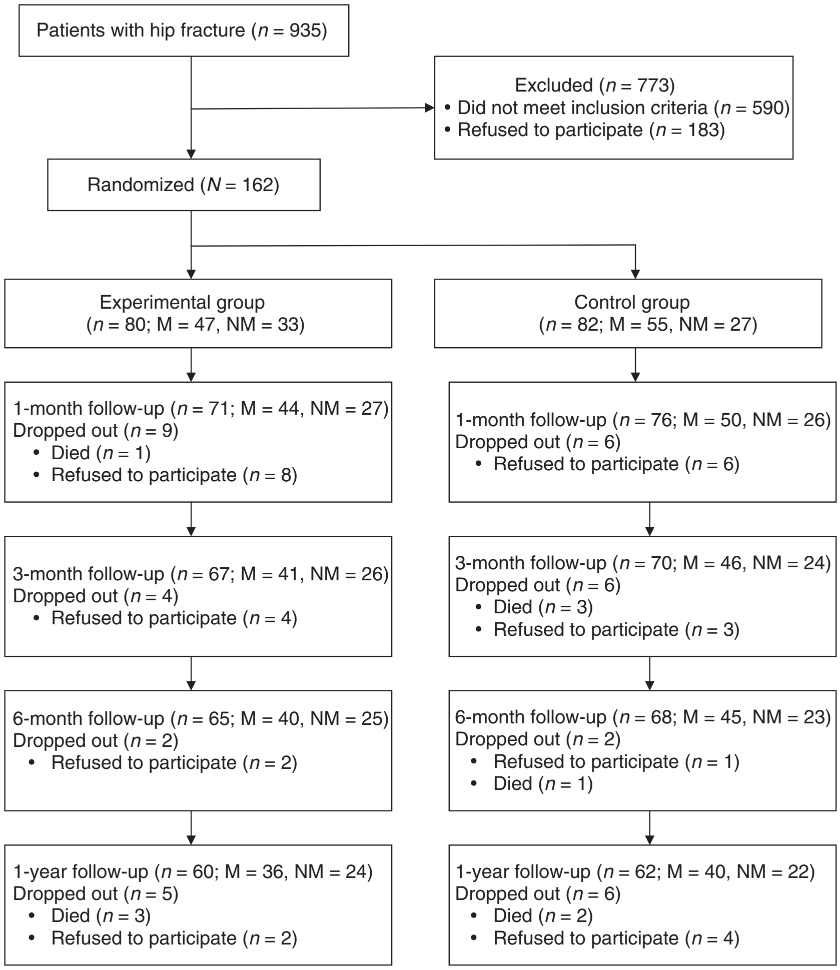

Figure 1 Study flow diagram. M, malnutrition; NM, non-malnutrition.

was reported as having established reliability and validity and as being appropriate for assessing older people in different settings and from different countries (Guigoz 2006). It is composed of 18 simple and readily measured items involving: (1) anthropometric assessment (weight, height, arm and calf circumferences, and weight loss); (2) global assessment (six questions related to lifestyle, medication, and mobility); (3) dietary assessment (eight questions related to number of meals, food and fluid intake, and autonomy of feeding); and (4) subjective assessment (self-perception of health and nutrition). The sum of the MNA score distinguishes between older patients with: (1) adequate nutritional status, MNA ≥ 24; 2) protein-calorie malnutrition, MNA <17; and (3)at risk of malnutrition, MNA between 17– 23·5 (Guigoz *et al.* 1996, Vellas *et al.* 1999). In the current study, the subjects who met the MNA score <17 prior to hospital discharge were categorized as the malnutrition group and the subjects who met the MNA score ≥ 24 prior to hospital discharge were categorized as the non-malnutrition group. Subjects with potential malnutrition, an MNA score between 17–23·5 prior to hospital discharge, were assessed further by checking their serum albumin level prior to hospital discharge. Those with a serum albumin level <3·5 g/dL prior to hospital discharge were also categorized as being in the malnutrition group, whereas those with a serum albumin level $\geq 3{\cdot}5$ g/dL prior to hospital discharge were categorized in the non-malnourished group. The baseline nutritional status of these four groups was confirmed by a geriatrician.

Physical function

In this study, we examined the physical function of older people with hip fracture for their ability to perform activities of daily living (ADL) and the recovery of their walking ability. ADL was measured by the Chinese Barthel Index (CBI), including dependencies in eating, transferring, grooming, toileting, bathing, walking, climbing stairs, dressing, and bowel and bladder functions. The CBI was translated by Chen *et al.* and colleagues (Chen *et al.* 1995) and was reported as having established reliability and validity and as being appropriate for assessing frail older people in Taiwan. The score ranges from 0–100, with 0 representing total dependence and 100 representing total independence.

Recovery of walking ability was defined by comparing the rating of the patient's walking ability before and after the hip fracture. Walking ability is one item on the CBI and is rated from 0–15: 0 (immobile or <50 yards); 5 (wheelchair dependent, >50 yards); 10 (walks with verbal or physical help of one person; >50 yards); and 15 (independent, but may use any aid, e.g., a cane, >50 yards).

Instrumental function

The Chinese version of Lawton and Brody's instrumental activities of daily living (IADL) scale, translated by Chen *et al.* (1995) and reported as having established reliability and validity, was used to assess the instrumental function of the older patients with hip fracture. The scale includes ability to use a telephone, go shopping, prepare food, do housekeeping, do laundry, use transportation, take medicine, and handle money. The score ranges from 0–8, with 0 representing total dependence and 8 representing total independence.

Treatment

The interdisciplinary community-based intervention program, consisting of geriatric assessment/consultation, discharge planning, and in-hospital and 3-month postdischarge rehabilitation was provided by geriatric nurses, a physical therapist, and a geriatrician. The details of the interdisciplinary intervention program have been described in our previous studies (Shyu *et al.* 2005, 2008a). The nutritional assessment/consultation was part of the geriatric assessments/consultation. The geriatric nurses completed the nutritional assessment using MNA for all participants prior to hospital discharge and referred to the geriatrician those that met the MNA score $\leq 23{\cdot}5$. Based on further assessment, the geriatrician then provided clinical suggestions to the surgeon and the geriatric nurses provided nutritional education to those participants who were categorized as the malnutrition group. However, the nutritional assessment/consultation by the geriatrician and the geriatric nurses was not continued after the patient was discharged from the hospital.

Ethical considerations

Human subject approval and access permission were obtained from the hospital used in this study prior to data collection. After the researcher explained the purpose, method and risks of the study, the participants were asked to sign an informed consent form before they could participate in this study. The participants were encouraged to express any misgivings they might have about the study and they could withdraw from the study at any time.

Data analysis

Chi-square tests or analysis of variance (ANOVA) were used to examine the difference in the baseline characteristics of the four groups, i.e. malnourished experimental, malnourished control, non-malnourished experimental, and the non-malnourished control group. Chi-square tests were also used to examine the differences in the functional recovery rates of these four groups at 1, 3, 6 and 12 months postdischarge respectively

General estimating equations (GEE), providing consistent estimators of the regression coefficients, were used to test any correlation in repeated observations over time. Before proceeding with the GEE analysis, Pearson's correlation, Spearman's correlation, and multiple regression were used to test the correlation between potential predictors (treatment, nutritional status, age, cognition level, readmission to hospital, depression, length of hospital stay, comorbidity, pre-ADL, and pre-IADL) and outcome variables (ADL, IADL, and recovery of walking ability). These predictors (including treatment, nutritional status, age, depression, pre-ADL, and pre-IADL) were selected because they were statistically significant for the outcome variables in these cross-sectional analyses. For a given outcome variable (using ADL, IADL, and recovery of walking ability respectively), the GEE model included the following predictors: (1) treatment (coded 0 for the control group and 1 for the experimental group); (2) nutritional status (coded 0 for the non-malnourished group and 1 for the malnourished group); (3) time (viewed as continuous variable); (4) the interaction term (treatment x malnutrition); and (5) other covariates (including age, depression, pre-ADL, and pre-IADL).

As the assumption underlying the GEE model is that all missing data are missing completely at random (MCAR), multinomial logistic regression was used to test whether demographic characteristics (including age, gender, marital status, and educational background), baseline functional status (including ADL and IADL) and treatment (including experimental and control group) could predict a subject's condition of following up (including death, refusal, or remain). The result of the multinomial logistic regression showed that those predictors could not predict a subject's decision for following up. These analyses were performed using SPSS for Windows, Version 15·0 (SPSS Inc., Redmond, WA).

We also carried out the intention-to-treat analysis to avoid deviations from randomized allocation and missing responses (Hollis & Campbell 1999). According to the principle of intention-to-treat, missing data at the baseline due to death and refusal to participate after randomization were imputed by multiple imputation (Little & Rubin 1987, Rubin 1987) to ensure that all randomized subjects could be included in the analysis (Hollis & Campbell 1999). NORM, software developed by Schafer (1997), was used to impute four complete data sets and analyses were run on each data set. Estimates and their standard errors were then averaged across the four imputations to derive a single estimate and standard error. Except for the baseline missing data, no imputation was made. The rationale for this was that the information, before dropping out in the GEE model, had already contributed to the estimation of the parameters relative to the available data.

Results

Baseline characteristics

One hundred and sixty-two patients participated in this study, 111 (68·5%) were female and 51 (31·5%) were male. Their average age was 78·16 years (range 60–98 years). Most were married (51·9%) and illiterate (48·8%). The average length of hospital stay, pre-fracture ADL score, pre-fracture IADL score, and pre-fracture walking ability score were 9·89 days (range 3–35 days), 96·08 (range 70–100), 5·59 (range 0–8), and 14·23 (range 10–15) respectively. Except for pre-fracture IADL, no statistically significant differences were found in the baseline characteristics of these four groups, consisting of the malnourished experimental, malnourished control, non-malnourished experimental, and the non-malnourished control group (Table 1). In this study, the majority of older patients with hip fracture were malnourished according to their MNA score and serum albumin level prior to hospital discharge (48/80, 60% in the experimental group vs. 55/82, 67% in the control group).

Functional recovery

Table 2 indicates that the recovery rates of ADL and walking ability in these four groups are significantly different at 3, 6, and 12 months after hospital discharge ($P < 0·01$) and that the recovery rates of IADL in these four groups show no statistically significant differences at any time point ($P > 0·05$). In other words, the recovery rate of ADL and walking ability in the malnourished control group was the

Table 1 Demographic characteristics of hip fractured patients with and without malnutrition.

Characteristics	Subjects with malnutrition (n = 103)		Subjects without malnutrition (n = 59)		
	Control group (n = 55)	Experimental group (n = 48)	Control group (n = 27)	Experimental group (n = 32)	P-value
#Age (years), Mean (SD)	80·29 (6·71)	77·58 (8·89)	76·19 (7·75)	77·03 (7·12)	0·076
§Gender, n (%)					
Female	39 (70·9)	33 (68·8)	17 (63·0)	22 (68·8)	0·911
Male	16 (29·1)	15 (31·2)	10 (37·0)	10 (31·2)	
§Marital status, n (%)					
Married	27 (49·1)	24 (50·0)	19 (70·4)	14 (43·8)	0·188
Single	28 (50·9)	24 (50·0)	8 (29·6)	18 (56·2)	
§Educational background, n (%)					
Illiterate	29 (52·7)	24 (50·0)	9 (33·3)	17 (53·1)	0·511
Primary school	17 (30·9)	13 (27·1)	13 (48·1)	9 (28·1)	
High school	6 (10·9)	5 (10·4)	2 (7·4)	5 (15·6)	
College or above	3 (5·5)	6 (12·5)	3 (11·2)	1 (3·2)	
#Length of hospital stay, Mean (SD)	9·85 (4·38)	10·45 (3·77)	9·31 (5·88)	9·61 (3·27)	0·708
#Pre-fracture ADL, Mean (SD)	95·73 (6·70)	94·90 (7·11)	97·22 (5·77)	97·50 (5·39)	0·246
#Pre-fracture IADL, Mean (SD)	5·15 (2·52)	5·19 (2·49)	6·44 (2·06)	6·19 (2·04)	0·034
#Pre-fracture walking ability, Mean (SD)	14·09 (1·95)	13·96 (2·05)	14·44 (1·60)	14·69 (1·23)	0·283

Using the case numbers at time of admission, experimental group (n = 80), control group (n = 82).
ADL, activities of daily living; IADL, instrumental activities daily living; SD, standard deviation.
§Chi-square tests or #ANOVA were used to examine the difference in the baseline characteristics of the four groups.

Table 2 Comparisons of functional recovery rates.

Functional recovery	Subjects with malnutrition		Subjects without malnutrition		χ^2 (*P*-value)
	Control group	Experimental group	Control group	Experimental group	
ADL					
At 1 month postdischarge, *n* (%)					
Recovery[§]	3 (6·5)	10 (22·7)	4 (14·3)	5 (18·5)	4·878 (0·181)
Non-recovery	43 (93·5)	34 (77·3)	24 (85·7)	22 (81·5)	
At 3 months postdischarge, *n* (%)					
Recovery	8 (20·0)	20 (48·8)	7 (25·9)	16 (61·5)	15·299 (0·002)
Non-recovery	32 (80·0)	21 (51·2)	20 (74·1)	10 (38·5)	
At 6 months postdischarge, *n* (%)					
Recovery	12 (30·8)	23 (57·5)	17 (60·7)	19 (76·0)	14·038 (0·003)
Non-recovery	27 (69·2)	17 (42·5)	11 (39·3)	6 (24·0)	
At 12 months postdischarge, *n* (%)					
Recovery	12 (33·3)	23 (63·9)	19 (76·0)	19 (82·6)	18·558 (< 0·001)
Non-recovery	24 (66·7)	13 (36·1)	6 (24·0)	4 (17·4)	
IADL					
At 1 month postdischarge, *n* (%)					
Recovery	6 (13·0)	8 (18·6)	6 (22·2)	1 (3·7)	4·449 (0·217)
Non-recovery	40 (87·0)	35 (81·4)	21 (77·8)	26 (96·3)	
At 3 months postdischarge, *n* (%)					
Recovery	9 (22·5)	9 (22·0)	4 (15·4)	6 (23·1)	0·637 (0·888)
Non-recovery	31 (77·5)	32 (78·0)	22 (84·6)	20 (76·9)	
At 6 months postdischarge, *n* (%)					
Recovery	10 (26·3)	15 (37·5)	8 (29·6)	10 (40·0)	1·824 (0·610)
Non-recovery	28 (73·7)	25 (62·5)	19 (70·4)	15 (60·0)	
At 12 months postdischarge, *n* (%)					
Recovery	10 (27·8)	15 (41·7)	7 (29·2)	12 (52·2)	4·555 (0·207)
Non-recovery	26 (72·2)	21 (58·3)	17 (70·8)	11 (47·8)	
Walking ability					
At 1 month postdischarge, *n* (%)					
Recovery	17 (37·0)	24 (54·5)	10 (35·7)	16 (59·3)	5·905 (0·116)
Non-recovery	29 (63·0)	20 (45·5)	18 (64·3)	11 (40·7)	
At 3 months postdischarge, *n* (%)					
Recovery	18 (45·0)	32 (78·0)	18 (66·7)	23 (88·5)	16·626 (0·001)
Non-recovery	22 (55·0)	9 (22·0)	9 (33·3)	3 (11·5)	
At 6 months postdischarge, *n* (%)					
Recovery	19 (48·7)	34 (85·0)	22 (78·6)	21 (84·0)	16·456 (0·001)
Non-recovery	20 (51·3)	6 (15·0)	6 (21·4)	4 (16·0)	
At 12 months postdischarge, *n* (%)					
Recovery	18 (50·0)	31 (86·1)	22 (88·0)	20 (87·0)	18·757 (<0·001)
Non-recovery	18 (50·0)	5 (13·9)	3 (12·0)	3 (13·0)	

Chi-square tests were used to examine the differences in the functional recovery rates of these four groups at 1, 3, 6, and 12 months post-discharge respectively.

[§]Recovery was defined as regaining prior functional ability following repair surgery.

worst and the recovery rate in the non-malnourished experimental group was the best at 3, 6, and 12 months following hospital discharge.

Table 2 also shows that the recovery rate of ADL in the malnourished experimental group was higher than in the non-malnourished control group at 1 and 3 months postdischarge. On the other hand, the recovery rate of ADL in the non-malnourished control group was higher than in the malnourished experimental group at 6 and 12 months postdischarge. In addition, the recovery rate of walking ability in the malnourished experimental group was higher than in the non-malnourished control group at 1, 3, and 6 months postdischarge. On the other hand, the recovery rate of walking ability in the non-malnourished control group was higher than in the malnourished experimental group at 12 months postdischarge.

Overall effects

The regression coefficients (β) determined by the GEE analyses are presented in Table 3. Except for the main predictors (including time, malnutrition, treatment, and malnutrition x treatment) in these analyses, the results shown in Table 3 were controlled by other covariates including age, pre-ADL, pre-IADL, and the GDS (Geriatric Depression Scale) score. The data for the subjects without malnutrition were used as the baseline for the overall malnutrition effect. Malnutrition had a negative effect on the performance of ADL ($\beta = -4{\cdot}53$, $P < 0{\cdot}05$), performance of IADL ($\beta = -0{\cdot}55$, $P < 0{\cdot}05$), and recovery of walking ability ($\beta = -0{\cdot}07$, $P < 0{\cdot}05$). In other words, the subjects with malnutrition appeared to have significantly worse performance trajectories in ADL, IADL, and recovery of walking ability than those without malnutrition after controlling for treatment, time, interaction between malnutrition and treatment, age, pre-ADL, pre-IADL, and GDS score.

In terms of treatment effect, the data from the control groups were used as the baseline. Treatment had a positive effect on the performance of ADL ($\beta = 5{\cdot}33$, $P < 0{\cdot}01$), performance of IADL ($\beta = 0{\cdot}72$, $P < 0{\cdot}01$), and recovery of walking ability ($\beta = 0{\cdot}11$, $P < 0{\cdot}001$). In other words, the subjects in the experimental groups appeared to have significantly better performance trajectories in ADL, IADL, and recovery of walking ability than those in the control groups after controlling for malnutrition, time, interaction between malnutrition and treatment, age, pre-ADL, pre-IADL, and GDS score.

For the overall time effect, time had a positive effect on the performance of ADL ($\beta = 1{\cdot}94$, $P < 0{\cdot}001$), performance of IADL ($\beta = 0{\cdot}15$, $P < 0{\cdot}001$), and recovery of walking ability ($\beta = 0{\cdot}04$, $P < 0{\cdot}001$). That is to say, the subjects appeared to have significantly better performance trajectories in ADL, IADL, and recovery of walking ability over time after controlling for malnutrition, treatment, interaction between malnutrition and treatment, age, pre-ADL, pre-IADL, and GDS score.

Interaction effects

It was found that the interaction between malnutrition and treatment had a statistically significant positive effect on the performance of ADL ($\beta = 6{\cdot}69$, $P < 0{\cdot}05$) and recovery of walking ability ($\beta = 0{\cdot}14$, $P < 0{\cdot}05$) (Table 3). In other words, the intervention had a larger effect on the performance of ADL and recovery of waking ability in malnourished patients than in non-malnourished patients. Based on the regression coefficients from Table 3, the ADL score and rate of recovery in walking ability before hospital discharge and at 1, 3, 6 and 12 months following hospital discharge were calculated and plotted in Figures 2 and 3. The ADL score in the malnourished control group was lower than the ADL scores in the other three groups at any time point (Figure 2). Similarly, the recovery rate of walking ability in the malnourished-control group was also lower than the recovery rate of the walking ability in the other three groups at any time point (Figure 3). These results showed that the intervention

Table 3 Regression coefficients from GEE analyses.

Outcome variables Independent variables	ADL[§] B(SE)	IADL[¶] B(SE)	Walking ability recovery[#] B(SE)
Intercept	39·39 (18·79)*	4·41 (2·41)	1·11 (0·36)**
Time	1·94 (0·17)***	0·15 (0·02)***	0·04 (0·15)***
Malnutrition[†]	−4·53 (1·80)*	−0·55 (0·23)*	−0·07 (0·03)*
Treatment[††]	5·33 (1·70)**	0·72 (0·22)**	0·11 (0·03)***
Malnutrition x treatment	6·69 (3·53)*	0·73 (0·45)	0·14 (0·07)*

General estimating equations (GEE) were used to test any correlation in repeated observations over time.
These results have adjusted several potential confounders, including age, pre-ADL, pre-I ADL, and GDS.
*$P < 0{\cdot}05$;**$P < 0{\cdot}01$;***$P < 0{\cdot}001$.
§ADL (activities of daily living): the index scale ranges from 0 (total dependence) to 100 (total independence).
¶IADL (instrumental activities of daily living): the index scale ranges from 0 (total dependence) to 8 (total independence).
#Recovery of walking ability was defined by comparing the rating of the patient's walking ability before and after fracture.
†Data for the participants without malnutrition was used as the reference.
††Data for the control group was used as the reference.

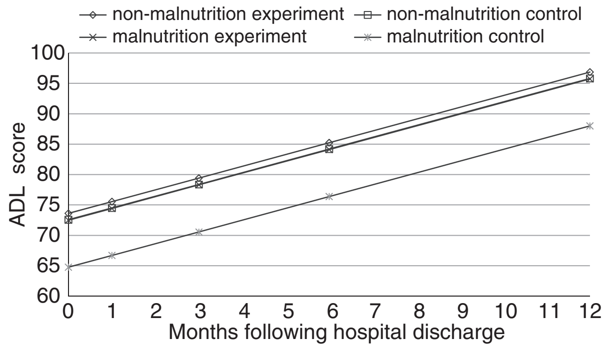

Figure 2 Longitudinal changes in ADL score before hospital discharge and at 1, 3, 6, and 12 months following hospital discharge.

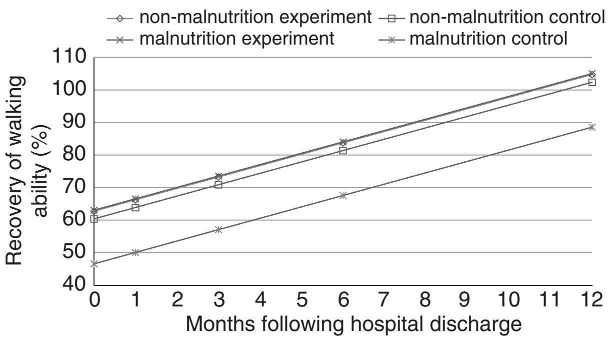

Figure 3 Longitudinal changes in recovery of walking ability before hospital discharge and at 1, 3, 6, and 12 months following hospital discharge.

had a greater effect in ADL performance and recovery rate of walking ability on subjects with malnutrition.

Discussion

This study is the first to explore the effects of PEM on the functional recovery of non-Western older people with hip fracture who participated in an interdisciplinary intervention. However, this study has some limitations that must be taken into consideration when interpreting its results. First, a single-blind design was used in this study. That is to say, the personnel involved in this study were not blind to the implementation of the intervention nor when assessing the outcomes. Therefore, we purposely assigned the staff involved different research duties to minimize any potential bias. Second, 24·69% of the subjects in this study were lost to follow-up during the 1 year following hospital discharge. Thus, we used the GEE, which is an analytic method which allowed us to use all available data in this study. Third, we used the data collected more than 5 years ago in this study. However, we believe that these data are still relevant today because the profile of the older patients with hip fracture in our study sample was similar to that of their counterparts in a recent study (Lin *et al.* 2010) and postdischarge services for older patients with hip fracture have remained the same during the past 10 years (Department of Health, Executive Yuan, R.O.C. 2010). Moreover, the influence of malnutrition on functional recovery of older people with hip fracture has seldom been explored. Hence, the results of this study warrant publication. Finally, the generalizability of the study results is limited because the sample in this study was only recruited from a single medical centre in northern Taiwan. Furthermore, malnutrition in this study was identified using the MNA score and serum albumin level prior to hospital discharge. Other forms of malnutrition were not evaluated in this study. Therefore, more studies should be conducted in the future.

The majority of older patients with hip fracture in this study were malnourished prior to hospital discharge (48/80, 60% in the experimental group vs. 55/82, 67% in the control group). Because, fasting before the operation and the inflammatory response of the injury and surgical stress may lead to catabolism (Hedstrom *et al.* 2006), PEM is a common finding (about 52–64%) in older patients with hip fracture (Patterson *et al.* 1992, Lumbers *et al.* 1996, Hanger *et al.* 1999, Ponzer *et al.* 1999, Akner & Cederholm 2001). Malnutrition may be detrimental to the recovery from hip fracture (Hedstrom *et al.* 2006). Previous studies have shown that the female orthopaedic older patients with high nutritional risk had a longer recovery periods and a greater proportion were dependent on walking frames (Lumbers *et al.* 1996). Our study also found that the participants with PEM prior to hospital discharge appeared to have significantly worse trajectories in performance of ADL, IADL, and recovery of walking ability than those without PEM. Thus, it is necessary to pay attention to the nutritional issues of older people with hip fracture.

Previous studies have shown that patients with hip fracture usually regain their functional ability in 6 months after surgery (Jette *et al.* 1987, Tsauo *et al.* 2005) and that patients who participate in a home-based physical therapy program tend to recover even sooner between 1 and 3 months after surgery (Meeds & Pryor 1990, Tsauo *et al.* 2005). However, in the past little was known about the effects of the nutritional status of older people with hip fracture prior to hospital discharge and the influence of interdisciplinary intervention on their functional recovery following hospital discharge. In this study, it is found that the recovery rates of ADL and walking ability in the malnourished control group was the worst and the recovery rates of the non-malnourished experimental group was the best at 3, 6, and 12 months after hospital discharge. The

What is already known about this topic

- Many older people with hip fracture cannot resume their pre-fracture functional status following hospital discharge.
- The predictive factors of functional recovery following hip fracture include gender difference, age, pre-fracture motor control, fracture type, cognitive function, depression, coexisting diseases, and length of hospital stay.
- The increased prevalence of a poor nutritional status among older people with hip fracture as compared with the general population of older people has been well-documented.

What this paper adds

- Protein-energy malnutrition is a common phenomenon in older patients with hip fracture.
- Subjects with protein-energy malnutrition prior to hospital discharge appear to have significantly worse performance trajectories in activity of daily living, instrumental activities of daily living, and recovery of walking ability than those without protein-energy malnutrition.
- Nutritional intervention has a greater impact on the performance of activities of daily living and recovery of walking ability in malnourished patients than in non-malnourished patients.

Implications for practice and/or policy

- Nursing personnel should pay attention to the nutritional issues of older people with hip fracture in gerontological care.
- The healthcare providers should develop a nutritional assessment/management system and include them in their interdisciplinary intervention program to improve the functional recovery of older people with hip fracture. Nurses should play a crucial and active role in communication, cooperation, coordination, and implementation in the interdisciplinary intervention.
- Further studies should focus on long-term nutritional trend of older people with hip fracture following hospital discharge and its effect on functional recovery.

results showed that the nutritional status prior to hospital discharge and the interdisciplinary intervention are the factors that have a major influence on the functional recovery of older people with a hip fracture. Similar findings were found in other populations, for example, for frail older persons receiving ambulatory rehabilitation, malnourished patients, and those with mild malnutrition were found to have poorer physical function capacity (Chevalier *et al.* 2008).

This study also demonstrated that those older people who participated in an interdisciplinary intervention for hip fracture appeared to have better trajectories in the performance of ADL and IADL, and in the recovery of their walking ability, compared with those that did not participate in that program, after controlling for pre-discharge nutritional status, interaction between malnutrition and treatment, age, pre-ADL, pre-IADL, and GDS score during the first year after hospital discharge. Our previous study also showed that the interdisciplinary intervention benefitted older people with hip fracture by improving both their ADL and walking ability 1 year following hospital discharge (Shyu *et al.* 2008a). The most important finding of this study is that the intervention has a greater impact on the performance of ADL and recovery of walking ability in malnourished patients than in non-malnourished patients. These findings are worth for further future study.

Previous studies demonstrated that nutrition interventions were able to improve outcomes for patients with chronic respiratory failure (Pison *et al.* 2011) and stroke (Rabadi *et al.* 2008). In addition, protein-rich supplementation after surgery for hip fracture may reduce long-term complications, hospital stay, and mortality rate (Jensen *et al.* 1982, Tkatch *et al.* 1992, Espaulella *et al.* 2000, Lauque *et al.* 2000, Eneroth *et al.* 2006, Milne *et al.* 2009). On the other hand, a few studies found that protein supplementation did not improve functional recovery following hip fracture (Williams *et al.* 1989, Espaulella *et al.* 2000, Neumann *et al.* 2004, Milne *et al.* 2009). However, this study found that PEM had a negative effect on the performance of ADL, IADL, and recovery of walking ability during 1 year after a hip fracture.

Malnutrition is a cause for concern among older people. Without intervention, it shows a downward trajectory in health outcomes (Chen *et al.* 2001). Although our interdisciplinary intervention only contained a nutritional assessment/consultation prior to hospital discharge and did not include nutritional supplementation, the present study still found that the intervention was more effective on the performance of ADL and recovery of walking ability in malnourished patients than in non-malnourished patients. Therefore, a detailed nutritional assessment and instruction program and not only protein supplementation, should be included in the early phase after surgery and in the home-based intervention program to improve the functional recovery of older patients with hip fracture in the future. Nevertheless, further study is required to collect more evidence of the benefit from nutritional intervention for older people with hip fracture that are at risk of malnutrition.

Conclusion

The majority of older patients with hip fracture were malnourished prior to hospital discharge. Thus, nursing personnel should pay attention to the nutritional issues of older people with hip fracture in gerontological care. Protein-energy undernutrition is an important independent predictor of 1-year postdischarge functional recovery of older patients who have undergone surgical repair of an acute hip fracture. Subjects with PEM prior to hospital discharge appeared to have significantly worse performance trajectories in ADL, IADL, and recovery of walking ability than those without PEM. In addition, the interdisciplinary intervention described in this study has a greater impact on the performance of ADL and recovery of walking ability in malnourished patients than in non-malnourished patients.

As nutritional status prior to hospital discharge and interdisciplinary intervention are factors with a major influence on the functional recovery of older people with a hip fracture, healthcare providers should develop a nutritional assessment and nutrition management system and include them in their interdisciplinary intervention program to improve the functional recovery of older people with hip fracture. Nurses should play a crucial and active role in communication, cooperation, coordination, and implementation in the interdisciplinary intervention. In addition, we suggest that further studies should focus on long-term nutritional trend of older people with hip fracture following hospital discharge and its effect on functional recovery.

Acknowledgements

This study was funded by Grant no. NHRI-EX92–9023PL from the National Health Research Institute (NHRI) in Taiwan. The funding agency had no role in the study design; data collection; data analysis; data interpretation; writing of the manuscript; nor in the decision to submit the manuscript for publication. We also acknowledge Jersey Liang, PhD for his help in data analysis.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

All the authors claim to have no conflict of interest.

Author contributions

All authors meet at least one of the following criteria (recommended by the ICMJE: http://www.icmje.org/ethical_1author.html) and have agreed on the final version:

- substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data.
- drafting the article or revising it critically for important intellectual content.

References

Akner G. & Cederholm T. (2001) Treatment of protein-energy malnutrition in chronic nonmalignant disorders. *American Journal of Clinical Nutrition* **74**(1), 6–24.

Allison S.P. (2000) Malnutrition, disease and outcome. *Nutrition* **16**(7–8), 590–593.

Bonjour J.P. (2005) Dietary protein: an essential nutrient for bone health. *Journal of the American College of Nutrition* **24**(6), 526S–536S.

Bruyere O., Brandi M.-L., Burlet N., Harvey N., Lyritis G., Minne H., Boonen S., Reginster J.-Y., Rizzoli R. & Akesson K. (2008) Post-fracture management of patients with hip fracture: a perspective. *Current Medical Research and Opinion* **24**(10), 2841–2851.

Charlton K.E., Nichols C., Bowden S., Lambert K., Barone L., Mason M. & Milosavljevic M. (2010) Older rehabilitation patients are at high risk of malnutrition: evidence from a large Australian database. *Journal of Nutrition, Health & Aging* **14** (8), 622–628.

Chen Y.J., Dai Y.T., Yang C.T., Wang C.T., Wang T.J. & Teng Y.H. (1995) *A Review and Proposal on Patient Classification in Long-Term Care System*. Department of Health, Republic of China, Taipei, Taiwan, pp. 1–76.

Chen C.C., Schilling L.S. & Lyder C.H. (2001) A concept analysis of malnutrition in the elderly. *Journal of Advanced Nursing* **36** (1), 131–142.

Chevalier S., Saoud F., Gray-Donald K. & Morais J.A. (2008) The physical functional capacity of frail elderly persons undergoing ambulatory rehabilitation is related to their nutritional status. *Journal of Nutrition, Health & Aging* **12**(10), 721–726.

Council for Economic Planning and Development, Executive Yuan, ROC (2010) *Population Estimation in Taiwan: 2010–2060*. Retrieved from http://www.cepd.gov.tw/dn.aspx?uid=8966 on 20 April 2011.

Dawson-Hughes B. (2003) Interaction of dietary calcium and protein in bone health in humans. *Journal of Nutrition* **133**(3), 852S–854S.

Delmi M., Rapin C.H., Bengoa J.M., Delmas P.D., Vasey H. & Bonjour J.P. (1990) Dietary supplementation in elderly patients with fractured neck of the femur. *Lancet* **335**(8696), 1013–1016.

Department of Health, Executive Yuan, R.O.C. (2010) *Long-Term Care Insurance Planning*. Retrieved from http://www.doh.gov.tw/ufile/doc/Long-Term_Care_Insurance_Planning.doc on 18 February 2012.

Department of Statistics, Ministry of the Interior, ROC (2010) *Monthly Bulletin of Iinterior Statistics: Population by Age of 0–14, 15–64, 65+ and by 6-Year Age Group*. Retrieved from http://sowf.moi.gov.tw/stat/month/m1-05.xls on 20 April 2011.

Eneroth M., Olsson U.B. & Thorngren K.G. (2006) Nutritional supplementation decreases hip fracture-related complications. *Clinical Orthopaedics & Related Research* **451**, 212–217.

Espaulella J., Guyer H., Diaz-Escriu F., Mellado-Navas J.A., Castells M. & Pladevall M. (2000) Nutritional supplementation of elderly hip fracture patients: a randomized, double-blind, placebo-controlled trial. *Age and Ageing* **29**(5), 425–431.

Givens J.L., Sanft T.B. & Marcantonio E.R. (2009) Functional recovery after hip fracture: the combined effects of depressive symptoms, cognitive impairment and delirium. *Journal of the American Geriatrics Society* **56**(6), 1075–1079.

Guigoz Y. (2006) The Mini Nutritional Assessment (MNA) review of the literature: what does it tell us? *Journal of Nutrition, Health & Aging* **10**(6), 466–485.

Guigoz Y., Vellas B. & Garry P.J. (1996) Assessing the nutritional status of the elderly: the Mini Nutritional Assessment as part of the geriatric evaluation. *Nutrition Reviews* **54**(1), S59–S65.

Hanger H.C., Smart E.J., Merrilees M.J. & Frampton C.M. (1999) The prevalence of malnutrition in elderly hip fracture patients. *New Zealand Medical Journal* **112**(1084), 88–90.

Hedstrom M., Ljungqvist O. & Cederholm T. (2006) Metabolism and catabolism in hip fracture patients. *Acta Orthopaedica* **77** (5), 741–747.

Hollis S. & Campbell F. (1999) What is meant by intention to treat analysis? survey of published randomised controlled trials. *British Medical Journal* **319**(7211), 670–674.

Hung H.C., Yang R.S. & Tsauo J.Y. (2005) The epidemiology of hip fracture in Taiwan. *Journal of the Formosan Medical Association* **9**(1), 29–38.

Jallut D., Tappy L., Kohut M., Bloesch D., Munger R., Schutz Y., Chiolero R., Felber J.P., Livio J.J. & Jequier E. (1990) Energy balance in elderly patients after surgery for a femoral neck fracture. *Journal of Parenteral & Enteral Nutrition* **14**(6), 563–568.

Jamal Sepah Y., Umer M., Khan A. & Niazi Ullah Khan A. (2010) Functional outcome, mortality and in-hospital complications of operative treatment in elderly patients with hip fractures in the developing world. *International Orthopaedics* **34** (3), 431–435.

Jensen J.E., Jensen T.G., Smith T.K., Johnston D.A. & Dudrick S.J. (1982) Nutrition in orthopaedic surgery. *Journal of Bone & Joint Surgery- American Volume* **64**(9), 1263–1272.

Jette A.M., Harris B.A., Cleary P.D. & Campion E.W. (1987) Functional recovery after hip fracture. *Archives of Physical Medicine & Rehabilitation* **68**(10), 735–740.

Kaur S., Miller M.D., Halbert J., Giles L.C. & Crotty M. (2008) Nutritional status of adults participating in ambulatory rehabilitation. *Asia Pacific Journal of Clinical Nutrition* **17**(2), 199–207.

Kristensen M.T., Foss N.B., Ekdahl C. & Kehlet H. (2010) Prefracture functional level evaluated by the new mobility score predicts in-hospital outcome after hip fracture surgery. *Acta Orthopaedica* **81**(3), 296–302.

Lauque S., Arnaud-Battandier F., Mansourian R., Guigoz Y., Paintin M., Nourhashemi F. & Vellas B. (2000) Protein-energy oral supplementation in malnourished nursing-home residents: a controlled trial. *Age and Ageing* **29**(1), 51–56.

Lelovics Z. (2009) Nutritional status and nutritional rehabilitation of elderly people living in long-term care institutions. *Orvosi Hetilap* **150**(44), 2028–2036.

Lin C.-C., Ou Y.-K., Chen S.-H., Liu Y.-C. & Lin J. (2010) Comparison of artificial neural network and logistic regression models for predicting mortality in elderly patients with hip fracture. *Injury* **41**(8), 869–873.

Little R.J.A. & Rubin D.R. (1987) *Statistical Analysis with Missing Data*. Wiley, New York.

Lumbers M., Driver L.T., Howland R.J., Older M.W.J. & Williams C.M. (1996) Nutritional status and clinical outcome in elderly female surgical orthopaedic patients. *Clinical Nutrition* **15**(3), 101–107.

Magaziner J., Simonsick E.M., Kashner T.M., Hebel J.R. & Kenzora J.E. (1990) Predictors of functional recovery one year following hospital discharge for hip fracture: a prospective study. *Journal of Gerontology* **45**(3), M101–M107.

Magaziner J., Hawkes W., Hebel J.R., Zimmerman S.I., Fox K.M., Dolan M., Felsenthal G. & Kenzora J. (2000) Recovery from hip fracture in eight areas of function. *Journals of Gerontology Series A- Biological Sciences & Medical Sciences* **55**(9), M498–M507.

Meeds B. & Pryor G.A. (1990) Early home rehabilitation for the elderly patient with hip fracture. *Physiotherapy* **76**(2), 75–77.

Milne A.C., Potter J., Vivanti A. & Avenell A. (2009) Protein and energy supplementation in elderly people at risk from malnutrition. *Cochrane Database of Systematic Reviews (2)* C003288. doi: 10.1002/14651858

Neumann M., Friedmann J., Roy M.A. & Jensen G.L. (2004) Provision of high-protein supplement for patients recovering from hip fracture. *Nutrition* **20**(5), 415–419.

Nip W.F., Perry L., McLaren S. & Mackenzie A. (2011) Dietary intake, nutritional status and rehabilitation outcomes of stroke patients in hospital. *Journal of Human Nutrition & Dietetics* **24** (5), 460–469.

Patterson B.M., Cornell C.N., Carbone B., Levine B. & Chapman D. (1992) Protein depletion and metabolic stress in elderly patients who have a fracture of the hip. *Journal of Bone & Joint Surgery- American Volume* **74**(2), 251–260.

Pison C.M., Cano N.J., Cherion C., Caron F., Court-Fortune I., Antonini M.T., Gonzalez-Bermejo J., Meziane L., Molano L.C., Janssens J.P., Costes F., Wuyam B., Similowski T., Melloni B., Hayot M., Augustin J., Tardif C., Lejeune H., Roth H., Pichard C. & Investigators I.R.A.D. (2011) Multimodal nutritional rehabilitation improves clinical outcomes of malnourished patients with chronic respiratory failure: a randomised controlled trial. *Thorax* **66**(11), 953–960.

Ponzer S., Tidermark J., Brismar K., Soderqvist A. & Cederholm T. (1999) Nutritional status, insulin-like growth factor-1 and quality of life in elderly women with hip fractures. *Clinical Nutrition* **18**(4), 241–246.

Rabadi M.H., Coar P.L., Lukin M., Lesser M. & Blass J.P. (2008) Intensive nutritional supplements can improve outcomes in stroke rehabilitation. *Neurology* **71**(23), 1856–1861.

Rubin D.B. (1987) *Multiple Imputation for Nonresponse in Surveys*. Wiley, New York.

Samuelsson B., Hedstrom M.I., Ponzer S., Soderqvist A., Samnegard E., Thorngren K.G., Cederholm T., Saaf M. & Dalen N. (2009) Gender differences and cognitive aspects on functional outcome after hip fracture: a 2 years' follow-up of 2,134 patients. *Age and Ageing* **38**(6), 686–692.

Schafer J.L. (1997) *Analysis of Incomplete Multivariate Data*. Chapman & Hall, London.

Shyu Y.I., Chen M.C., Liang J., Wu C.C. & Su J.Y. (2004) Predictors of functional recovery for hip fractured elders during 12 months following hospital discharge: a prospective study on a Taiwanese sample. *Osteoporosis International* **15**(6), 475–482.

Shyu Y.I., Liang J., Wu C.C., Su J.Y., Cheng H.S., Chou S.W. & Yang C.T. (2005) A pilot investigation of the short-term effects of an interdisciplinary intervention program on elderly patients with hip fracture in Taiwan. *Journal of the American Geriatrics Society* **53**(5), 811–818.

Shyu Y.I., Liang J., Wu C.C., Su J.Y., Cheng H.S., Chou S.W., Chen M.C. & Yang C.T. (2008a) Interdisciplinary intervention for hip fracture in older Taiwanese: benefits last for 1 year. *Journals of Gerontology Series A: Biological Sciences & Medical Sciences* **63**(1), 92–97.

Shyu Y.I., Chen M.C., Cheng H.S., Deng H.C., Liang J., Wu C.C. & Tsai W.C. (2008b) Severity of depression risk predicts health outcomes and recovery following surgery for hip-fractured elders. *Osteoporosis International* **19**(11), 1541–1547.

Shyu Y.I., Liang J., Wu C.C., Su J.Y., Cheng H.S., Chou S.W., Chen M.C. & Yang C.T. (2010) Two-year effects of interdisciplinary intervention for hip fracture in older Taiwanese. *Journal of the American Geriatrics Society* **58**(6), 1081–1089.

Sieber C.C. (2006) Nutritional screening tools–How does the MNA compare? Proceedings of the session held in Chicago may 2–3, 2006 (15 Years of Mini Nutritional Assessment). *Journal of Nutrition, Health & Aging* **10**(6), 488–492.

Sullivan D.H., Sun S. & Walls R.C. (1999) Protein-energy undernutrition among elderly hospitalized patients: a prospective study. *Journal of the American Medical Association* **281**(21), 2013–2019.

Tkatch L., Rapin C., Rizzoli R., Slosman D., Nydegger V., Vasey H. & Bonjour J.P. (1992) Benefits of oral protein supplementation in elderly patients with fracture of the proximal femur. *Journal of the American College of Nutrition* **11**(5), 519–525.

Tsauo J.Y., Leu W.S., Chen Y.T. & Yang R.S. (2005) Effects on function and quality of life of postoperative home-based physical therapy for patients with hip fracture. *Archives of Physical Medicine & Rehabilitation* **86**(10), 1953–1957.

Vellas B., Guigoz Y., Garry P.J., Nourhashemi F., Bennahum D., Lauque S. & Albarede J.L. (1999) The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition* **15**(2), 116–122.

Visvanathan R., Penhall R. & Chapman I. (2004) Nutritional screening of older people in a sub-acute care facility in Australia and its relation to discharge outcomes. *Age and Ageing* **33**(3), 260–265.

Williams C.M., Driver L.T., Older J. & Dickerson J.W. (1989) A controlled trial of sip-feed supplements in elderly orthopaedic patients. *European Journal of Clinical Nutrition* **43**(4), 267–274.

Yip P.K., Shyu Y.I., Liu S.I., Lee J.Y., Chou C.F. & Chen R.C. (1992) An epidemiological survey of dementia among elderly in an urban district of Taipei. *Acta neurologica Taiwanica* **1**(4), 347–354.

Zuckerman J.D., Koval K.J., Aharonoff G.B. & Skovron M.L. (2000) A functional recovery score for elderly hip fracture patients: II. validity and reliability. *Journal of Orthopaedic Trauma* **14**(1), 26–30.

