ASSESSMENT OF NUTRITIONAL STATUS

AND

CLINICAL OUTCOME:

A STUDY OF ELDERLY FEMALE ORTHOPAEDIC PATIENTS

by

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ABSTRACT

An observation study of the nutritional status of a group of sixty elderly female orthopaedic patients was undertaken. Patients admitted to hospital for surgery for fractured neck of femur (FNF) or total hip replacement (THR) were studied from admission to six months following hospital discharge.

A nutrition risk allocation, based on the presence of three or more abnormally low admission values for serum albumin, haemoglobin and three anthropometric measurements, was used to allocate individual patients into high or low nutritional risk groups.

Clinical and nutritional outcomes within and between the two nutrition risk groups were evaluated over time. Data were analysed for the group of patients as a whole (FNF and THR), and for emergency patients (FNF) only. Patients allocated to the high risk group(s) had significantly longer stays in convalescence (p < 0.0009), and a greater proportion were still using walking frames at six months in the high risk group, compared with the low risk group(s), (p < 0.01). Although there was a trend for patients in the high risk groups to have a higher mortality rate at six months, this trend was only strong for the groups which included both THR and FNF patients.

Serial anthropometric measurements revealed differences in the post-surgical body compositional changes between the high and low nutritional risk groups. High risk patients showed little change in weight over the period of the study, whereas low risk patients lost weight following surgery, but returned to their usual weight by six months post-discharge. Upper arm anthropometry revealed significant losses in mid upper arm muscle circumference (MUAMC) in the low risk, but not in high risk patients when all the patients were considered (medians: -1.8 vs -0.1 cm, p < 0.007) and when emergency patients only were compared (medians: -1.4 vs 0.0 cm, p < 0.03). High risk patients showed losses in triceps skinfold thickness (TSF) measurements which did not return to pre-surgical values within the period of the study. The significance of these findings and their possible causes are discussed.

It was found that poor socio-medical factors, reported on admission, were more common in patients allocated into high risk groups, especially when the emergency patients only were considered. In particular, a greater number of patients in the high risk groups reported a history of recent falls (p < 0.0001) and...
depression \((p<0.07)\). Further studies are needed to determine whether socio-medical risk factors on admission can be useful in predicting outcome together with an investigation of the high prevalence of falls in patients allocated into the high risk groups.

Using the admission and clinical outcome data obtained from the sixty patients reported on in the present study and that of a further thirteen patients recruited subsequently, an analysis of data was undertaken to determine which admission measurements were most useful in predicting patients whose clinical outcome was inferior at six months post-discharge. Clinical outcome was quantified and related to objective and subjective admission measurements using a mathematical procedure termed discriminant analysis, which derived an equation relating clinical outcome to discriminating admission variables. The most influential or discriminating admission variables were found to be age, mental function and haemoglobin.

Data from a further cohort of 22 patients was used to undertake a initial, limited validation of the equation. The results indicated that for this smaller population the equation had a sensitivity of 100 percent and a specificity of 60 percent in predicting poor outcome. It is recognised that a more rigorous testing on a larger patient group is required involving randomised controlled supplementation.

The potential value of such a predictive model in the routine assessment of elderly orthopaedic patients is discussed together with its inherent limitations.
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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADFROM</td>
<td>Admitted from-</td>
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<tr>
<td>ADL</td>
<td>Activities of daily living</td>
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<tr>
<td>ALB</td>
<td>Serum albumin</td>
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<tr>
<td>BCG</td>
<td>Bromocresol green</td>
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<tr>
<td>CV</td>
<td>Coefficient of variation</td>
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<td>DCH</td>
<td>Delayed hypersensitivity skin test grading</td>
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<tr>
<td>DISTO</td>
<td>Discharged to-</td>
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<tr>
<td>fn</td>
<td>False negative</td>
</tr>
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<td>FNF</td>
<td>Fractured neck of femur</td>
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<tr>
<td>fp</td>
<td>False positive</td>
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<tr>
<td>HB</td>
<td>Haemoglobin</td>
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<td>HGS</td>
<td>Handgrip strength</td>
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<td>HRA</td>
<td>High risk all patients</td>
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<tr>
<td>HRE</td>
<td>High risk emergency patients</td>
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<td>I/O</td>
<td>Information and orientation scale</td>
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<td>LRA</td>
<td>Low risk all patients</td>
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<tr>
<td>LRE</td>
<td>Low risk emergency patients</td>
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<tr>
<td>MFT</td>
<td>Mental function test</td>
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<td>MOBIL</td>
<td>Mobility</td>
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<td>MUAC</td>
<td>Mid upper arm circumference</td>
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<tr>
<td>MUAMC</td>
<td>Mid upper arm muscle circumference</td>
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<td>OPV</td>
<td>Overall predictive value</td>
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<tr>
<td>PEM</td>
<td>Protein energy malnutrition</td>
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<tr>
<td>PNI</td>
<td>Prognostic nutritional index</td>
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<tr>
<td>POI</td>
<td>Prognostic outcome index</td>
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<tr>
<td>RBP</td>
<td>Retinol binding protein</td>
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<tr>
<td>RID</td>
<td>Radial immunodiffusion</td>
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<tr>
<td>SAS</td>
<td>Subjective assessment score</td>
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<tr>
<td>SGA</td>
<td>Subjective global assessment</td>
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<tr>
<td>STAY</td>
<td>Total length of stay in hospital and convalescence</td>
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<tr>
<td>TCOS</td>
<td>Total clinical outcome score</td>
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<tr>
<td>TFN</td>
<td>Serum transferrin</td>
</tr>
<tr>
<td>THR</td>
<td>Total hip replacement</td>
</tr>
<tr>
<td>tn</td>
<td>True negative</td>
</tr>
<tr>
<td>tp</td>
<td>True positive</td>
</tr>
<tr>
<td>TSF</td>
<td>Triceps skinfold thickness</td>
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<td>WCC</td>
<td>White cell count</td>
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CHAPTER 1

INTRODUCTION AND AIMS
1.1 BACKGROUND

Most health professionals would agree that there is probably some relationship between nutritional status and clinical outcome. However, this statement represents a challenge because of the uncertainties regarding the definition of optimal nutritional status; similarly the definition of clinical outcome varies depending on the patient group. As well as uncertainties in the definition of nutritional status, there are problems associated with the methods and criteria used for assessment, and their application in practice. Likewise the evaluation of clinical outcome is dependent upon the methods and criteria used.

There can be little doubt that, however difficult it may be to assess, the nutritional status of a patient is an important issue with respect to recovery. It has been documented widely that certain groups are particularly vulnerable to nutritional deficiencies and it is known that people with severe illness are at risk of an often unrecognised complication, namely malnutrition. This complication occurs either because people cannot or will not eat, or simply are not able to absorb the nutrients from a normal diet. The malnutrition which results may seriously delay or complicate recovery from medical and surgical disorders, or may contribute to increased mortality. In addition, at a time of financial stringency and accountability, there is evidence to show that better diagnosis and treatment of malnutrition not only improves clinical outcome of patients but also results in financial savings for the NHS.

One of the difficulties which has arisen in relation to the problem of malnutrition is that those people affected are a heterogeneous group, ranging from the very young to the very old, and who may be undergoing treatment for a variety of medical disorders. Furthermore, they may comprise those suffering a temporary acute form of malnutrition or those suffering chronic malnutrition, the latter being related to the presence of underlying illness or to poor socio-economic factors. Poor appetite, difficulty in swallowing and disorders which limit mobility such as arthritis, may limit the ability to prepare and consume meals. An acute episode of an underlying illness, or the need for surgery necessitating admission to hospital, may exacerbate a patient's inability to eat at a time when their nutritional requirements are likely to be greater than normal.
Unfortunately, not only does malnutrition often remain an unrecognised complication of illness but the importance of good nutrition in the maintenance of health is often overlooked. The improvement of care in this area requires that malnutrition is recognised at an early stage. However, with recognition comes the responsibility to take action, and those involved in caring for people in hospitals and the community must be able to implement and organise nutritional treatment in an appropriate and cost effective way, (Dickerson, 1986). Few British hospitals practise such assessment as part of routine care, although this may be changing with the advent of the setting of nutritional standards and other quality control measures currently being implemented. The introduction of nutritional assessment and support depends on the development of a more positive attitude to the identification of malnutrition using the combined strengths and skills of the primary care team. It requires that research be continued with respect to specific clinical groups in hospital and community settings, to provide information on the most appropriate assessment methods and their interpretation.

The consideration of people in both hospital and in the community is important to emphasise. Ideally, malnutrition should be recognised and treated prior to hospital admission. Obviously this is impractical where patients are admitted as emergencies. However, Nurses and G.P.’s in the community should monitor patients for signs of malnutrition or be aware of the relevant nutritional risk factors for particular groups. Indeed, published data show that as many as half of certain patient groups are malnourished on admission to hospital, (Hill et al, 1977). During a prolonged hospital stay malnutrition often becomes worse, or develops for the first time, increasing the period taken to recover after the patient returns home. It is probably true to say that only when the nutritional status of every patient is assessed will the benefits of nutritional care and support be realised. The elderly represent a particularly vulnerable group with respect to the predisposition to, and the consequences of poor nutritional status. Indeed, the latest government report on elderly people recommends that the "assessment of nutritional status should be a routine aspect of history taking and clinical examination when an elderly person is admitted to hospital," (DH, 1992).

The form nutritional assessment should take is a subject of considerable debate. It is acknowledged by many health professionals that doctors and nurses are probably in the best position to identify patients who may be at risk from malnutrition. Whilst dietitians would be the most appropriate people to undertake such screening there are simply too few to perform this function.
Nutritional screening requires a relatively high level of skill and knowledge of
nutrition to ensure effective nutritional support is implemented by the specialist
dietetic services. At present, doctors and nurses are not used to looking for
malnutrition. Therefore, the development of nutritional screening tools for use
with specific patient groups would be of benefit, especially where
these have been tested rigorously for validity, reliability and sensitivity.

This thesis therefore focuses on a specific group of elderly patients for reasons
described below.

1.2 DEMOGRAPHIC CONSIDERATIONS

Although the proportion of elderly people in society is increasing, relatively little
is known about their nutritional status or of what constitutes optimal nutritional
status. The increase in the numbers of people over the age of 65 years this
century is a direct result of the virtual eradication of life threatening infectious
disease, improved sanitation and housing and advances in medical care.
Moreover, population forecasts show that by the turn of the next century the
proportion of the population over 75 is expected to increase by 22 percent and
those over 85 years by 69 percent (Social Trends, 1984). Indeed, the past 10
years has seen a marked increase in the number of people over the age of 85,
(Social Trends, 1988). In this group the ratio of women to men is 2:1, and at
the age of 85, 3:1 (Thomas, 1988).

It should be emphasised that the vast majority of older people, (95 percent), are
not in hospitals, nursing homes or similar care establishments, but live in the
community, (Hunter et al, 1989). Statistics have shown that there has been a
significant increase in the proportion of these elderly people who live alone in
their own homes, dependent on their own resources for obtaining a good diet.
Of those who reach retirement, many individuals enjoy good health and an
active life. However, there is likely to be a greater number of highly dependent
frail elderly people both now and in the future who may be more at risk of
nutritional deficiencies than their healthy active counterparts.

Ageing in itself has little effect on the ability of people to care for themselves;
nor does it affect food intake provided good health is maintained. However, a
recent government report which reviewed the nutrition of elderly people, (DH,
1992), noted the impact of illness and disability on nutritional status. Indeed,
the report expressed concern that low body weight is a common finding among
chronically ill or disabled old people especially among very old people being cared for in institutions. Furthermore, the report confirms that little information is available regarding energy and nutrient requirements in healthy older people. Even less data exists on the nutrient requirements of elderly people who suffer acute illness, chronic illness or disability. The report also emphasises that the energy intakes of chronically ill and disabled old people are sometimes so low that unless the nutrient density of diets is high, adequate intakes of specific nutrients are unlikely to be achieved. However, it should be noted that the extent to which nutrition is likely to be the cause or consequence of poor health is difficult to ascertain. Nutrition in the elderly will assume increasing importance in future, especially in maintaining the quality of life. Indeed, according to the latest government report, (DH, 1992), "there needs to be greater awareness of the importance of good nutrition for maintaining health of elderly people and of its contribution to recovery from illness".

1.3 PREVALENCE OF MALNUTRITION IN THE ELDERLY LIVING IN THE COMMUNITY

Although malnutrition in the clinical or subclinical form is recognized increasingly in hospitalised elderly, there have been very few studies to determine the prevalence of undernutrition in non-institutionalised populations. Such studies have been sporadic and results have often been affected by the use of unvalidated reference data, as well as unrepresentative sampling. In addition there is the problem of defining "normality" for elderly people. It is preferable to use reference standards derived from healthy free-living elderly people who have a comparable genetic and geographical background to that of any study group. Furthermore, when comparing the results of different surveys it is essential that the nature of the populations being surveyed, is stated. It can be difficult to interpret data regarding the prevalence of malnutrition because of the use of different combinations of, and criteria for, anthropometric, biochemical and dietary data, measurements normally used as a basis for defining undernutrition. These particular considerations are discussed in detail in Chapter 3 in relation to the determination of the incidence of malnutrition on admission to hospital. However, the prevalence of malnutrition among non-institutionalised elderly living in the community has been investigated in two government surveys, (DHSS, 1972;1979).
1.3.1 Nutrition surveys of older people

The first COMA Panel on Nutrition of the Elderly stated that:

"there is little doubt that more is known of the nutritional state of our nation than any other in the world, but in relation to the elderly the evidence is still inadequate", (DHSS, 1972).

Indeed, twenty years later the evidence is still inadequate. The DHSS reports of surveys, (actually carried out in 1967/8 and 1972/3), are the most recent large scale studies of elderly people in the UK, (DHSS, 1972; DHSS, 1979). The energy and nutrient intakes of 764 free-living elderly people, from six towns in England and Scotland, were assessed in 1967/8 using dietary recall and diary methods, (DHSS, 1972). Approximately five years later, in 1972/3, 365 of the original participants were re-examined. The findings of these surveys did show geographical and sex differences in energy and nutrient intake. However, the diets of older people did not change substantially with age provided they remained in good health. Nevertheless, three percent of those examined in the original survey were diagnosed as malnourished. In three-quarters of the cases, malnutrition was associated with pre-existing disease and poor living circumstances. Interestingly, of those studied five years later in 1972/3, seven percent were malnourished and this finding was more common in subjects over 80 years of age. Several social and medical risk factors for malnutrition were identified of which the most important was being housebound. Thus, in people over 80 years, the prevalence of malnutrition was double that in the 70-79 year age group, (14 percent), and was even higher, (17 percent), in the housebound. Frank malnutrition was lowest in the ambulatory elderly living independently at home although it should be noted that both surveys excluded people in institutional care. Of the 3 percent of those reported to be suffering from malnutrition, frank nutritional deficiencies of folate, vitamin B12 and iron were found as well as some cases of protein calorie malnutrition.

The results of these surveys are widely reported in the literature; they provide the most recent published nutritional data for elderly people in the UK. It should be noted that a further study of 1000 older people was carried out in 1973/4, but unfortunately no report was published.

The prevalence figures quoted in the DHSS surveys, (1972, 1979), are considered an over-estimate by some workers, since the sample was thought to be unrepresentative of the population as a whole. MacLennan, (1988), found
that only 1-2 percent of old people examined in his study showed evidence of clinical malnutrition. In MacLennan’s study, malnutrition occurred in patients suffering from ill-health and in those admitted to hospitals with acute illness.

A number of other community prevalence studies have been reported in the literature. MacLeod et al, (1974), in their study of 264 people in Glasgow reported a community prevalence of 2-12 percent undernutrition, while Vir and Love, (1980), found that between 4-16 percent of the 37 people in their study demonstrated abnormal values for various parameters. A larger study by Burr et al, (1982), of 723 people from South Wales reported prevalence at between 3 and 50 percent. Finally, a study conducted in Ilkeston in Derbyshire of 136 subjects quoted prevalence at between 10-36 percent, (Kemm et al, 1985). The value of these studies is limited regarding the comparison of the prevalence of undernutrition because of the variations in the methods used. However, they have provided indices of nutrition useful in the assessment of elderly people which could provide a basis for screening in the community.

The overall findings of these studies has been that frank nutritional deficiencies are relatively uncommon among men and women living in their own homes or with relatives. Whilst surveys have identified numerous deficiencies of specific nutrients, such as protein, energy, calcium, vitamin D, vitamin C and folate as well as iron and potassium, it is difficult to quantify the effect that this has on health and well-being. However, such deficiencies undoubtedly contribute to the suggested high incidence of sub-nutrition, a condition where there are non-specific symptoms in association with certain nutrient deficiencies. Indeed, it is said that subclinical forms of malnutrition are becoming more commonly recognised in the elderly population, (Lehmann, 1989). Furthermore, as pointed out in the DHSS survey, (1979), diagnosis becomes more difficult when malnutrition is marginal. The DHSS survey, (1979), found that there were some people

"in whom the margin of safety must have been narrow",

It has been stated that, whilst the tools used to identify malnutrition may be becoming more sophisticated, they are still inadequate for diagnosing marginal or subclinical malnutrition, (Davies, 1984). Furthermore, only rarely are low dietary intakes and apparently abnormal biochemical findings found to be associated with the disturbance in form and function that is necessary for the diagnosis of clinical malnutrition. The detection and prevalence of subclinical malnutrition therefore is even more difficult to determine.
As mentioned above, abnormalities or differences from standard values, (which are often derived from young populations), could simply reflect physiological and biochemical variations with increasing age. Early signs of protein-calorie malnutrition include: anaemia, behavioural and neurological deterioration, connective tissue changes, and muscle weakness, all of which are features of chronic diseases of older people, (Lipschitz and Mitchell, 1984). Nevertheless, the extent of subclinical malnutrition which appears to exist in free-living "healthy" elderly subjects in the community is still a cause for major concern in many reports (DHSS, 1979a). Other workers have expressed considerable apprehension that substantial subclinical malnutrition exists in the aged population leading to poor health, apathy, and disinterest in food (Anderson, 1968).

Subclinical malnutrition can easily precipitate to a stage of frank malnutrition under the environmental and pathological stresses to which the elderly are very prone, (Exton-Smith, 1968). The estimation of the prevalence of subclinical malnutrition therefore needs more attention, consideration and documentation. Furthermore, its relationship with increased morbidity and mortality in the community needs to be investigated, (Kemm, 1985). Studies should take the form of prospective rather than cross-sectional studies.

Prospective studies are valuable in providing the opportunity to investigate the prognostic significance of various indices of nutritional status, although association does not necessarily imply causation. Their interpretation continues to present difficulties as any factor which changes with age will predict mortality even when age is allowed for. In addition there are substantial variations in individuals' nutrient requirements (Burr, 1985). Older people often exhibit classical signs of nutrient deficiency, but these may be a result of underlying illness, (MacLennan, 1988). Indeed nutrient requirements can be altered by many factors, including age, body metabolism, functional capacity, absorption, drug therapy, physical state and adaptive ability. Vir and Love, (1979), consider that there is an increased need for nutrients in the elderly as a result of disease, metabolic abnormality and structural changes in the gastrointestinal tract.

However, even if subclinical malnutrition can be identified some uncertainty exists as to the effect on the health of older people. Whilst abnormal values of clinical and biochemical indices are associated with acute illness and increased mortality some workers question whether nutrition is the cause or effect. Stress is known to cause older people to move into negative nitrogen balance and
acute infections alter the ratio of buffy coat to plasma ascorbic acid, (MacLennan et al, 1977). Although elderly people have been reported to have low serum vitamin concentrations these may simply reflect increased physiological and biochemical variation in old age. Individuals at nutritional risk cannot be identified merely by selecting those at the lower end of the ranges as, without any diagnosable change in form or function, they do not necessarily provide evidence of malnutrition.

It is clear that research is needed to investigate the nutrition of older people to clarify some of the shortcomings which are associated with dietary, clinical and biochemical assessments. Until nutritional deficiency has been defined clearly, epidemiological surveys cannot estimate the prevalence of clinical or sub-clinical undernutrition with any certainty. Socio-economic factors are important too and these could be evaluated as a possible alternative means of identifying nutritional risk in elderly individuals. The background of some of these nutritional risk factors is now considered.

1.4 CAUSES OF POOR NUTRITIONAL STATUS IN THE ELDERLY

1.4.1 General

It is recognised generally that a combination of factors, both medical and social, contribute to the development of malnutrition. In acknowledging the complex interactions of disease, drugs, appetite and other socio-economic factors, many workers have emphasised that malnutrition among the elderly may be as much a socioeconomic as medical problem, (Davies, 1990).

A number of studies have shown clearly that elderly people suffering chronic illness or disability are at greatest risk of nutritional deficiencies. In a DHSS survey of elderly people, as stated earlier, three percent of the population surveyed showed evidence of undernutrition, (DHSS, 1979). Of those people found to be malnourished, 44 percent had major medical disorders, 26 percent had socio-economic problems, and in 30 percent of the cases no clear reason was found. The DHSS study found that malnutrition was associated with both medical and social "risk factors". Among these, certain medical conditions were
associated with a higher incidence of malnutrition such as:

- chronic bronchitis
- emphysema,
- dementia,
- depression,
- long-term effects of gastrectomy,
- difficulty in swallowing,
- poor dentition,

and social factors associated with being housebound including:

- having no regular cooked meals,
- bereavement,
- being in social classes IV and V
- in receipt of supplementary benefit.

Subjects affected by several risk factors were particularly prone to malnutrition. Thus, a major finding of these surveys was that whilst the dietary pattern of most old people remains unchanged, other factors associated with age in general can lead to nutritional deficiencies.

1.4.2 Physical and medical disability

Elderly people in poor health tend to consume less nutritionally adequate diets than those in better health. In the case of acute illness, the temporary decline in nutritional status may be overcome once normal eating is resumed. However, some elderly people suffer from recurrent episodes of ill-health resulting in a steady decline in nutritional status. In a survey conducted on old people living in their own homes, Exton-Smith, (1977), found that those whose general condition was judged to be worse than average on the basis of clinical judgement consumed fewer calories. In the group with the lowest intake of calories, 20 percent had a serious chronic condition, such as failing vision or osteoarthritis, which impeded the consumption and/or preparation of food. The effects of ill-health on nutrient intakes was also well illustrated in the DHSS survey, (1972), which showed energy intakes of chronically ill elderly men to be 20 percent lower than in healthy men of a similar age. Hence, disability or disease appears to have a greater effect than does age alone.
The nutrient quality of diets low in calories, as stated earlier, has been found to be poor in the elderly and a substantial number of older people may be affected in this way. Morley, (1986), reported that 16 percent of the over 60's in a particular survey had energy intakes of less than 1000 Kcals/day. On such low intakes, there is an inability to achieve adequate protein and energy requirements; vitamin, mineral and trace element intakes will be correspondingly low. In a study of 60 elderly women living at home Exton-Smith and Stanton, (1965), reported that compared with 70 year old women, women aged over 80 years had dietary intakes of 19 percent less calories, 18 percent less calcium, 30 percent less iron and 30 percent less vitamin C. Further confirmation that ill-health results in reduced food intake comes from studies of the elderly in long stay geriatric hospitals. In a study of long-stay elderly subjects, 19 of 21 patients had energy intakes which were less than 1.27 x BMR and they lost weight over a period of one year, (Thomas et al, 1988). The latest government review of nutrition and the elderly (DH, 1992), suggests that ill-health may lower food intake for a number of reasons:

- impairment of appetite due to taste changes or as a consequence of drug therapy;
- inability of sick people to shop and cook, with those requiring assistance being particularly vulnerable;
- poor dentition and oral health;
- gastrointestinal disease or drug therapy which may cause nausea, vomiting, dysphagia, steatorrhoea or diarrhoea affecting food intake or absorption.

The exact relationship between disability and reduced dietary intake remains unclear however, apart from the obvious factors such as disease.

In those studies in which it is recorded, physical disability appears to account largely for the age-associated fall in dietary intake. In a longitudinal study of the dietary intake of elderly women, calorie intake fell by 20 percent between the ages of 70 and 80 years in those women with physical disability, (Stanton and Exton-Smith, 1970).

Being housebound is associated with inadequate diet, in both calories and protein. Bunker et al, (1987), studied 20 housebound people (aged between 69
to 85 years), who were suffering from various chronic illnesses although those with known renal, hepatic, gastrointestinal, malignant or acute disease were excluded. Eighteen of this group were housebound for physical reasons and two because of depression, but despite formal and informal meal provision the housebound subjects were eating inadequate diets in which energy and protein intakes were 29 and 33 percent lower respectively than in the fit active elderly subjects, (Bunker et al, 1987). This housebound group also had diets which were found to be at greater risk of deficiencies of zinc, copper, iron, selenium, calcium and phosphorus when compared with apparently healthy people of similar age, (Bunker et al, 1989).

The same housebound group were found to be in negative nitrogen balance, (Bunker et al, 1987). The average protein intake of the housebound group was only 0.67 g/kg/day and they were unable to maintain positive nitrogen balance. Whilst Munro et al, (1987), have questioned the validity of nitrogen balance studies to determine the adequacy of protein intakes, they recommend that protein intake in the elderly should exceed 0.8g/kg/day, because of the frequency of illnesses in the elderly resulting in transient losses of body protein which require dietary replacement. Furthermore, low protein intakes in elderly people are usually associated with reduced calorie intake which in turn reduces the efficiency of nitrogen retention. Bunker et al, (1987), were reluctant to attribute the negative nitrogen balance in their housebound subjects to poor diet. Their explanation was that the negative nitrogen balance was due to immobility resulting in lean tissue losses particularly when protein and energy intakes are marginal.

However, the relationship between disability and undernutrition is likely to be multifactorial. As well as physical inactivity, factors such as: psychological well-being; financial burdens resulting from the disability; anorexia due to disease; drugs and their effect on nutrient absorption, may be important, (Lehmann, 1989).

Hurdle et al, (1966), found that low serum folate values were significantly related to the severity of disability. Immobility in older people is associated with elevated cortisol levels and faster protein turnover, (Frayn et al, 1983; Lehmann et al, 1989). In contrast, protein balance is unaffected if nutrition is adequate and the subject is in steady state, possibly because of raised levels of growth hormone. If protein requirements or intake alters adversely, however, immobile elderly people are at risk of severe negative nitrogen balance, (James et al, 1986). People with reduced mobility thus appear in general to consume food of
a lower nutritional value. This applies particularly to the housebound living alone without adequate support. Since twenty two percent of the elderly in the UK have severe physical disabilities, (DHSS, 1979), and eight percent are housebound, (Exton-Smith, 1980), there is potentially a large group at high risk of undernutrition. Although previously described by Exton-Smith, (1980), the apparently strong relationship between disability and undernutrition in elderly people has only recently been demonstrated clearly by Morgan et al, (1986).

Morgan et al, (1986), measured anthropometric and biochemical indices of nutritional status in 450 elderly women divided into groups according to their degree of physical dependence. The study showed that weight, body composition and dietary intakes were significantly different in women who were day patients or inpatients when compared with the free-living elderly population. Furthermore, a high incidence of abnormal values for anthropometric and biochemical measurements was also found in subjects living in the community who were attending a geriatric day hospital. Indeed, in the case of some of the measurements, there was a higher incidence of abnormalities in the community living group, who were attending the day hospital, than in a group of long stay hospital patients. Thus, 40 percent of women attending a day hospital had abnormally low values for body weight whilst 50 percent had abnormally low values for TSF and MUAMC. Furthermore, in the case of biochemical measurements, the percentage of abnormally low values for serum albumin was the same for both the day hospital and long stay patients. However, over 50 percent of the community living group attending day hospital had abnormally low values for vitamin C in contrast to only 12 percent in the long stay patients.

Earlier, Vir and Love, (1979), had conducted a comparative study of institutionalised and non-institutionalised elderly people living in Belfast. They found a high prevalence of malnutrition among elderly people living in sheltered accommodation in the community. There was a higher percentage of abnormally low levels of the vitamins, thiamine, pyridoxine and ascorbate in people living in their own homes or in sheltered accommodation than in long-stay hospital patients. Furthermore, of those living in sheltered accommodation:

"more than 50 percent were dependent on a domiciliary meal service during the day and avoided cooking or eating proper evening meals"

and

"the occurrence of biochemically deficient levels of iron, folate, thiamin, riboflavin and vitamin B6 was highest in these subjects".

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Although the majority of these individuals were considered to be capable of self care, in practice, most of the elderly people in this study were unable to shop and cook for themselves and were dependent on domiciliary meal services for their hot meals.

These studies support the conclusion that nutritional problems may be most prevalent in elderly people living in the community, who although suffering from some form of chronic ill-health, are not considered to require full-time care in a long stay hospital or nursing home. When the support of family and friends is absent, the nutritional status of such individuals is highly dependent on the availability of community services provision and may fluctuate according to the individual’s health and the degree to which the practical problems of shopping, cooking and eating are identified and acted upon by those responsible for providing care.

1.4.3 Mental disorders

Stokoe, (1965), observed that the medical, nursing and social needs of the elderly suffering from psychiatric disorders are the most neglected. In terms of nutrition, Hurdle et al, (1966), in their study found that two-thirds of those identified as having no motivation were folate deficient. Longergan et al, (1971), found females with dementia had significantly lower intakes of up to five nutrients. In community surveys cognitive function has been found to be more frequently associated with riboflavin and ascorbic acid deficiencies, (Kemm et al, 1985). In contrast hospital patients, with dementia and acute confusional states have tended to be associated with thiamine and folic acid deficiency, (Older and Dickerson, 1982; Katakity et al, 1983). Recent work shows that thiamine deficiency may have an influence and be the result rather than the cause of confusional states following surgery, (Day et al, 1988). The reason for the occurrence of folate deficiency with dementia may be the same as that for thiamine deficiency and acute confusion, especially as both nutrients are largely destroyed during food storage and cooking, (Sneath et al, 1973; Thomas et al, 1985). Mental state is important according to a recent review of nutrition in the elderly ; people who are confused cope poorly with preparing and eating food, (DH, 1992). Malnutrition occurs in elderly people suffering from chronic brain syndrome and confusional states. However, equally important is the association between malnutrition and depressive illness, which leads to a disinclination to buy food, cook and in some cases eat. Apart from the obvious effect of depression on food intake, bereavement appears to be a common cause of
undernutrition, and pathological grief reaction may be associated with severe undernutrition, (Lehmann, 1989).

1.4.4 Social factors

Increasingly, social factors are being shown to be associated with poor nutritional status of the elderly. Income has been found to correlate inversely with the degree of nutrient deficit found in older people, (DHSS, 1979), while social class is inversely associated with the risk of age-associated decreases in dietary calcium, vitamin A, vitamin C and protein, (McGandy et al, 1966).

Healthy affluent older people show no evidence of protein deficiency according to Munro et al, (1987). In general the elderly tend to be poorer than other sectors of the population and this certainly relates to their nutritional vulnerability. In a Family Expenditure Survey, (1981), carried out by the Department of Employment, it was found that the retired elderly, especially those relying on a pension as their sole financial means, spent less on food. Brockington and Lempert, (1967), found that pensioners who were able to supplement their income from savings or part-time earnings had a better diet. It is important for health professional to be aware of the relationship between income and undernutrition, especially with regard to preventative work as part of the promotion of good health.

Many other factors contribute to undernutrition in older people, although present knowledge is based on a limited number of studies in this area, (DHSS 1979). Examples of those studies which exist have been reported earlier. However, the findings of a study by Exton-Smith and Stanton, (1965), considered that poor nutrition education of some elderly people was an important factor contributing to malnutrition. It is interesting to note therefore that social isolation in itself may have metabolic and endocrinological effects such as catabolism and weight loss which are likely to further reduce nutrient intake in the elderly. Indeed, dietary intake has been found to be greater in those old people who eat with others, be it at home or in luncheon clubs, whilst old people living alone in social isolation demonstrate a lack of interest and disinclination to prepare adequate meals. However, some workers have found that eating with others improves diet only if done in such a way as to avoid feelings of dependency in the participants, (McIntosh et al, 1984).

Being unwell often results in a failure of appetite. This may be compounded by the practical problems of shopping and preparing meals. Inadequate food intake, as a result of a passing or long continued impairment of appetite, in an individual
whose nutritional status is already marginal as a result of some of the factors already mentioned above or relating to extensive use of medication, may precipitate clinical malnutrition. The time taken to recover appetite following infections is also longer in the older person.

In conclusion, the relatively high levels of malnutrition found among older people and the strong relationship between poor nutritional status and chronic ill-health underlines the need for preventative measures to be adopted, (White et al 1991). Many hospital and nursing home patients are already malnourished on admission. Simple preventative approaches could be adopted in the community by being alert to the nutritional risk factors, (Davies and Knutson, 1991). It can be seen from the discussion that in certain cases key single causes, such as rapid weight loss, can operate to produce malnutrition. However, in the majority of cases a number of factors are involved; limited mobility, loneliness, social isolation and depression are all found in housebound old people and make them prone to malnutrition. Malnutrition can be treated successfully if correctly identified. Indeed the authors of the DHSS report, (1979), observed that malnutrition can be prevented if the warning signals are recognised and acted upon. Furthermore, prevention based on early recognition and intervention is preferable in both human and financial terms. An interesting observation is that in marked contrast to the high percentage of elderly patients in hospitals who are diagnosed as malnourished, only rarely is malnutrition reported in elderly non-institutionalised men and women, (DHSS 1979). However, these surveys have shown that it is very difficult to diagnose mild malnutrition even when there is a large amount of information on individuals. In spite of this many workers continue to warn that the elderly are especially vulnerable to malnutrition and that subclinical malnutrition is probably relatively common, (Vir and Love, 1979). In older people the margin of safety is much narrower than in younger people. In the elderly, the homeostatic balance may be impaired or upset by hazards to which the elderly are prone, (Davies and Knutson 1991). As people get older the key combinations of factors such as disease, physical or mental disabilities, and environmental, economic and social difficulties as outlined above can exceed the ability to respond effectively.

Lehmann, (1989), stated that:

"there is a need for more detailed investigations of the epidemiology of undernutrition in the elderly; at present there is little information on the prior probabilities of the various possible diagnoses."
The poor clinical prognosis of elderly patients with undernutrition has only recently been recognized. The 90-day fatality of patients with anthropometrically defined undernutrition admitted to a geriatric assessment ward was 50 percent compared with 16 percent among the better nourished, (Friedman et al, 1985). Bastow et al, (1983), found that 18 percent of severely malnourished fracture neck of femur patients died compared with 4 percent of well-nourished patients, a difference not due to age or illness. In a study of housebound old people on self-selected and largely inadequate diets, "nearly all had deteriorated to the point of being too poorly to participate in further studies" at 6-12 months after initial measurements, (Bunker et al, 1987). Whilst it clear that the relationship between undernutrition and poor prognosis can work either way it is still important to establish which patients might benefit from intervention. Morbidity from undernutrition is less easily quantified and is also under-diagnosed and reported. However, complications of malnutrition have been reported to include increased risk of hypothermia and fractured femur, (Bastow et al, 1983), pneumonia, (McLaren, 1981), and pressure sores, (Pinchcofsky-Devin et al, 1986), and a predisposition to winter-related cardiovascular events, (Alden et al, 1987). Nutritional status has been also associated with muscle strength, (Pearson et al, 1985).

The diagnosis of malnutrition still remains problematic and as discussed in Chapter 3 most workers advocate the use of a combination of measurements. At present no single diagnostic test exists. However, the principles of prevention follow closely on an understanding of the causes of undernutrition. Screening of elderly people, particularly those at risk, is not routine at present but would be highly desirable. At present there is no consensus as to the best strategies to adopt, although some advocate that the use of routine arm anthropometry on all new geriatric patients might be a reasonable aim. Others consider the over-riding influence of social factors could be used as the basis of a screening device. This would have particular value for non-institutionalised elderly people and those recently admitted to hospital from the community.

1.5 AIMS OF THE STUDY

1.5.1 The specific patient group

The above provides the background against which the aims of this study were devised. In order that the relationship between nutritional status and clinical outcome could be investigated in greater depth, a group of elderly female
orthopaedic patients undergoing total hip replacement or surgery for fracture neck of femur were chosen. This is a group whose clinical outcome is often poor following surgery and whose nutritional status is known to be variable. Criteria of clinical outcome are well documented for these two conditions so that published information is readily available for comparison. Morbidity and mortality rates are higher among elderly injured patients compared with younger patients. Furthermore, morbidity and mortality can occur over a longer period after injury. As stated by Horan et al, (1988), the extent to which pre-existing malnutrition and other factors, such as social and medical characteristics, might contribute to these age-related differences requires further study.

A limitation of many previous hospital based studies which have investigated the relationship between nutritional status and clinical outcome has been that patients have been studied only for the period of hospitalisation itself, (Hill, 1977). Very little follow-up information has been obtained in the period after discharge to enable a range of clinical parameters to be monitored in the longer term. The need to obtain detailed clinical and nutritional data following hospitalisation is itself extremely important, as at present, there is little information on the changes in nutritional status which occur during recovery and rehabilitation, particularly when this is prolonged as in elderly orthopaedic patients.

It is well documented that the effect of major illness and injury is to increase nutritional requirements. The elderly may be particularly vulnerable with respect to their ability to achieve nutritional repletion during the recovery period. Whilst recovery may be inevitably complicated by the effects of ageing and underlying disease, other more preventable factors may be involved which constrain the return to optimal health. This failure to assess long-term outcome, both in terms of clinical and nutritional criteria, means that at present we have an inadequate scientific base for making decisions regarding the need for long term nutritional intervention, in this group of patients.

As mentioned above there is good evidence to support the view that, in the elderly, poor nutritional health has a deleterious effect on outcome and recovery rates from surgery. Indeed, Bastow et al, (1983), showed recovery times from fractured neck of femur to be prolonged significantly in malnourished elderly women compared with women considered to be in good nutritional condition. When a randomised selection of the malnourished women were given nasogastric feeding overnight following surgery, they had better healing times and returned to previous mobility sooner than did the malnourished patients.
offered normal hospital food, (Bastow et al, 1983). This apparent clear benefit of short term and intensive nutritional support in hospital studies has only been demonstrated in those individuals shown to be malnourished on admission to hospital. It follows that some form of screening would be useful to identify those patients most at-risk and hence most likely to benefit from nutritional support. The development of such a procedure, based on data obtained from the long-term follow-up study, was a further aim of the present study.

1.5.2 Summary of aims

The general aims of the present study were therefore:-

- to investigate the relationship between the nutritional status of elderly orthopaedic female patients on admission to hospital and their subsequent clinical outcome
- to investigate changes in nutritional status over six months in elderly patients undergoing orthopaedic surgery
- to develop a nutritional assessment procedure which could be used routinely to screen all patients on admission to hospital

The specific aims of each study are given in the experimental Chapters 3 and 4.
CHAPTER 2

METHODS
CHAPTER 2 METHODS

2.1 INTRODUCTION

This Chapter describes the measurements used in the present study for the assessment of nutritional status and also the procedures used to evaluate clinical outcome in elderly orthopaedic patients. Prior to the detailed description of each method, a general review of the methods used by others is given together with comments regarding their practical application. Whilst it is clear that the identification of starving patients requires no special investigation, it is more difficult to identify people in the early stages of malnutrition in order that nutritional support can be implemented in an economic and effective way. In particular the nutritional assessment of older people presents special difficulties. The wide variability in the effect of the ageing process from one individual to another and the higher incidence of physical and psychological diseases in the elderly affect nutritional status (Lipschitz and Mitchell, 1984). The problems associated with nutritional assessment of the elderly are compounded by the fact that very few appropriate standards exist for this age group.

The selection of the methods of nutritional assessment which have been used in this study is described in Section 2.2. It was important to include a wide range of routinely available methods, not only to evaluate the nutritional status of patients, (the subject of Chapter 3), but also to provide a variety of parameters for possible inclusion in the development of a clinically applicable predictive model (the subject of Chapter 4). Furthermore, the reliability and validity of each measurement required investigation, particularly in terms of sensitivity and specificity, prior to selection.

Nutritional assessment is the first step in the nutritional care of a patient, (Goode 1981). Chapter 1 discussed the prevalence of malnutrition in older people both in hospital and community settings. The possible causes and consequences were reviewed and the need for recognition of the problem was emphasised in order that appropriate action be taken. To provide the correct nutritional support any assessment should be an accurate evaluation of the patient’s present nutritional status. The assessment and evaluation of nutritional status can involve a wide range of different methods designed to detect changes in body dimensions, composition or function which can be induced by malnutrition.
2.2 REVIEW AND SELECTION OF THE METHODS

The techniques which are currently available for routine use include clinical examination, dietary histories and simple anthropometric or biochemical tests. More sophisticated methods, such as computerised axial tomography and nuclear magnetic resonance are not yet readily available in ward situations and are both expensive and potentially unacceptable to older patients. It should be noted that all methods of nutritional assessment have limitations and therefore the selection of appropriate techniques needs careful consideration. Furthermore, great care should be exercised in the interpretation of the data generated using these methods.

2.2.1 Subjective assessment

Many studies have been carried out specifically to determine which techniques are most sensitive, (i.e. predict poor outcome), for use with specified patient groups. The value of simple and straightforward subjective assessment was emphasised by Detsky et al, (1984), especially with regard to prognostic significance. Detsky found that a subjective global assessment (SGA), comprising a dietary and medical history, functional assessment and a physical examination, offered the best combination of sensitivity and specificity in predicting outcome. It was concluded that other objective nutritional methods, for example serum albumin, used singly or in combination may be less sensitive and specific in predicting outcome.

Volkert et al, (1992), (reporting the evaluation of nutritional status in geriatric patients), also found that clinical diagnosis of undernutrition was the best of numerous methods, as well as being the most accurate in predicting long term mortality. However, this study is difficult to evaluate since the only information given by Volkert et al, (1992), was that patients were "subjectively" graded as undernourished, well-nourished or obese, and then subsequently confirmed as being undernourished if sub-cutaneous skinfolds were reduced or a low mid-arm circumference measured.

The prediction of increased risk of mortality and morbidity, based on admission nutritional assessment measurements, is an important application of data derived from assessment procedures. The value of subjective assessment may be in initial screening, (for example by a clinician), to identify patients who need to be referred to dietetic services for more comprehensive testing. However, it is acknowledged that the reliability of any subjective global assessment used as
a single measure of nutritional status requires careful observation, clinical experience, good judgement and time spent with the patient.

2.2.2 Dietary assessment

(i) Dietary history

Good clinical judgement by competent practitioners and the patients own account of dietary habits are accepted as being potentially useful in identifying malnutrition. However, this is disputed by Durnin and Fidanza, (1985). They consider that the estimation of dietary intake has almost no useful place in a critical evaluation of nutritional status, mainly because techniques indicate only current dietary habits. Although a dietary history may be used to elicit a retrospective pattern of food intake prior to the admission, it is difficult to interpret and use the information in a systematic and objective way. Furthermore, the accuracy and reliability of the data depends on the skill of the interviewer and the recall capabilities of the patient. A dietary history however will elicit whether the patient is on a special diet and if there are any social, economic or drug therapy factors which might affect nutritional status.

(ii) Quantitative assessment

Although more quantitative information can be obtained using a 24 hour dietary recall, Beaton et al, (1979), have questioned the validity of such information which may not be representative of habitual intake. Furthermore, Roberge, (1984), found that 24 hour recalls were ill-suited for correlation with clinical and biochemical data. Marr and Heady, (1986), found that they did not discriminate reliably between individuals and therefore advocated the use of this method be confined to the assessment of groups.

Obviously the individual weighed inventory method is the most reliable way of quantifying what an individual actually eats but this technique demands a cooperative, literate and highly motivated and physically able participant. A single day's survey is reported to classify no single nutrient with 80% reliability. Although a week long survey is said to classify most nutrients with this level of reliability or better, (Marr and Heady, 1986), such a method would neither have been feasible or appropriate given the specific population in the study described in this thesis.
Despite the limitations of most dietary assessment methodologies some dietary data may assist in the interpretation of clinical, anthropometric and biochemical data. However, none of the more reliable dietary assessment methods were feasible to undertake in the present study. Because of these limitations and restrictions it was decided to obtain information regarding food habits as part of a detailed social and medical history taken on admission. The inclusion of this qualitative information is justified on the basis that it might highlight the specific type of dietary data that is most useful to collect on admission with the view to its inclusion in a predictive model (the subject of Chapter 4).

2.2.3 Anthropometric methods

Useful information on the amount and rate of change in body energy stores and protein mass can be obtained by measuring body weight, height, the thickness of skinfolds and arm muscle circumference. Protein energy malnutrition may be indicated if depletion of these parameters is recorded.

2.2.3.1 Body weight

Body weight provides some indication of changes in energy stores but does not yield information regarding the nature of tissue loss. It is usually considered to be an easy measure to obtain, but this is not true for a proportion of the elderly population, (DH, 1992). This may partly explain the findings of a survey carried out by Butterworth, (1974). He found 23 percent of hospital patients had no record of body weight and that in 43 percent of those weighed on admission, no regular records were kept thereafter. It would be interesting to obtain similar statistics on an exclusively elderly patient group bearing in mind the difficulty of weighing older people. Thus, although Heymsfield et al, (1984), rightly suggest that all hospital patients should be weighed routinely and that body weight in high risk patients should be recorded weekly, this is not standard practice nor necessarily practical at present.

As discussed above, if possible, body weight should be recorded on admission to help to identify nutritionally at-risk individuals and to provide a baseline measure against which further serial measurements can be compared. The latter is of particular importance since relative weight itself has little value as a predictor of nutritional status, (Lipschitz and Mitchell, 1984), whereas changes in body weight can be clearly indicative of an altered nutritional status or disease. Therefore, a history of weight loss is clinically more relevant; the shorter the
time frame for a given weight loss the more likely it is that nutritional status will be compromised.

Accurate body weights recorded serially over a period of time will allow a trend to be examined enabling an estimation of the extent and rate of energy deficit. This represents an improvement over subtracting the last body weight from the previous value in elderly populations, because fluctuations in body water are more exaggerated, especially where pathological states co-exist. However, it should be noted that the body weight of malnourished subjects may remain constant for several weeks. Also whilst a loss of body weight of 20 % or more has been shown to affect the outcome of surgery, (Studley, 1936), the significance of lesser degrees of weight loss is still not clear (Ryan and Taft, 1980).

The interpretation of the body weight and body weight loss measurement is made more difficult as there are no standardised methods of expressing weight or weight changes (Taylor and Goodinson-McLaren, 1992). Because it was so difficult to weigh recently admitted fracture patients in the present study, an attempt was made to assess weight loss by comparing current body weight with the pre-hospital body weight obtained by patient recall. However, Morgan et al, (1980), consider this limits the importance of the technique, since values for recalled body weight are subject to considerable error. Additionally the use of the height-weight tables such as the Metropolitan Life Insurance Tables, (1983), are inappropriate for older people.

The need for age-specific anthropometric reference values was emphasised by Volkert et al, (1992). Morgan et al, (1986), constructed percentile distributions of body weight from their study of healthy active elderly women and these are useful when used in conjunction with the suggestion of Heymsfield et al, (1984), that if a patient’s body weight is below the fifth percentile the weight can be considered to be abnormal. Limitations of the value of this measure should always be considered, for example, in the presence of fluid retention and where drugs may cause fluid loss, (diuretics), or retention (corticosteroids). Furthermore, body weight measurements provide no information on the nature of the tissue loss i.e. fat or muscle.
2.2.3.2 Triceps skinfold

Since approximately 50% of fat is found subcutaneously, skinfold thickness measurement can give an indication of total body fat, (Wormersley and Durnin, 1977). The measurement of skinfold thickness using constant pressure calipers at standard sites provides a cheap and non-invasive assessment of subcutaneous fat. However, the technique is only reliable using skilled operators, where a coefficient of variation of about 6 percent reported, (DH, 1992). Furthermore, the distribution of fat varies from one individual to another, (McKay et al, 1981), and skinfold compressibility changes with age, (Durnin and Wormersley, 1974). Therefore, skinfold thickness measurements in older people offer only an approximation of body fatness and should be used in conjunction with other parameters. Although other methods are available which are potentially more accurate, anthropometry using skinfold calipers still remains the most practical technique to estimate body fat in community studies. The only possible exception to this may be the use of bio-electric impedance. Bio-electric impedance of the body is related to the proportions of fat and lean tissue and has been validated in older people against underwater weighing. The technique is cheap, non-invasive, and requires no special skills in the operator, (DH, 1992). It would be valuable for use with elderly people but unfortunately was not available for use in the present study at the time of initiating the research.

Other methods include ultrasound scanning, which can estimate the thickness of fat at specific sites. This has mainly been used in animal husbandry and has the disadvantages of skinfold measures, whilst being more expensive and cumbersome. The fairly new technique of near infra-red interactance, whilst systematically underestimating fat, may be a useful measurement but has not yet been validated in groups of elderly people.

It should be noted that low skinfold measurements do not necessarily denote undernutrition, simply that the individual is lean. Bastow, (1982), does not recommend that estimation of ‘degrees’ of malnutrition be made from extrapolation of these skinfold values because the cut off for supposed undernutrition in fact encompasses a sample of up to 10-20% or more of the normal healthy population, (Durnin and Fidanza 1985). However, serial measurements of skinfolds may be useful for monitoring changes in individuals, and for comparing different groups of patients. It should be emphasised that the most accurate representation of body fat, is total body fat calculated from skinfold measurements at multiple sites; the least accurate is a single skinfold thickness measured at one anatomic site. A balance was drawn in the context
of the present study between accuracy and what was both practicable and acceptable to the patient group.

2.2.3.3 Estimation of lean body mass

The somatic muscle mass, which comprises a reserve of 15,000-20,000 kcals, can be reduced by as much as 50-70 percent in severe undernutrition, (Taylor and Goodinson-McLaren, 1992). Although there are no accurate methods available to determine changes in total body muscle mass, anthropometry can be used to determine the muscle mass in the arms by measuring arm muscle circumference. Indeed, Bistrian et al, (1974), proposed that measurements of mid upper arm circumference, (MUAC), could be used as a single measure of lean tissue nutritional state and Blackburn, (1977b), suggested mid upper arm muscle circumference, (MUAMC), to be one of the best available single indicators of protein energy malnutrition. Furthermore, where it is not possible to obtain weight, the arm circumference can provide useful information for the nutritional assessment of elderly patients. The MUAC can be measured easily and accurately and compared with the TSF is less likely to be affected by changes in skin thickness, elasticity, and compressibility, all of which are associated with ageing, (Kubena et al, 1991).

Mid upper arm circumference measurements are used in conjunction with triceps skinfold (TSF) to calculate the MUAMC using standard equations (Gurney and Jelliffe, 1973). A weakness of the index is that it assumes that: both the arm and the arm muscle are circular; bone and neurovascular tissue can be overlooked; and that the MUAMC reflects total muscle mass. These assumptions are open to question and should be taken into consideration when interpreting data. Studies using axial tomography have shown that the arm is elliptical, not circular- the muscle has a pinnate arrangement and the distribution of fat is asymmetric, (Heymsfield et al, 1979). Furthermore, the measurement assumes that the bone area can be neglected, whereas it has been reported that this assumption leads to an over-estimate in the MUAMC value by as much as 15-25 percent. The area of the upper arm muscle is assumed to reflect total skeletal muscle mass which it almost certainly does not. Although validation of the MUAMC measurement could be performed by assessing total body potassium, this method requires the application of whole body gamma counting, a facility unavailable to the investigator and impractical in the context of the present study.
The natural gamma radiation from the small amount of isotopic body potassium can be used to assess lean body mass non-invasively since most potassium is in this compartment. As elderly people have a lower lean body mass than younger adults more sensitive gamma counters would be required or a longer period of counting needed. Frail elderly people might not tolerate lying alone on a hard surface in unfamiliar surroundings which this technique necessitates.

Comparisons between anthropometric measurements and body nitrogen estimation have also been made using neutron activation analysis. However, this specialised procedure is unsuitable for routine use. Using neutron activation analysis experimentally it has been found that measurements of MUAMC do not detect changes in body nitrogen in individuals over short period (such as 2 weeks), (Collins et al, 1979).

Summarising therefore, not only is MUAMC slow to respond to changes in nutritional status, but it is also difficult to compare values obtained from individuals using the established reference ranges. The importance of using appropriate reference ranges for anthropometric measurements was again highlighted by Volkert et al, (1992). Using currently accepted standards of normality for the estimation of fat and protein stores by TSF and MUAMC respectively they showed that 76 percent of male subjects and 63 percent of females would be considered as fat depleted and two thirds as protein depleted. In their opinion this was an over-estimate and demonstrated the need for age-specific standards. As discussed previously some reference data are available for use with older adults, (Morgan et al, 1986; Pearson et al, 1985). Serial measurements over time provide the most useful information regarding changes in nutritional status. Because the MUAMC value is slow to respond to changes in nutritional status, the present study aims to monitor changes in body composition for 6 months following surgery.

Finally, the imprecision of anthropometric methods in general results from two types of errors: those due to between measurement differences for the same observer, (intra-observer), and those due to between observer measurement differences, (inter-observer), (Heymsfield 1984). The lack of dependability discussed above refers to non-nutritional factors that influence the reproducibility of measurements e.g. age, genetic background, muscle tone, disease state, amount of fat measured and compressibility and hydration status.
2.2.4 Dynamometry

Depleted body protein, (defined as existing when the MUAMC is below 85 percent normal), is the factor most closely associated with postoperative complications. According to Kammerling et al, (1978), estimation of skeletal muscle protein, (by measurement of MUAMC), was found to predict serious complications more reliably than weight, weight loss or serum albumin concentration. In a later study these workers examined the use of hand dynamometry and found it was the most sensitive test compared with the standard anthropometric and biochemical tests, in predicting serious postoperative complications in patients undergoing elective abdominal surgery (Klidjian et al, 1980). Dynamometry is certainly a rapid and inexpensive technique. It avoids the imprecision of anthropometric indices due to intra- and inter- observer differences. However, because of the influence of many non-nutritional variables (Taylor and Goodinson-McLaren, 1992), it is considered to be undependable as a measure. For example, Pearson et al, (1985), found a loss of absolute strength with age, especially in proportion to body weight. Defects such as paralysis, arthritis and trauma obviously impair grip strength but according to Klidjian et al, (1980), this does not diminish the usefulness of the test. Furthermore, no consistent relationship was found between nutritional intake and muscle strength in a study of the attenders at elderly day centres and hospitals (Mowett et al, 1992). Phillips et al, (1986), investigated the prognostic significance of several nutritional parameters in female geriatric patients and found that a reduced grip strength, mental impairment and malnutrition were associated with an increased risk of mortality. They reported that grip strength in particular appeared to be an important indicator of nutritional status. However, the low grip strength in the mentally impaired group may have partly been due to malnutrition and partly due to lack of cooperation with the test. The increased mortality of in patients with lower grip strength may have resulted from underlying illness. Alternatively, the weakness observed might have been a prelude to serious or terminal illness.

Many of the patients in a study by Phillips, (1986), died from chest infections with: chronic lung disease; weakness of cough reflex and the muscles of respiration; aspiration pneumonia; and immunodeficiency being the underlying factors. Philipp was concluded that low grip strength identifies a population at risk because of associated malnutrition, generalized muscle weakness and immunodeficiency. This study questions the extent to which abnormal values obtained using some nutritional parameters may indeed reveal more about the
general condition of the patient than the actual nutritional status. This issue is discussed further in Chapter 4.

Skeletal muscle is an extremely important reserve of amino acids that can be mobilised during trauma or stress. Half of the total body protein turnover is accounted for by skeletal muscle protein. Muscle protein breakdown is doubled after surgery and grip strength declines rapidly in the immediate postoperative period. Although it seems logical to attempt to measure the size of the muscle protein reserve, the extent to which the use of grip strength, or indeed MUAMC, is valid in this respect is still open to question. However, in view of the simplicity of dynamometry and the acceptability to the patient it was considered to be a useful parameter to employ in the context of the study.

It is apparent that there is a wide variety of opinion regarding how best to assess the nutritional status of elderly people and to establish which patients are at "risk". The ideal nutritional parameter should: be unaffected by non-nutritional factors; specifically reflect the presence of protein energy malnutrition; and be highly sensitive to the effects of nutritional repletion, (Buzby and Mullen, 1984).

2.2.5 Biochemical methods

Unfortunately the biochemical methods currently available have many limitations. Inevitably most biochemical tests necessitate venepuncture which is invasive for the patient and which then requires further analysis. There are many factors known to affect biochemical nutrition profiles including age, sex, heredity factors, nutrient and drug interactions and disease. There is currently no widely accepted biochemical test which distinguishes with certainty, the deficient from the non-deficient person; this is even more uncertain in older people. A further area of difficulty is that a low value may either be the result of poor dietary intake or be due to an alteration in metabolic function, due to the metabolic response to illness and injury. The serum proteins most commonly used in the assessment of nutritional status include albumin, transferrin, prealbumin and retinol binding protein.

2.2.5.1 Serum albumin (ALB)

The sensitivity of a test to changes in the status of a particular nutrient is an important criterion in the context of the present study. For example, diagnosis of protein energy malnutrition is often based on the measurement of low
concentrations of hepatic transport proteins such as serum albumin. This protein has a long half-life, so that it is slow to respond to changes in protein intake. However, studies have shown that although a minor reduction in the rate of albumin synthesis occurs with ageing, serum levels are not significantly reduced. As a result, hypoalbuminaemia is an excellent indicator of long term protein-calorie malnutrition in the elderly. Whilst decreased levels of albumin are almost always present in the malnourished, clinical judgement must still be used in their interpretation. Liver disease and urinary and gastrointestinal losses must be excluded. There is recent evidence to suggest that bed rest alone significantly decreases serum albumin levels and, as a negative acute phase reactant, marked reductions can occur in acute illness or trauma such as bronchopneumonia, infarction, fractures or operation, (Hodkinson, 1977). Thus, a primary concern in the use of negative acute-phase reactants, such as serum albumin and retinol binding protein, as indicators of protein depletion and deficiency, is the extent to which the acute phase response determines the regulation of these proteins compared with nutritional factors. Whilst the regulation of these plasma proteins in relation to the acute-phase response has yet to be systematically evaluated, those studies that have been reported, do demonstrate the importance of non-nutritional factors (Fidanza 1991). Nevertheless, of the various classes of plasma proteins, albumin and retinol binding protein are among those which have been most widely studied as indicators of nutritional status, (James and Coward, 1981), and will allow comparison of data from the present study with that of other workers.

2.2.5.2 Retinol binding protein (RBP)

The shorter half life and smaller pool size of retinol binding protein, means that it can exhibit more rapid changes in concentration and can thus be a more sensitive indicator of the immediate nutritional state than albumin. Indeed, in a study of children with kwashiorkor, one week of treatment induced a doubling of RBP with no change in albumin or any measurable anthropometric indicator of nutritional status, (Ingenbleek et al, 1975). Therefore, the distinction needs to be made between those indicators of immediate, as opposed to long-term nutritional state. Levels of RBP, will also change in response to alterations of vitamin A status, and its levels are depressed by low energy intakes, (Shetty et al, 1979). However, Kemm and Alcock, (1984), in their study of the distribution of indicators of nutritional status of elderly patients, found that albumin and retinol binding protein, (as well as anthropometric measures), had prognostic significance. Hodkinson, (1977), also noted the prognostic significance of albumin in hospitalized elderly. Whilst the levels of serum
albumin and retinol binding protein have been measured in the present study, it is acknowledged that caution should be exercised in the interpretation of low or "abnormal" values for these parameters. It is common to find low values on admission, in hospitalized elderly, and non-nutritional influences on many of the so-called nutritional indicators are now widely recognised. Thus, low levels of serum albumin and retinol binding protein may also indicate the severity of illness, stress and trauma rather than malnutrition.

Indeed, because of the many limitations inherent in single measures of nutritional status, Kemm and Allcock, (1984), stress the need to examine several indicators simultaneously, particularly in relation to anthropometric and biochemical parameters. They argue that these measures have often been used uncritically as indicators of nutritional status in the elderly. As discussed, these measures are difficult to interpret, since they are influenced by many non-nutritional factors including the normal ageing process. Although there are extensive data on anthropometric values for adults under 60 years it is not appropriate to use these normative data at older ages because changes due to ageing affect body shape, size and composition, (DH, 1992).

Furthermore, the applications of these data sets to the interpretation of an individuals' measure may be misleading and tables of "normal" reference values give little consideration to the widespread variation in body composition that exists between individuals, (Bastow, 1982). Often comparisons are made between individual and population norms derived from different racial and geographical data on inappropriate population statistics. Indeed, there are few published research papers that have established values for nutritional assessment parameters as applied to normal active persons, and few researchers have combined anthropometric and biochemical parameters, (Burns et al, 1986).

2.2.6 Functional tests

Most traditional methods of assessment, including biochemical indices, are at best static indices of total body nutrition and the relatively high prevalence of biochemically diagnosed marginal malnutrition has raised the issue of the health significance of the so-called "deficient" and "low" values. This has led some workers to suggest the use of functional assessments of nutritional status as an alternative. These tests aim to determine whether the biological functions of the cell, tissue, organ or whole body, dependent on adequate nutritional status, are performing optimally.
There is now some evidence that functional tests may be overcome some of the limitations of traditional nutritional assessment methods although they may not be specific for a particular nutrient, (Solomons, 1983). Solomons argues that diagnostic techniques for assessing nutritional status have not kept pace with advances in experimental nutrition. As standards for static indices are based on comparison with mean values in healthy "reference" populations, and cut-off criteria are based on the degree of deviation from these means, normal individuals who fall into the lower tail of the distribution curve can be diagnosed as "deficient". The concern expressed when using reference ranges is illustrated using the diagnosis of iron deficiency anaemia as an example. A haemoglobin value which falls into the 5th percentile of the range for healthy individuals might be said to be "abnormal". However, such a low value may provide the optimal oxygen transport capacity for a minority of patients although others may have a deficit of tissue oxygenation at this level of haemoglobin. Also haemodilution effects may reduce the level of haemoglobin and incorrectly indicate deficiency. Frustration with the problem of relating static measures to nutritional status has led workers to propose that changes in nutritional status in response to supplementation studies may be the only valid way of confirming the existence of deficiency. However, whilst valid for those nutrients which are homeostatically regulated, such as haemoglobin, it may not be valid for those which are not i.e. supplementation will produce a change in level regardless of whether the patient was deficient or not.

Because of the problems of poor specificity and sensitivity of the traditional methods of nutritional assessment, a group of workers have identified five important areas of functional competence which they consider are likely to be affected by malnutrition. These include: cognitive ability; disease response; reproductive competence; physical activity and work performance; and social/behavioural performance, (National Academy of Sciences, 1976). This led Solomons et al, (1983), to suggest that the functional performance of an individual could be used as an index of nutritional status. Similar factors, (with the exception of reproductive competence), have been identified by workers researching nutritional risk in the elderly. Solomon's approach is particularly relevant for use with older patients and is in accordance with the aims of the present study which is to evaluate the use of social and medical factors in the overall assessment of older patients.

Measuring nutritional status using functional rather than static indices may therefore be relevant for use with hospitalised elderly. Malnutrition is most frequently observed as secondary to the primary disease which leads to
hospitalisation. A small group of patients however have primary malnutrition. Such patients are usually over the age of 70 years, housebound and have poor social circumstances. A member of the family or primary carer may report a recent change in mental status. When dietary histories are available these often confirm inadequate intakes and evidence that the patient is unable or unwilling to cook for themselves. Bereavement is common in older people and severe endogenous depression may be reported or suspected. In such patients the most frequent complication of nutritional deficiency is infection, and the most common symptom presents itself as confusion or a recent alteration in mental status. This may be present on admission or noted later on during the hospital stay. In view of the above, mental function tests were included in the present study.

2.2.7 Summary

As the relationships between nutrition and health become more apparent the need for assessment of nutritional status will increase. Static indices of nutrition will continue to play an important role as they are already established, and are offered routinely by clinical laboratories. However, functional indices of nutritional status, are rapidly emerging as an important diagnostic class although these are still in their infancy. Such tests should be subjected to the same rigorous assessment as more traditional approaches. In addition some clarification of the use of the term functional assessment and what methods it encompasses is required. Potentially whole body functional assessment offers a less invasive and more acceptable procedure obviating the need to collect blood. The assessment of function itself might be more meaningful to the patients, promoting better compliance with prescribed nutritional support compared with venepuncture and biochemical analysis.

The methodology of the present study therefore has been chosen to assess the nutritional status of a group of elderly female orthopaedic surgical patients and to provide an indication of those at nutritional risk. However, nutritional assessment remains an inexact science and there are at present no universally acceptable gold standard tests that conclusively establish the presence of malnutrition and against which other methods can be compared. This section has reviewed some of the currently available methods of nutritional assessment and discussed their limitations.

The relationship between nutritional status and clinical outcome is also of great interest. Many studies have investigated nutritional status and clinical outcome
but have not followed the patients progress in the longer term, when the effects of poor nutritional intake become apparent. Knowledge of the nature of the relationship between nutritional status and clinical outcome derived from Chapter 3 will be used retrospectively to discriminate patients at high or low nutritional risk on the basis of their known clinical outcomes at 6 months in the development of a predictive model described in Chapter 4.

The procedures for monitoring clinical outcome are therefore presented here and include factors known to particularly affect the quality of life of elderly female orthopaedic patients following discharge such as: duration of stay in hospital and convalescence; activities of daily living; mobility; postoperative complications and mortality.

2.3 METHODS EMPLOYED

2.3.1 Anthropometric methods

Anthropometric methods were used to assess and monitor nutritional status and to estimate changes in body composition.

2.3.1.1 Body weight

(i) Introduction

It was difficult to weigh some patients on admission, especially emergency patients because of pain and immobility. However, weight was taken where practicable at some point before discharge. A record of usual weight, as well as weight loss in the last two months, was therefore recalled from each patient. As this is subject to error it was only used qualitatively. Further difficulty was also experienced when weighing some patients following their discharge from hospital.

(ii) Equipment

For hospital measurements of body weight a chair balance scale, (Marsdens, UK Ltd), was used. After discharge, a portable electronic digital scale, (Salter, model 980), was employed.
(iii) Procedure

Patients were weighed in their night clothes in hospital and in day clothes on their return home. Subjects were weighed with either no shoes on or in light slippers only. Weight changes following surgery were monitored at various time intervals.

(iv) Reference values

As there are no universally accepted standards for ideal weights for elderly people individual body weights were not compared with the weights given in reference tables in order to calculate % ideal body weight. To be reliable, reference data must be obtained from large samples and should include individuals with the same characteristics as those being studied.

Weight was used in the present study as one of five parameters to categorise patients into high and low nutritional risk groups for the purpose of comparing different groups of patients as described in Chapter 3. The reference fifth percentile value was used to denote abnormal weight derived from studies of healthy active elderly females (Morgan et al, 1986).

(v) Repeatability

The repeatability of the procedure was assessed by one investigator carrying out repeat measurements on the same subject. The coefficient of variation for intraobserver repeatability was found to be ± 0.5%.

2.3.1.2 Triceps skinfold thickness

(i) Introduction

The measurement of skinfold thickness is a direct measurement of the subcutaneous adipose tissue thickness, and as such can provide a simple and inexpensive measurement of energy nutritional status. The triceps skinfold thickness (TSF) measurement was used in this study to assess and monitor adiposity.
(ii) Equipment

Triceps skinfold values were measured using Holtain skinfold calipers (Nottingham Rehabilitation Ltd).

(iii) Procedure

The TSF measurement recorded was the mean of three readings taken at the mid-point of the non-dominant upper arm between the tips of the acromial and olecranon processes using Holtain skinfold calipers. The skinfold is gently pinched from the underlying muscle just below the point of application of the calipers between the thumb and the forefinger so that the pressure applied to the point of measurement is from the calipers and not the fingers. The calipers are designed to exert a constant pressure over a wide range of jaw openings, although the measurements are less accurate when the value is above 20mm. The triceps skinfold thickness was measured with the patient's arm hanging loosely at the side. Occasionally, when the patient was confined to bed with the patient supine the measurement was taken with the arm folded across the chest. However, it was difficult to record the TSF in this way and accuracy was inevitably compromised.

Location of the correct site is extremely important as small variations may move from the site of the fat deposit. One of the criticisms of the TSF measurement is that it lacks reliability because of differences in individual technique. Careful adherence to recommended procedures and continued practice, however, improves precision. In the present study the investigator took care to develop a repeatability procedure and to obtain a level of precision comparable with other workers reported values.

(iv) Reference values

Whilst the normal anthropometric ranges derived from Morgan et al, (1986), were used in this study, there is still no consensus as to the most appropriate standards. Thus, in the present study, changes in fat were monitored using TSF, to compare the relative losses and gains of the low and high nutritional risk groups. The triceps skinfold measurement was also used in calculating the mid upper arm muscle circumference.
(v) Repeatability

An intraobserver error (CV) of 4 percent and an interobserver error of 10 percent were obtained when five repeat measurements were carried out by two investigators on the same subject over a period of a day.

### 2.3.1.3 Mid upper arm circumference and arm muscle area.

The mid upper arm circumference (MUAC) and mid upper arm muscle circumference (MUAMC) are anthropometric indicators of skeletal muscle protein mass, and were used:

- as an index of lean tissue following surgery
- to monitor changes in lean tissue
- to compare the relative losses between the high and low risk patient groups.

#### 2.3.1.3.1 Mid upper arm circumference

(i) Procedure

The mid upper arm circumference was measured in centimetres at the same level as the triceps skinfold thickness, using a non-stretchable tape measure. Care was taken not to pinch the arm and to take the measurement at the mid-point of the upper arm, as the arm is fusiform in shape.

(ii) Repeatability

The intraobserver error (CV) for this measure was extremely small (< 1 percent) due to the simplicity of the method.
2.3.1.3.2 Mid upper arm muscle circumference

(i) Procedure

MUAMC was calculated from measurements of TSF and MUAC, by the method described by Jelliffe, (1966):

\[ \text{MUAMC (cm)} = \text{MUAC (cm)} - [0.314 \times \text{TSF (cm)}] \]

The above equation assumes that the arm and muscle are circular, when in fact it is more elliptical. Also it is assumed that the bone area is negligible. Again it must be noted that care must be taken to take these measurements at the mid-point; even slight displacement from the mid point may affect serial measurements significantly. The variations in the measurements of the skinfold thickness and arm circumference by different individuals can result in up to 33 per cent error in arm muscle area, (Mullen et al, 1979). This can be reduced to 10 per cent by using the same observer.

(ii) Repeatability

The intraobserver error (CV) for MUAMC was 5 percent. This is expected since the repeatability of the method is dependent upon the TSF measure which has a higher CV, particularly in elderly subjects.

2.3.2 Voluntary hand grip strength

(i) Equipment

Measurements of maximal handgrip strength were made using a strain gauge handgrip dynamometer (Nottingham Rehabilitation Group).

(ii) Procedure

Grip strength was measured using the hand of the non-dominant arm usually with the patient in a sitting position. Three readings were taken and the highest value chosen. Accurate measurement of grip strength was not possible in some patients because of local disease of the hand, due to arthritis and previous Colles fracture.
(iii) Repeatability

The repeatability (CV) of the measure in single subjects over a day was shown to be 2 percent.

2.3.3 Biochemical methods

In the study described in Chapter 3 a sample of blood was obtained on admission and discharge and at 8 weeks and 6 months following surgery. A venous blood sample of 5-10 ml was obtained at each time. Aliquots of serum were obtained and stored at -20 degrees C., until analysis. Serum retinol binding protein and serum albumin determinations were made, plus routine biochemistry measurements of haemoglobin, white cell count and creatinine.

2.3.3.1 Serum albumin determination

Serum albumin measurements were made using a manual spectrophotometric method based on the binding of bromocresol green to albumin.

(i) Principle

Albumin is effective in binding a wide range of endogenous and exogenous materials including bilirubin, salicylate and fatty acids. Anionic dyes such as methyl orange and bromocresol green (BCG) also bind avidly to albumin. At pH 4.0 the BCG dye displaces most substances bound to albumin, to form a dye-protein complex which exhibits optical properties different from the free dye. Human serum albumin reacts specifically with BCG to form a stable green colour complex with an absorption maximum at 632 nm.

(ii) Reagents

1. BCG Reagent

70 mg of BCG (Sigma Chemical Co. Ltd.) was dissolved in 5 ml of NaOH. The solution was made up to one litre with 0.06M succinate buffer (pH 4.1) and 0.7g of Brij 35 detergent was added.
2. Albumin standard solution

A stock solution of albumin (10mg/ml) was prepared by dissolving bovine serum albumin (Sigma Chemical Co. Ltd.) in 1% NaCl. On each day of analysis a series of standards covering the range 1-10 mg/ml was prepared using 1% NaCl as a diluent. All serum samples were diluted 1:5 in 1% NaCl prior to analysis.

(iv) Linearity

The plot of absorbance against standard albumin concentration was linear over the range 1-10 mg/ml and all samples analysed fell within this range. The mean regression coefficient for a series of five standard runs was 0.99 with a SD of 0.03 (CV = 0.04%).

(v) Procedure

150 ul of diluted test serum were mixed with 2.5 ml of BCG reagent and mixed thoroughly. A reagent blank was prepared with 150 ul of 1% NaCl in place of the sample. Standard samples were included in each assay run and treated in an exact manner to test samples. Samples and standards were kept at room temperature for 10 minutes and absorbance read against the reagent blank at 632 nm using a Kontron Uvikon 860 spectrophotometer. All samples were analysed in duplicate and samples re-run if duplicate values differed by > 0.04 mg/ml. Quality control serum, (Boehringer Ltd.), were included in each assay run. If these fell outside of ± 5% of the predicted values the samples were re-analysed using fresh reagent.

The interassay CV for analyses carried out on separate days over a month was 4%. All serum samples for individual patients were kept stored at -20 degrees C., until assay could be performed on all samples simultaneously.

2.3.3.2 Serum retinol binding protein determination

Serum RBP measurements were carried out using a radial immunodiffusion (RID) method employing the use of commercially prepared immunodiffusion plates.
(i) Principle

Immunodiffusion plates containing an agar gel to which specific antiserum to RBP has been added are used to quantitate the concentration of RBP in biological samples, by measurement of the diameter of the antigen-antibody precipitate formed by reaction of the sample RBP (antigen) with the agar gel antibody.

(ii) Reagents

1. LC-Partigen Immunodiffusion plates (Behring Ltd)

Plates are prepared using agar gel with rabbit antisera to RBP. Sodium azide (1g/l) and sodium p-ethyl-mercury-mercapto-benzene-sulphonate (0.1 g/l) are added as preservatives.

2. RBP Standards

A stock solution of RBP (108 mg/l) is prepared in 1% NaCl. On the day of analysis a range of standards (12-72 mg/l) is prepared by dilution of the stock solution in 1% NaCl.

(iii) Linearity

The plot of (diameter)$^2$ of the precipitates against standard RBP concentration was found to be linear over the range 18-72 mg/l. The mean regression coefficient of a series of five standard runs analysed on different days was found to be 0.98 with a SD of 0.06.

The regression line equation from the standard curve was shown to be:

$$y = 0.50x + 20.29$$

where $y = (diameter)^2$ (mm) and $x = RBP$ standard concentration (mg/l)

(iv) Procedure

The plastic immunodiffusion plate is removed from the aluminium container and allowed to stand at room temperature for 5 minutes to allow evaporation of any condensation water that may have entered the wells.
Each plate contains 20 sample wells. Serum albumin (20 ul) are transferred to the wells using an accurate Gilson pipette set to 20ul dispensing volume. Samples are plated in duplicate. After loading, the plates are allowed to stand open for 10-20 minutes, then they are closed with the plastic lid and left to stand at room temperature.

The diameters of the antigen-antibody precipitates are read after a diffusion time of 3 days. The diameters can be read with an accuracy of 0.1 to 0.2 mm. For accurate readings a measurement ruler is used with illumination of the plate from the side and with the plate placed on a dark background.

Standards are treated in an exactly similar manner with a set of standards run for every 40 samples.

If duplicate samples differed by 0.5 mg/l, repeat determinations were carried out. If sample values were obtained above the normal range (30-60 mg/l) the determinations were repeated using a more dilute sample (e.g. 1:2).

The interassay coefficient of variation for analyses carried out on separate days over a month was found to be 6.6 percent.

All serum samples for the individual patients collected over a period of time were kept stored at -20 degrees C., until the assay could be performed on all samples simultaneously.

(v) Calculation of results

The concentration of RBP in individual samples was calculated from the regression equation above where:

\[
RBP \text{ (mg/l)} = \frac{(diameter)^2 - 20.29}{0.50}
\]

2.3.4 Biochemical and haematological methods carried out in hospital laboratories

Serum creatinine, haemoglobin and total white cell count (WCC) measurements are made routinely on all patients on admission and these hospital measures were used by the investigator in Chapters 3 and 4.
2.3.4.1 Serum creatinine

Serum creatinine measurements were carried out in the Department of Clinical Biochemistry, St Luke’s Hospital, using the standard Yaffe method based on the colorimetric change on reaction of creatinine with picric acid. Measurements were made using an Encore centrifugal autoanalyser, with a reported CV of 0.5 percent.

2.3.4.2 Haemoglobin and white cell count

These measurements were carried out in the Department of Haematology, St Luke’s Hospital, using their standard Coulter Counter methods.

2.3.5 Mental competence

Mental competence was assessed after one week of hospitalisation, at 4 weeks and 6 months post-discharge (Appendix A, Figure 2.i). Whilst confused or senile patients were not eligible for recruitment into the study assessment of mental competence was thought to provide useful information regarding the patient’s mental state during their hospital stay as well as the extent to which this changed following discharge and whether there were any differences in the mental abilities of patients allocated to high and low risk groups.

The measurement used the twelve-item Information/Orientation (I/O) scale and the Mental Ability Scale based on the Clifton Assessment Procedures for the Elderly (Pattie and Gilleard 1975, 1977). The Mental Ability Scale involves writing, reading, counting and recall of the alphabet under timed conditions.

2.3.6 Social and medical admission history

A detailed history of social, nutritional and medical factors was taken on admission. This profile included:

- a concise social, functional status history and information regarding food habits were obtained by a standardised series of questions administered to each patient;
a complete list of all the patients' primary and secondary diagnoses, derived from the medical notes and records, including the reason for admission, type of surgery (elective or emergency), the type of prothesis used and admitting ward.

During the course of the structured interview the patient was asked to provide information on a variety of topics including age, previous/current mobility, lifestyle, psychological well-being, physical health, dentition, falls and current drug history. In Stage I of the study a checklist of questions used during the interview are listed in Appendix A, Figure 2.ii. In Stage II the number of questions was reduced to the 20 of most apparent importance, (Appendix C, Figure 4.i).

2.3.7 Clinical outcome and functional status

Various measures of clinical outcome were recorded following a personal interview with the patient or primary carer in hospital and at each of the post-discharge visits. These were in the following categories:

2.3.7.1 Duration of stay in hospital and convalescence

The total number of days, (i.e. pre-operative and post-operative) and the number of days in hospital following surgery (i.e. post-operative) were recorded from patient notes. Data were collected regarding: the time spent in convalescence and the also the location of the patients at 4 weeks, 8 weeks, and 6 months following surgery. In general, it appeared to be hospital policy to discharge patients from the acute hospital after 14-15 days. Patients who required further rehabilitation were discharged to various satellite cottage/rehabilitation hospitals in the area including the hospitals at Milford, Haslemere, Holy Cross and Mount Alvernia and Cranleigh Hospital. Systematic follow-up procedures had to be formulated to keep track of patients and to obtain permission to visit patients.

2.3.7.2 Activities of daily living

The functional status tool used in this study was the modified Visick Mobility Scoring System used by Buzby et al, (1988). Using this method the patient is assessed by the researcher following discharge and assigned a grade according to six point grading system to assess independence and mobility. A score of 0 relates to patients who were: "fully active, able to carry out all pre-disease
performances without restriction." A score of 6 is allocated to those patients who died. The complete grading system is given in Appendix A, Figure 2.iii.

2.3.7.3 Mobility

The time taken for patients to graduate to frame, sticks, crutches and then to independent mobility was recorded. The mobility aid used at discharge, 4 weeks, 8 weeks and 6 months was recorded. In recording this information it was the aid which was used in the home at the various time points. Some patients would revert to using a mobility aid, such as a stick when out-of-doors, to increase their confidence.

2.3.7.4 In hospital and post-discharge complications

Information was collected from the patient, (or their primary carer), on the incidence of complications: following surgery; whilst still in hospital; and after their return home. Records were kept of wound infection or dehiscence, septicaemia, urinary tract infection, pneumonia, pulmonary embolus, falls, reduced food intake, re-admission (related or unrelated to their orthopaedic surgery), pressure sores or ulcers.

2.3.7.5 Mortality

The numbers of patients who died in hospital and at 4 weeks, 8 weeks, and 6 months was recorded. Where possible the cause of death was ascertained.

A summary of nutritional assessment parameters collected for each subject is presented in Appendix A, Figure 2.iv. Included in this database are the nutrition variables, diagnoses, reason for admission, socioeconomic variables and clinical and functional outcomes following surgery (Appendix A Table 2.iv).
CHAPTER 3

AN OBSERVATION STUDY OF
ELDERLY FEMALE ORTHOPAEDIC PATIENTS
CHAPTER 3  AN OBSERVATION STUDY OF ELDERLY FEMALE ORTHOPAEDIC PATIENTS

3.1 INTRODUCTION

Many elderly patients admitted to hospital for surgery subsequently develop serious complications which require intensive nursing care. The high prevalence of malnutrition found in hospital patients is known to prolong recovery from illness and can lead to death, (Jensen et al, 1982). Despite the fact that a number of studies have demonstrated the benefits of nutritional support in terms of improved clinical outcome, (Bastow et al 1983a), as yet the potential role of nutrition in aiding recovery from surgery, and accelerating return to previous mobility and independence, has received insufficient attention. A recent National Survey in U.K. hospitals showed great diversity of nutritional support practices in different health districts, (Payne-Jones, 1990). Among patients receiving the least nutritional support were those in orthopaedic wards, even though it had already been reported by Bastow et al, (1983a), that patients with fractured neck of femur have been shown to benefit from supplementary feeding as judged by an improved rate of mobilisation and reduction in hospital stay.

Elderly female orthopaedic patients undergoing surgery for fractured neck of femur or total hip replacement are occupying increasing numbers of orthopaedic bed space. In addition it has been shown that such patients are particularly prone to poor outcome following surgery. Of those who fracture their hips, 40% are said to die within 6 months, (Grimley Evans, 1982). Other workers have quoted lower mortality figures. Lockie, (1990), for example, stated that around 25 per cent of women over 60 years with a fractured hip die within 6 months. This is greater than the combined total of those dying from carcinoma of the breast, uterus and cervix. Whilst the death of a patient may be related to an underlying pathology, rather than directly to the fall, many studies have shown that patients who are diagnosed as being malnourished on admission have: an increased length of stay in hospital; greater morbidity rates and higher mortality rates, than those with the same condition whose nutritional state is normal (Bastow et al, 1983a ; Jensen et al, 1982).

Surveys of the nutritional state of adults in surgical wards in the UK, (Hill et al, 1977), Australia, (Zador and Truswell, 1987), and wards for the elderly (Larsson et al, 1990), have shown a surprisingly high incidence of malnutrition. Even
though it is 15 years since attention was first drawn to the high prevalence of malnutrition in hospital the problem appears still to remain, (Payne-Jones et al, 1990).

The consequences of malnutrition to the patient can be serious and it should also be noted that the financial cost of malnutrition to hospitals is also high, if related to length of stay and postoperative complications. The introduction of diagnosis related groups (DRGs) in the United States, with increased payment for co-morbidity including malnutrition, has led to studies of the effects of malnutrition on treatment. A prospective audit of 100 admissions to a medical unit was performed by Robinson et al, (1987), to determine the relationship of the initial nutritional status of the patients to the actual length of stay and hospital charges. The average length of hospital stay was 15 days among those patients judged as malnourished compared with about 10 days in the remainder whereas the hospital charges were more than double. Another retrospective study of 771 patients found the admission of a malnourished patient cost four times that of a normal patient with an uncomplicated course, (Anderson et al, 1985). The Kings Fund report, (1992), on the role of enteral and parenteral feeding in hospital and at home provides evidence that feeding malnourished patients improves recovery rates, decreases complications, reduces length of hospital stay and cost per day. An estimated saving of £266 million, based on a 5-day reduction in hospital stay for 10% of hospital inpatients, could be made even after taking into account the cost of nutrients and increased nursing time for their administration.

Elderly females, over the last 30 years, have been increasingly occupying orthopaedic bedspace due to the rising incidence of hip fracture worldwide, (Obrant et al, 1989), and in the UK, (Lewis et al, 1981). Indeed, a UK study stated that the incidence of fractured neck of femur has reached epidemic proportions, (Boyce et al, 1985), although some workers argue that this dramatic increase has now begun to level off, (Spector et al, 1990). However, any predicted reduction in the numbers of patients being admitted to hospital may not take into account the increasing proportion of elderly people in the UK population, nor does it take into account the large numbers of revisions to hip operations which currently take place. By the end of the century, 20% of the population will be over 65 years of age, and those over the ages of 75 and 85 years are predicted to increase by 22% and 69% respectively (OPCS, 1987). The potential scale of the problem is large therefore, particularly since most fractures occur in the over 75’s, (Wickham et al, 1989). Because of the increasing numbers of elderly people it is predicted that there will be a doubling
of the numbers of hip fractures before the end of the century in most countries. While the age specific incidence is only twice as high in women as in men, the larger number of elderly women in the population results in about 80% of all hip fracture occurring in women who are over the age of 65, according to data from the Hospital In-Patient Enquiry (OPCS, 1987). Hip fracture has become so common in elderly people that affected individuals are reported to occupy between 20-50% of all orthopaedic beds in England and Wales, (Royal College of Physicians 1989; Schorah and Morgan, 1985). Indeed, as many as 3,500 elderly fracture patients can be in hospital on any one day, (RCP, 1989). The average length of stay in hospital for this patient group is 30 days, costing the N.H.S. an estimated £160 million per annum. Therefore the provision of nutrition support for malnourished patients could lead to substantial financial savings.

The benefits to this large group of patients in terms of improvement in well-being and quality of life could also be considerable. This is because the clinical outcome of elderly patients with fracture of the hip could be expected to be affected particularly by complications associated with malnutrition, such as delayed wound healing, impaired immunity and longer time to rehabilitation leading to longer periods in hospital and convalescence times, (Reilly et al, 1987).

The incidence of malnutrition in surgical and medical hospital patients is quoted by some workers as being as high as 50 percent, (Bistrian et al, 1974; Bistrian et al, 1976; Hill et al, 1977; Weinsier et al, 1979; ). Orthopaedic patients have been reported as having a similar incidence of protein calorie malnutrition when compared with other medical and surgical patients, (Dreblow et al, 1981). In a study of 40 patients with hip fracture, Foster et al, (1990), found that those patients with low values of serum albumin, (often used as an indicator of malnutrition), had a significantly longer stay in hospital. Nutrition associated complications, such as increased infection rates, were observed in both emergency and elective orthopaedic patients by Jensen et al, (1982).

The fact that elderly patients are more likely than the younger population to be admitted to hospital suffering from some degree of malnutrition is well known. Very few studies have been carried out on individuals in the community, but Vir and Love, (1979), found sub-clinical malnutrition was highly prevalent in the elderly subjects examined from hospital institutions, residential accommodation, sheltered dwellings and also in non-institutionalised settings. Indeed, by taking adequate preventative measures at an earlier stage in the community, patients
admitted to hospital would rarely show such marked signs of malnutrition, (Durnin and Fidanza, 1985). According to Morgan et al, (1986), many elderly patients continue to be admitted to hospital in a nutritionally depleted state. This study showed that 50% of all elderly patients admitted to hospital with acute illness demonstrated abnormally low values for a series of anthropometric measurements, compared with the values seen in healthy active elderly in the community. In a survey of all elderly patients admitted to hospital over a period of one year, Kemm and Allcock, (1984), found significantly lower admission values for these measurements in patients who subsequently died, compared with those who survived. These data suggest that a high incidence of malnutrition already exists among elderly people admitted for hip fracture and replacement surgery which may significantly compromise the clinical outcome of certain patients. Bastow et al, (1983a), in a study of 744 elderly women with femoral neck fractures found a significant correlation between mortality and nutritional status on admission. Furthermore, those patients who received supplementary nasogastric feeding were observed to have a much reduced rehabilitation time and a shorter duration of stay overall than the control group.

These observations have prompted workers to try to identify which patients are at greatest nutritional risk so that nutritional support can be given to best effect. Most studies of nutritional assessment of hospital patients have concentrated on the evaluation of nutritional status in patients admitted for gastrointestinal surgery. A reduction in complication rates and an improved survival rate has been observed in patients admitted for gut surgery who were correctly identified as needing nutritional support, (Harvey et al, 1981). A large number of these studies have investigated the relationship between nutritional status in surgical patients and their clinical outcome whilst in hospital (Buzby et al, 1980; Mullen et al, 1979). Very few studies have evaluated nutritional status and outcome of patients following their discharge from hospital, when the full consequences of malnutrition in terms of clinical outcome may only then become apparent. Thus, many of these studies have not evaluated the full impact of poor nutritional status on clinical outcome.

It is known that patients recently discharged from hospital are more vulnerable in terms of nutrition, although no specific studies have been reported. The nutritional vulnerability of patients discharged from hospital is the result of a number of factors. The effects of major illness, surgery and possible trauma as a result of a fall, in increasing nutritional requirements, especially for energy and protein, are well documented, (James, 1980; Kinney, 1983). Even when considerable efforts are made by medical and nursing staff to try to meet the
need for additional calories and nutrients, their attempts are often thwarted by the patients poor appetite, unfamiliarity with hospital food and ward routines. This may be the reason why these patients still show significant weight loss during the period of hospitalisation, (Studley, 1936; Rhoads et al, 1955). Much of this weight reduction represents a loss of body protein, (James, 1980). This can have a detrimental effect on wound healing, immune function and resistance to infection. A diminished muscle mass and subsequent impairment of muscle function will lead to a reduction in the level of ambulation and independence.

Research shows that nutritional support during the catabolic phase, following major surgery, illness and infection, may only partly prevent losses of body fat and protein, (MacFie, 1984). Indeed, excessive nutrient provision during the catabolic phase may exacerbate the metabolic abnormalities observed during this phase (MacFie, 1986). These studies suggest that nutritional depletion may be an inevitable consequence of severe illness. Hence, it is even more important that nutritional repletion occurs during the convalescent period, when metabolic disturbances have ceased. The implication is that additional emphasis should be placed on understanding and meeting the nutritional needs of patients during the recovery period when they may have returned home, as well as in hospital. In order to achieve this aim more information on the post-discharge period and convalescence, is required.

In conclusion, this introduction has set out to show that malnutrition is often high among elderly women admitted for surgery for fractured neck of femur and total hip replacement and that not only is the cost to the patient high, in terms of increased morbidity, mortality, delayed return to mobility and normal activities of daily living, but the financial cost to the Health Service is great in terms of increased time spent in hospital and extra support needed on return to the community. Despite studies which demonstrate the benefits of nutritional support in orthopaedic patients in terms of improved clinical outcome, recent studies indicate that orthopaedic patients are still among those receiving the least nutritional support. Studies show that the prevalence of malnutrition is high in elderly patients on admission and by deduction this must be reflected in independent elderly in the community. Whilst this has been confirmed, too few studies have been carried out to investigate this effect, (DH, 1992). Furthermore, nutritional requirements increase as a result of surgery and these increased needs then continue into the post discharge period when social and medical factors may prevent them from being met. There have been very few studies to investigate the effect of poor nutrition on clinical outcome in the longer term. Of the studies which have been reported only a limited range of
clinical outcomes have been investigated. Many of the studies have investigated patients undergoing gastrointestinal surgery and the main outcome which has been monitored has been the incidence of peritoneal and respiratory infection.

This provides the background to the present study and indicates the reasons for choosing elderly female orthopaedic patients as the study group. Despite its importance, there is very little, if any, documented data, regarding the changes in patients following discharge in terms of their nutrition and clinical outcome. Hence, the distinguishing features of this study were:-

- the follow-up of a group of patients after hospital discharge for a period of 6 months and,

- the use of a variety of clinical outcome parameters which were monitored and documented for this extended period.

The principal aims of this element of the study, (as stated in Chapter 1 and repeated here for convenience), were as follows:

- To follow a group of elderly female orthopaedic patients from admission to six months post discharge, to investigate the nutritional characteristics of the group and to observe how this related to clinical outcome in the longer term.

- To investigate the use of a range of clinical outcome criteria in studying an elderly orthopaedic group.

- To allocate patients on admission into high and low nutritional risk groups by objective tests of nutritional status to test the ability of a simple risk allocation procedure to predict patients who do less well clinically.

- To determine whether there are specific social and medical factors which contribute to poor nutritional status on admission.

- To obtain information to design a simple nutritional assessment procedure incorporating results of both objective and subjective information for this clinical group. This aim is developed in Chapter 4 through the development of a predictive model.
3.2 METHOD

3.2.1 The study group

The study group consisted of 60 elderly female patients who were admitted to two orthopaedic wards of the Royal Surrey County Hospital (Guildford) on weekdays between January 1988 and June 1989. The patients were admitted for surgery for either total hip replacement (THR-elective), or for fracture of the femur (FNF-emergency), (Table 3.1). All female patients over the age of 60 years, who were admitted for hip surgery (emergency or elective), were eligible for recruitment into the study with the exception of confused or delirious patients. Ethical consent for the study was obtained from the Hospital Ethics Committee and all patients gave their consent to participate in the study and to be visited for the purpose of long-term follow-up. Details of the patient group are shown in Table 3.1. Variation of the sample was minimised by studying only elderly female patients, the reason for studying this particular cohort is explained in the previous section. Whilst it is recognised that patients admitted for emergency hip surgery may be at greater risk than those admitted for total hip replacement, it was unlikely that sufficient numbers of patients would have been recruited to the study if either of the groups had been omitted. Furthermore, the criteria of clinical outcome are well documented for both of these conditions so that published information is readily available for comparison of results with those of the proposed study.

3.2.2 Experimental protocol

Each patient was approached within 48 hrs (usually 24 hrs) after admission and asked if they would be prepared to participate in the study. Verbal consent was sought from the patient only after giving a thorough explanation of the study and its duration.

Patients were visited during hospitalisation and at 4 weeks, 8 weeks and 6 months after discharge. A summary of the experimental protocol is presented in Figure 3.1.

A detailed history of social and medical factors was taken on admission. During the course of the structured interview the respondent was requested to provide information on a variety of topics, including mobility, lifestyle, food habits, psychological well-being, physical health, falls and drug history.
### Table 3.1 Details of patients admitted for total hip replacement and fractured neck of femur

Values are medians (25th percentile; 75th percentile)

<table>
<thead>
<tr>
<th></th>
<th>Number of patients n = 60</th>
<th>Age (yrs)</th>
<th>Average duration of stay in acute hospital (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hip Replacement (THR)</td>
<td>28</td>
<td>75.2</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(68.0; 82.1)</td>
<td>(13.0; 23.8)</td>
</tr>
<tr>
<td>Fractured Neck of Femur (FNF)</td>
<td>32</td>
<td>81.3*</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(73.4; 85.0)</td>
<td>(13.3; 27.0)</td>
</tr>
</tbody>
</table>

* p<0.05 compared with THR
Figure 3.1 Experimental Overview of the Study

<table>
<thead>
<tr>
<th></th>
<th>HOSPITAL</th>
<th>POST DISCHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admission</td>
<td>One week</td>
</tr>
<tr>
<td>Patient details: Social/medical history</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Anthropometry (TSF, MUAC, MUAMC)</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Weight</td>
<td>(†)</td>
<td>↑</td>
</tr>
<tr>
<td>Hand Grip Strength</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Blood biochemistry:</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Haemoglobin; creatinine and white cell count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum albumin and Retinol binding protein</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Mental Function Test</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Activities of Daily Living Assessment using Modified Visick Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical outcome</td>
<td>↑</td>
<td>↑</td>
</tr>
</tbody>
</table>

(†) Weight recorded on admission, or during hospital stay
Although it was difficult to weigh some of the patients on admission because of pain or immobility, weight was taken where practicable at some time before discharge. A record of usual weight as well as weight loss in the last 2 months, was recalled from each patient. Weight was recorded where possible by the investigator at each post-discharge visit. Because the first value for body weight was not always obtained on admission this measure is referred to as "hospital weight," whereas other admission measures are described as "admission" values.

Baseline anthropometric measurements were taken on admission during hospitalisation, at discharge and then at 4 weeks, 8 weeks and 6 months. The measurements taken were: triceps skinfold thickness (TSF), mid upper arm circumference (MUAC), and mid upper arm muscle circumference (MUAMC).

Measurements of handgrip strength (HGS) were made using a strain gauge handgrip dynamometer, on admission and then at discharge, 4 weeks, 8 weeks and 6 months.

A sample of blood was obtained on admission and discharge and at 8 weeks and 6 months following surgery. Aliquots of serum were obtained and stored at -20 degrees C., until analysis, when retinol binding protein and serum albumin determinations were made by the investigator. Routine biochemistry results of haemoglobin, white cell count and creatinine values obtained on admission were also recorded. These analyses were carried out routinely in the hospital laboratories.

Mental competence was assessed using the 12-item Information/Orientation (I/O) scale from the Clifton Assessment Procedures for the Elderly (Pattie and Gilleard 1975, 1977), after one week of hospitalisation, at 4 weeks and 6 months post-discharge.
A range of clinical outcome criteria were monitored and recorded in hospital and at the post-discharge visits. Data were collected on:

- the duration of stay in hospital and convalescence;
- time taken to graduate from the use of walking frames, sticks and eventually in some cases full independent mobility;
- return to normal activities of daily living by means of the modified Visick Index (Methods, Chapter 2);
- mortality.

Full details of the methods used are presented in Chapter 2.

3.2.3 Risk allocation procedure based on admission measures

Patients were retrospectively categorised into high and low risk nutritional groups on the basis of results of anthropometric and biochemical measurements made within 24-48 hours of admission. Patients were categorised into the high nutritional risk group if they had three or more values below the fifth percentile, (Table 3.2), for:-

- body weight;
- triceps skinfold thickness;
- mid upper arm muscle circumference;
- serum albumin;
- haemoglobin.

Values for the fifth percentile were those derived from the healthy elderly population studied by Morgan et al, (1986), except for haemoglobin, where the local laboratory value for the fifth percentile for the healthy adult population was used.

Patients were allocated to a group designated HIGH RISK ALL (HRA) if they had three or more values below the fifth percentile. The remaining patients who had anthropometric and biochemical values above the fifth percentile were allocated to a group called LOW RISK ALL (LRA).
Table 3.2  Fifth percentile values for anthropometric and biochemical indices of nutritional status

<table>
<thead>
<tr>
<th>Index</th>
<th>Fifth percentile value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>48 kg</td>
</tr>
<tr>
<td>Triceps skinfold thickness</td>
<td>10.5 mm</td>
</tr>
<tr>
<td>Mid upper arm muscle circumference</td>
<td>20.2 cm</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>37 g/l</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>11.2 g/dl</td>
</tr>
</tbody>
</table>
3.2.3.1 Sub-categorisation according to type of surgery (THR or FNF).

As the HRA and LRA groups contained both THR and FNF patients it could be argued that any differences observed between the two nutritional risk groups (HRA and LRA), might result from this confounding factor. Thus, for the purpose of comparing nutritional risk with clinical outcome a further two nutritional risk groups were derived. This allocation involved only those patients who were admitted for emergency surgery for FNF. Emergency patients who had three or more anthropometric/biochemical values below the fifth percentile were allocated to a group called HIGH RISK EMERGENCY (HRE) and the remaining patients were allocated to the LOW RISK EMERGENCY (LRE) group. Women admitted for THR surgery were thus excluded from these groups.

The risk allocation procedure involving all patients (HRA;LRA) and emergency fractured neck of femur patients (HRE;LRE) is illustrated diagrammatically below:

ALL PATIENTS
n = 60

<table>
<thead>
<tr>
<th></th>
<th>HRA</th>
<th>LRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>14</td>
<td>46</td>
</tr>
<tr>
<td>FNF + THR</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>[HRE]</td>
<td>[LRE]</td>
</tr>
<tr>
<td>n</td>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>

3.2.4 Presentation of results and statistical methods

The response of patients to questions obtained from the medical and social interview, and the values for other admission measurements were analysed according to the nutritional risk categorisation described above. Comparison of the clinical and nutritional outcome measurements were also analysed according to risk allocation. Data were analyzed for all patients [high risk (HRA) and low risk (LRA)] and for patients admitted for emergency surgery (FNF) only [high risk (HRE) and low risk (LRE)].
Calculation of the changes in anthropometric, biochemical and handgrip strength measurements within groups were also carried out to determine the nature and extent of changes with time. Changes with time are reported for the periods:

- admission to discharge,
- admission to 8 weeks,
- admission to 6 months.

Changes in body weight are reported from hospital to 4 weeks, hospital to 8 weeks and hospital to 6 months. In the case of the modified Visick score, changes were measured from 1 week to 4 weeks, 1 week to 8 weeks and 1 week to 6 months following discharge.

As much of the data was not normally distributed, the results have been expressed as medians with 25th and 75th percentile ranges. Non-parametric methods of statistical analysis have been used throughout.

Differences in median values between groups were identified by analysis of variance (Kruskal-Wallis) and differences found between groups (HRA vs LRA or HRE vs LRE) were tested for their significance using the Mann-Whitney ‘U’ test. Median changes within groups with time (usually admission to discharge, admission to 8 weeks, admission to 6 months) were calculated and tested for their significance using the Wilcoxon procedure for paired analysis. Comparison of changes between groups with time were tested by the unpaired Mann-Whitney ‘U’ test. Calculation of descriptive variables and all significance tests were undertaken using the SPSS-PC statistical package. Differences in percentage values were compared by use of the Chi-square test. In the case of all significance tests p<0.05 was taken as the level of statistical significance. Where values close to, but greater than 0.05 were obtained these have been reported and their relevance discussed.

3.3 RESULTS

3.3.1 Details of the patients

Sixty elderly female orthopaedic patients admitted for surgery were studied (Table 3.1). Twenty-eight women were admitted for elective surgery for total hip replacement (THR) and thirty-two for emergency surgery for fractured neck of femur (FNF). The median age of the THR group was 75.2 years which was
younger than that of the FNF group who had a median age of 81.3 years (p<0.05). The median duration of stay in the acute hospital was similar in both groups, that is 16 days in the THR group and 17 days in the FNF group. According to the nutritional risk allocation used there was a 4 percent incidence of malnutrition in the elective (THR) patients and 41 percent incidence in emergency (FNF) patients, (Table 3.3).

3.3.2 Admission characteristics of the study group according to risk allocation

The admission characteristics have been analyzed for all patients and for emergency (FNF) patients only according to the nutritional risk categorisation. Admission characteristics in relation to age, anthropometry, biochemistry, mental function and handgrip strength are presented in Table 3.4. Details of patients' social and medical histories obtained by interview and by reference to medical notes are presented in Table 3.5.

3.3.2.1 Nutritional and biochemical admission characteristics

Patients in the low risk groups were younger than in the high risk groups (p<0.002 HRA vs LRA; p<0.05 HRE vs LRE), (Table 3.4). As expected, patients in the high risk groups weighed significantly less than the low risk groups (p<0.0001 HRA vs LRA; p<0.0002 HRE vs LRE); had significant differences in TSF values (p<0.0001 HRA vs LRA; p<0.002 HRE vs LRE). Significant differences in MUAC and MUAMC measurements were also found between the groups (p<0.0001 HRA vs LRA; p<0.0001 HRE vs LRE; p<0.0001 HRA vs LRA; p<0.0001 HRE vs LRE), respectively as expected.

In contrast values for serum albumin and retinol binding protein were only slightly lower in the HRA vs LRA groups and differences did not reach a level of statistical significance. The median value for serum albumin was lower in the HRE vs LRE group although in the HRE vs LRE group the median value for retinol binding protein was higher in the HRE group. The median values for haemoglobin were significantly lower in the high risk groups compared with the low risk groups (p< 0.002 HRA vs LRA; HRE vs LRE). The white cell counts and creatinine values were higher in the high risk groups but this difference did not reach statistical significance.
<table>
<thead>
<tr>
<th>Table 3.3 Prevalence of malnutrition in all patients</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Number of patients</td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>32</td>
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</tbody>
</table>

Total hip replacement (THR) and Fractured neck of femur (FNF)
<table>
<thead>
<tr>
<th>ADMISSION DATA</th>
<th>ALL PATIENTS</th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td>ADMISSION DATA</td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>84.5 (79.3; 90.3)</td>
<td>77.0* (70.0; 82.0)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>43.7 (38.1; 47.9)</td>
<td>63.5*** (50.3; 70.9)</td>
</tr>
<tr>
<td>Triceps skinfold thickness (mm)</td>
<td>8.1 (7.1; 10.8)</td>
<td>16.4*** (12.2; 18.8)</td>
</tr>
<tr>
<td>Mid upper arm circumference (cm)</td>
<td>22.9 (21.8; 24.3)</td>
<td>32.3*** (29.5; 34.1)</td>
</tr>
<tr>
<td>Mid upper arm muscle circumference (cm)</td>
<td>20.2 (19.1; 20.9)</td>
<td>26.9*** (25.1; 29.1)</td>
</tr>
<tr>
<td>Serum albumin (g/l)</td>
<td>40.0 (35.0; 48.5)</td>
<td>43.5 (41.0; 49.3)</td>
</tr>
<tr>
<td>Retinol binding protein (mg/l)</td>
<td>46.0 (34.8; 57.0)</td>
<td>47.0 (35.5; 57.0)</td>
</tr>
<tr>
<td>Haemoglobin (g/dl)</td>
<td>11.2 (9.8; 12.5)</td>
<td>13.2** (12.5; 14.4)</td>
</tr>
<tr>
<td>Creatinine</td>
<td>113.0 (85.0; 124.0)</td>
<td>93.0 (86.0; 108.0)</td>
</tr>
<tr>
<td>White cell count</td>
<td>10.5 (8.2; 14.0)</td>
<td>8.9 (7.0; 10.4)</td>
</tr>
<tr>
<td>Mental function score</td>
<td>21.0 (19.0; 23.0)</td>
<td>23.0a (22.0; 23.0)</td>
</tr>
<tr>
<td>Handgrip strength (mmHg)</td>
<td>2.0 (0.9; 3.6)</td>
<td>4.5* (2.0; 6.0)</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.002; *** p<0.0001 compared with HRA; † p<0.05; †† p<0.002; ††† p<0.0001 compared with HRE; a p<0.009 compared with HRA; b p<0.0002 compared with HRE
Table 3.5 Social and medical characteristics in all patients and in patients admitted for emergency surgery (FNF) only, according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>% Patients</th>
<th>ALL PATIENTS</th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td></td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
</tr>
<tr>
<td>Live alone</td>
<td>57</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>61</td>
<td>26†</td>
</tr>
<tr>
<td>Recently bereaved</td>
<td>29</td>
<td>7a</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>Unable to walk &gt;400yds unaided</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Leave house &lt;twice per week</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>21b</td>
</tr>
<tr>
<td>With very poor vision</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>With history of confusion</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>With history of recent falls</td>
<td>85</td>
<td>3***</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>5ttt</td>
</tr>
<tr>
<td>With poor dentition</td>
<td>14</td>
<td>0a</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0b</td>
</tr>
<tr>
<td>Who are on a therapeutic diet</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Who require help with shopping</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>5†</td>
</tr>
<tr>
<td>Who require assistance with cooking</td>
<td>57</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>61</td>
<td>21†</td>
</tr>
<tr>
<td>Who eat alone &gt;4 days per week</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Who eat &lt;5 hot meals per week</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Who are provided with all their meals by another</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>21b</td>
</tr>
<tr>
<td>Are suffering apathy or depression</td>
<td>50</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>16b</td>
</tr>
</tbody>
</table>

* p<0.05;  *** p<0.0001 compared with HRA;  † p<0.05;  ††† p<.001 compared with HRE

a p<0.07 compared with HRA;

b p<0.07 compared with HRE
Interestingly, patients in the low risk groups had a higher mental function score than those in the high risk groups although this reached significance in the HRA vs LRA group only (p<0.009). Patients in the low risk group (LRA) had a stronger handgrip (p<0.05) than those in the high risk group (HRA). Differences in median values for HGS between the HRE vs LRE groups did not reach statistical significance.

### 3.3.2.2 Social and medical factors

Social and medical characteristics, obtained by means of patient interview, were analyzed according to nutritional risk categorisation (Table 3.5).

In the emergency patients (FNF), a greater percentage of the patients in the high risk group (HRE) lived alone (p<0.05) than the low risk group (LRE), and a greater number had a history of recent falls prior to the fall causing the present admission (p<0.001). Furthermore, many of these patients required help with their shopping (p<0.05) and cooking (p<0.05). There was a trend for a greater number of patients in the HRE group to have poor dentition (p<0.07) and to suffer depression (p<0.07) than the LRE group. Compared with the HRE group there was a strong trend for more of the patients in the LRE to leave the house less than twice a week (p<0.07) and to be totally dependent upon others for their meals, (p<0.07).

When all the patients were considered together (FNF and THR) fewer statistically significant differences in social and medical characteristics were evident according to nutritional risk allocation. More patients in the high risk group (HRA) than the low risk group (LRA) had a history of recent falls (p<0.0001) and there was a strong trend for more of these patients to be recently bereaved (p<0.07) and to have poor dentition (p<0.07) than in the low risk group.

### 3.3.3 Nutritional and biochemical values over time according to nutritional risk categorisation.

As stated in the experimental protocol, (Section 3.2.2), body weight, TSF, MUAC, MUAMC, handgrip strength, serum albumin and retinol binding protein were measured at time intervals over a period of 6 months. These data are presented graphically in Figures 3.2-3.8, and also in the Appendix B (Tables 3.i-3.iv).
Figure 3.2

Body Weight Values in Hospital at 4 weeks, 8 weeks and 6 months Post Discharge

(a) All patients

Values are medians with 25th and 75th percentiles in brackets

*** p<0.0001 compared with HRA

(b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

- - - p<0.0001 compared with HRE
Figure 3.3 Triceps Skinfold Measurements at Admission, Discharge, 4 weeks, 8 weeks and 6 months Post Discharge (a) All patients

Values are medians with 25th and 75th percentiles in brackets

- p<0.0001 compared with HRA

(b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

- p<0.005; *p<0.02 compared with HRE
Figure 3.4  
Mid Upper Arm Circumference Measurements  
at Admission, Discharge, 4 weeks, 8 weeks and 6 months Post Discharge  
(a) All patients  

![MUAC Measurement Graph for All Patients](image)

Values are medians with 25th and 75th percentiles in brackets

- *** p<0.0001 compared with HRA
- HRA
- LRA

(b) Fracture neck of femur only  

![MUAC Measurement Graph for Fracture Neck of Femur Only](image)

Values are medians with 25th and 75th percentiles in brackets

- --- p<0.0002
- --- p<0.0001 compared with HRE
- HRE
- LRE

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Figure 3.5  Mid Upper Arm Muscle Circumference Measurements at Admission, Discharge, 4 weeks, 8 weeks and 6 months Post Discharge

(a) All patients

(b) Fracture neck of femur only
Figure 3.6  
Handgrip Strength Measurements at Admission,  
Discharge, 4 weeks, 8 weeks and 6 months Post Discharge  
(a) All patients

Values are medians with 25th and 75th percentiles in brackets

*p<0.05; **p<0.01; ***p<0.001 compared with HRA  
- - HRA  - - LRA

(b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

- - HRE  - - LRE

*p<0.05; **p<0.01 compared with HRE
Figure 3.7: Serum Albumin Concentration at Admission, Discharge, 8 weeks and 6 months Post Discharge

(a) All patients

Values are medians with 25th and 75th percentiles in brackets

(b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets
Figure 3.8  Retinol Binding Protein Concentration at Admission, Discharge, 8 weeks and 6 months Post Discharge

(a) All patients

(b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

*p<0.05 compared with HRA

- HRA - LRA

HRE LRE
3.3.3.1 Anthropometric values

Patients from the high risk groups weighed significantly less than those in the low risk groups whilst in hospital, and at 4 weeks, 8 weeks, and 6 months post discharge (HRA vs LRA p < 0.0001 at all time points), (HRE vs LRE p < 0.0002 except at 4 weeks p < 0.0001), (Figure 3.2). The high risk groups also had lower values for TSF, MUAC and MUAMC than the low risk groups and these differences reached statistical significance at each time interval, (Figures 3.3-3.5).

3.3.3.2 Handgrip strength

When all patients were considered together the high risk group (HRA) had significantly weaker handgrip strengths than those in the low risk group (LRA), throughout the observation period: on admission and at discharge (p < 0.05), at 4 weeks (p < 0.01), at 8 weeks (p < 0.001) and at 6 months post discharge (p < 0.01). In the case of emergency patients only, the HRE patients had a significantly weaker handgrip strengths at 4 weeks and 8 weeks (p < 0.05), and at 6 months post discharge (p < 0.01), compared with the LRE group, (Figure 3.6, Appendix B - Table 3.iii).

3.3.3.3 Biochemical values

There were no significant differences in the values obtained for serum albumin or retinol binding protein, although median values were lower in the high risk groups in general (HRA vs LRA; HRE vs LRE). There was a trend for serum albumin values to increase gradually from admission to six months post discharge in both high risk groups compared with their corresponding low risk groups, but this did not reach statistical significance. In contrast, retinol binding protein values increased in the low risk groups from admission to 6 months compared with the corresponding high risk groups. The value for retinol binding protein in the HRA group was also significantly lower (p < 0.05) than in the LRA group at 6 months. In addition the discharge value for retinol binding protein was unusually high (outside the normal range) in both the HRA and HRE groups due to very high values in a few subjects. Repeat tests on the same blood samples yielded the same results and no explanation could be offered for this seemingly spurious result. These values have caused the high median values for RBP at discharge and should be interpreted with caution.
3.3.4 Changes in anthropometric and biochemical parameters from admission to six months

Changes in body weight from hospital to 4 weeks, hospital to 8 weeks and hospital to 6 months are reported. The anthropometric changes in TSF, MUAC and MUAMC from admission to discharge, admission to 8 weeks and admission to 6 months post-discharge are presented below for each parameter. These findings are presented graphically in Figures 3.9-3.15 and also in the Appendix B (Tables 3.v-3.viii). In order to aid the presentation of findings, only significant differences in the changes in anthropometric parameters between groups have been indicated by significance values on the figures and tables.

3.3.4.1 Body weight

Changes in weight measurements from hospital to 4 weeks, 8 weeks and 6 months post-surgery, differed between the high and low risk groups (Figure 3.9). Although none of the trends described below reached a level of statistical significance (due to the wide range of individual variations in the weight changes), their general features are described because the trends correlate well with other anthropometric changes.

There was a trend towards a loss of weight in both the LRA and LRE from hospital to 4 weeks (median -0.9kg LRA; -1.1kg LRE); hospital to 8 weeks (median -0.9kg in both LRA and LRE); and from hospital to 6 months in the LRE group only (median -0.8kg). The high risk groups either gained a very small amount of weight or remained the same weight. The only exception to these general trends was a weight gain in the LRA group for the period from hospital to 6 months (median +1.3kg).

3.3.4.2 Triceps skinfold thickness

Changes in TSF between admission and up to 6 months discharge are presented in Figure 3.10. Changes in TSF measurements differed between the high and
Figure 3.9  
Change in Body Weight after Surgery

a) All patients

Values are medians with 25th and 75th percentiles in brackets.

b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets.
Figure 3.10  Change in TSF after Surgery

a) All patients

Values are medians with 25th and 75th percentiles in brackets

* p<0.02; *** p<0.003 compared with HRA

b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

- - p<0.01 compared with HRE

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low risk groups. In both HRA and HRE groups there was a non-significant
decrease in TSF measurements from admission to discharge (median -0.2mm
HRA; -0.3mm HRE); but a significant decrease from admission to 8 weeks
(median -0.9mm HRA; -1.1mm HRE); and admission to 6 months (median -
1.5mm HRA; -1.4mm HRE), p<0.05 in all cases. Similarly in the LRA and LRE
groups there was a non-significant decrease in the TSF measurement from
admission to discharge (median -0.7mm LRA; -0.3mm LRE), but this was
followed by a significant increase in TSF from admission to 8 weeks (median
+1.0mm LRA; +0.9mm LRE) and from admission to 6 months (median
+2.4mm LRA; +2.4mm LRE), p<0.05 in all cases. Thus, the net change for
the HRA and HRE groups was a loss in TSF, whilst in the LRA and LRE groups
there was a gain in TSF. These differences in the changes in TSF between the
HRA and LRA groups reached significance at 8 weeks (p<0.02) and at 6
months (p<0.0003) and between the HRE and LRE groups at 6 months
(p<0.01 LRE vs HRE).

3.3.4.3 Mid upper arm circumference

Changes in MUAC measurements did not differ significantly between the high
and low risk groups from admission to discharge, 8 weeks or 6 months (Figure
3.11). Both groups however showed losses in median MUAC measurements
over time. Losses in the HRA group remained relatively constant compared with
the LRA group. In the LRA group losses increased from admission to discharge
(median -0.4cm); admission to 8 weeks (median -1.5cm) p<0.05; admission to
6 months (median -1.4cm) p<0.05. Median values for MUAC in the HRE group
did not change from admission up to 6 months, whereas a trend towards
increased losses in the LRE group was observed from admission to discharge
(median -0.4cm); admission to 8 weeks (median -0.9cm) and especially in the
period from admission to 6 months (median -1.5cm) p<0.05.

3.3.4.4 Mid upper arm muscle circumference

Changes in MUAMC measurements differed between the high and low risk
groups, (Figure 3.12; Table 3.vi). Significant losses in MUAMC occurred in the
LRA group from admission to 8 weeks compared with the corresponding HRA
group (medians: -1.8 vs -0.3 cm, LRA;HRA, p<0.02). A similar trend for
greater losses in the MUAMC in the low risk group compared with the high risk
Figure 3.11 Change in MUAC after Surgery

a) All patients

Values are medians with 25th and 75th percentiles in brackets

b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets
Figure 3.12 Change in MUAMC after Surgery

a) All patients

Values are medians with 25th and 75th percentiles in brackets

* p<0.02; ** p<0.007 compared with HRA

b) Fracture neck of femur only

Values are medians with 25th and 75th percentiles in brackets

- p<0.03 compared with HRE
group was observed in the emergency patients from admission to 8 weeks (medians: -1.4 vs -0.4 cm, LRE; HRE), although this difference was not statistically significant. Significant losses in MUAMC occurred from admission to 6 months in the LRA compared with the HRA group (medians: -1.8 vs -0.1 cm, LRA; HRA, p < 0.007) and in the LRE compared with the HRE group (medians: -1.4 vs 0.0 cm, LRE; HRE, p < 0.03). In summary, there were no significant losses in MUAMC in the high risk groups from admission to 6 months post discharge whilst there were significant losses in the low nutritional risk groups. The differences observed in the changes in MUAMC measurements between the high and low risk groups were interesting and unexpected and are discussed in Section 3.4.3.

3.3.4.5 Handgrip strength

Improvements in handgrip strength from admission were recorded in the low risk but not in the high risk patients, (Figure 3.13; Appendix B, Table 3. vii). Thus, there was a significant improvement in HGS from admission to discharge in the LRA compared with the HRA group (medians: 1.0 vs 0.2 mmHg, LRA vs HRA, p < 0.05). Although the trend was similar in the emergency patients it did not reach statistical significance, (medians: 1.5 vs 0.0 mmHg, LRE; HRE). Similarly, a significant improvement in grip strength was observed from admission to 8 weeks in the low risk groups compared with the corresponding high risk groups [medians: (1.5 vs 0.0 mmHg, LRA; HRA, p < 0.05); (2.5 vs -0.25 mmHg, LRE vs HRE, p < 0.05)]. Lastly, there were significant improvements in grip strength found in the both the low risk groups from admission to 6 months compared with the corresponding high risk groups, [medians: (1.0 vs 0.0 mmHg, LRA; HRA, p < 0.05) (2.5 vs 0.0 mmHg, LRE; HRE, p < 0.01)].

3.3.4.6 Serum albumin and retinol binding protein values

There were no significant differences in the changes in values of serum albumin between the high and low risk groups from: admission to discharge; admission to 8 weeks or admission to 6 months, (Figure 3.14). In general, median albumin values fell during hospitalisation but increased in the 6 months post-discharge. However, none of the time trends were statistically significantly different, because of the wide variation in the individual changes.
Figure 3.13 Change in Handgrip Strength after Surgery

a) All patients

Change in Handgrip Strength (mm Hg)

<table>
<thead>
<tr>
<th></th>
<th>Hospital to Discharge</th>
<th>Hospital to 8 weeks</th>
<th>Hospital to 24 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.0; 1.6)</td>
<td></td>
<td></td>
<td>(0.0; 2.4) *</td>
</tr>
<tr>
<td>(-1.0; 1.0)</td>
<td></td>
<td></td>
<td>(0.0; 3.0) *</td>
</tr>
<tr>
<td>(0.0; 1.3)</td>
<td></td>
<td></td>
<td>(0.0; 3.5) *</td>
</tr>
</tbody>
</table>

Values are medians with 25th and 75th percentiles in brackets

HRA LRA

* p<0.05 compared with HRA

b) Fracture neck of femur only

Change in Handgrip Strength (mm Hg)

<table>
<thead>
<tr>
<th></th>
<th>Hospital to Discharge</th>
<th>Hospital to 8 weeks</th>
<th>Hospital to 24 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.0; 1.3)</td>
<td></td>
<td></td>
<td>(-0.25; 3.0)</td>
</tr>
<tr>
<td>(-1.1; 1.0)</td>
<td></td>
<td></td>
<td>(-0.3; 3.9) -</td>
</tr>
<tr>
<td>(1.0; 0.25) *</td>
<td></td>
<td></td>
<td>(0.12; 5.3) -</td>
</tr>
</tbody>
</table>

Values are medians with 25th and 75th percentiles in brackets

HRE LRE

- p<0.05; -- p<0.01 compared with HRE
Figure 3.14  Change in Serum Albumin after Surgery

a) All patients

Change in Serum Albumin (g/l)

Values are medians with 25th and 75th percentiles in brackets

<table>
<thead>
<tr>
<th></th>
<th>HRA</th>
<th>LRA</th>
</tr>
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<tbody>
<tr>
<td>Admission to Discharge</td>
<td>(8.5;6.3)</td>
<td>(-8.0;1.0)</td>
</tr>
<tr>
<td>Admission to 8 weeks</td>
<td>(-6.5;4.5)</td>
<td>(-3.8;4.2)</td>
</tr>
<tr>
<td>Admission to 24 weeks</td>
<td>(-2.8;4.0)</td>
<td>(0.0;4.0)</td>
</tr>
</tbody>
</table>

b) Fracture neck of femur only

Change in Serum Albumin (g/l)

Values are medians with 25th and 75th percentiles in brackets

<table>
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<tr>
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<th>LRA</th>
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<td>Admission to Discharge</td>
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<td>(-6.0;4.0)</td>
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<tr>
<td>Admission to 8 weeks</td>
<td>(-6.5;4.5)</td>
<td>(-5.5;5.5)</td>
</tr>
<tr>
<td>Admission to 24 weeks</td>
<td>(0.0;4.0)</td>
<td>(3.0;7.0)</td>
</tr>
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</table>
Figure 3.15  Change in Retinol Binding Protein after Surgery

(a) All patients

<table>
<thead>
<tr>
<th>Change in RBP (mg/l)</th>
<th>Admission to Discharge</th>
<th>Admission to 8 weeks</th>
<th>Admission to 24 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-4.8; 40.5)</td>
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<td></td>
</tr>
<tr>
<td>(-15.0; 4.0)</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>(-17.0; 11.8)</td>
<td></td>
<td>(-6.5; 10.5)</td>
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</tr>
<tr>
<td>(-4.0; 19.0)</td>
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</table>

Values are medians with 25th and 75th percentiles in brackets

* p<0.03 compared with HRA

<table>
<thead>
<tr>
<th></th>
<th>HRA</th>
<th>LRA</th>
</tr>
</thead>
</table>

(b) Fracture neck of femur only

<table>
<thead>
<tr>
<th>Change in RBP (mg/l)</th>
<th>Admission to Discharge</th>
<th>Admission to 8 weeks</th>
<th>Admission to 24 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-4.8; 40.5)</td>
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<td></td>
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</tr>
<tr>
<td>(-14.0; 19.0)</td>
<td></td>
<td>(-17.0; 11.8)</td>
<td></td>
</tr>
<tr>
<td>(-4.0; 19.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are medians with 25th and 75th percentiles in brackets

<table>
<thead>
<tr>
<th></th>
<th>HRE</th>
<th>LRE</th>
</tr>
</thead>
</table>
Although the median values for retinol binding protein, (Figure 3.15), increased during hospitalisation in the HRA and HRE groups this change was not statistically significant. No further changes occurred from admission to 8 weeks and from admission to 6 months. The RBP value fell in the LRA group but not in the LRE group from admission to discharge. Values for both groups then increased up to 6 months. The differences in the changes between the LRA and HRA group reached statistical significance in the period from admission to discharge (medians 8.5mg/l HRA; -5.0mg/l LRA; p<0.03 LRA vs HRA). It has been noted (section 3.3.3.3.) that the median discharge value for RBP was unusually high in both the HRA and HRE groups, indicating the need for caution when interpreting these data.

3.3.5 Clinical outcome following surgery according to nutritional risk categorisation

Comparisons of clinical outcome measurements, (Tables 3.6-3.11), are presented below for high and low risk groups according to the nutritional risk categorisation. The justification for the inclusion of these clinical criteria was given in Chapter 2, and the importance of investigating these parameters in relation to nutritional status is discussed in the introduction to this Chapter.

3.3.5.1 Mortality

Although there was a trend for mortality to be greater at 6 months following surgery in both the high risk groups than in their equivalent low risk groups, these differences did not reach levels of statistical significance (Table 3.6).

At 6 months following surgery there was an incidence of 23 percent mortality in the HRA group and 9 percent in the LRA group. In the emergency patients the incidence of mortality was 25 percent (HRE) compared with 19 percent in the corresponding low risk group (LRE). When mortality at 4 weeks, 8 weeks and 6 months in the HRA and LRA groups is considered it can be seen that from 8 weeks to 6 months the difference in mortality widened. The mortality incidence at 4 weeks was not very different but by 6 months the differences were much more marked, justifying long-term follow-up.
Table 3.6  Clinical outcome (mortality) after surgery in all patients and in emergency (FNF) patients only, according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Mortality (%)</th>
<th>ALL PATIENTS</th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n=14)</td>
<td>LRA (n=46)</td>
</tr>
<tr>
<td>Hospital</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4 weeks</td>
<td>7</td>
<td>4.3</td>
</tr>
<tr>
<td>8 weeks</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>6 months</td>
<td>23</td>
<td>9</td>
</tr>
</tbody>
</table>
3.3.5.2 Duration of stay

Duration of stay in the acute hospital was not significantly different between any of the groups, (Table 3.7), whereas the duration of stay in the convalescent hospital was significantly longer in the HRA and HRE groups than in their corresponding low risk groups (p<0.0009 HRA vs LRA; p<0.0009 HRE vs LRE). Consequently the total length of stay (in the acute and convalescent hospital) was also significantly longer in the HRA and HRE groups than in their corresponding low risk groups (p<0.007 HRA vs LRA; p<0.02 HRE vs LRE).

3.3.5.3 Mobility

Eighty-five percent of HRA and 92 percent of HRE patients were discharged from hospital on frames, compared with 46 percent and 61 percent in the LRA and LRE groups (p<0.01 HRA vs LRA; p<0.01 HRE vs LRE), (Table 3.8).

At 4 weeks and 8 weeks post discharge 69 percent and 67 percent of the HRA group and 75 percent and 73 percent of the HRE group were still on frames. In the equivalent low risk groups the proportion of patients still using frames was much lower at 26 percent and 15 percent in the LRA group, and 38 percent and 23 percent in the LRA and LRE groups at 4 and 8 weeks post-discharge (p<0.01 HRA vs LRA and HRE vs LRE at 4 weeks; p<0.01 HRA vs LRA and HRE vs LRE at 8 weeks).

Six months following surgery 46 percent and 50 percent of the HRA and HRE patients were still using frames, whilst only 11 percent and 33 percent of the corresponding low risk patients were still on frames. Differences only reached significance when all the patients were considered together, (p<0.01 HRA vs LRA).

Similarly a greater percentage of patients in the low risk groups were discharged from hospital using sticks rather than frames compared with the high risk group, although this did not reach statistical significance.

At 6 months following surgery only 27 percent and 20 percent of the HRA and HRE groups had reached full independent mobility requiring no walking aids. This contrasted with the LRA and LRE groups in which 55 percent and 33 percent of patients were walking without the use of aids at 6 months post-discharge. These differences only reached statistical significance in the HRA vs LRA group (p<0.01).
Table 3.7 Clinical outcome. Duration of stay in all patients and in patients admitted for emergency surgery (FNW) only, according to nutritional risk categorisation

<table>
<thead>
<tr>
<th></th>
<th>ALL PATIENTS</th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td>Stay in acute hospital pre and post operative (days)</td>
<td>16.5 (13.0; 27.0)</td>
<td>16.0 (13.0; 27.2)</td>
</tr>
<tr>
<td></td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
</tr>
<tr>
<td>Stay in acute hospital post operative only (days)</td>
<td>15.0 (12.0; 26.0)</td>
<td>15.0 (12.0; 26.3)</td>
</tr>
<tr>
<td></td>
<td>16.0 (12.5; 26.0)</td>
<td>16.0 (12.0; 27.0)</td>
</tr>
<tr>
<td>Stay in convalescence (days)</td>
<td>27.5 (5.3; 40.0)</td>
<td>0.0*** (0.0; 10.3)</td>
</tr>
<tr>
<td></td>
<td>28.0 (10.5; 43.0)</td>
<td>0.0†† (0.0; 22.0)</td>
</tr>
<tr>
<td>Total length of stay (acute and convalescence) (days)</td>
<td>44.0 (25.0; 60.0)</td>
<td>19.0** (14.0; 3.0)</td>
</tr>
<tr>
<td></td>
<td>45.0 (29.5; 64.0)</td>
<td>30.0† (14.0; 38.0)</td>
</tr>
</tbody>
</table>

** p<0.007; *** p<0.0009 compared with HRA; † p<0.02 compared with HRE; †† p<0.0009 compared with HRE
Table 3.8 Clinical outcome (mobility) at discharge (DISC), 4 weeks (4W), 8 weeks (8W) and 6 months (6M) after surgery in all patients and in emergency (FNF) patients only, according to nutritional risk categorisation

| Mobility | ALL PATIENTS | | | | EMERGENCY PATIENTS | | | |
|----------|--------------|-----|-----|-----|---------------------|-----|-----|-----|-----|
|          | HRA (n = 14) | LRA (n = 46) | HRE (n = 13) | LRE (n = 19) | | | | | |
| Patients still on frames (%) | Disc | 4W | 8W | 6M | Disc | 4W | 8W | 6M | Disc | 4W | 8W | 6M | Disc | 4W | 8W | 6M |
| 85 | 69 | 67 | 46 | 46* | 26* | 15* | 11* | 92 | 75 | 73 | 50 | 61† | 38† | 23† | 33.3 |
| Patients still using crutches (%) | 0 | 0 | 0 | 0 | 16 | 14 | 2.5 | 0 | 0 | 0 | 0 | 22 | 25 | 8 | 0 |
| Patients still using sticks (%) | 15 | 23 | 16.5 | 27 | 38 | 51 | 55 | 34 | 8 | 25 | 18 | 30 | 17 | 31 | 54 | 33.3 |
| Patients using no aid (%) | 0 | 8 | 16.5 | 27 | 0 | 9 | 27.5 | 55* | 0 | 0 | 9 | 20 | 0 | 6 | 15 | 33.3 |

* p<0.01 compared with HRA  
† p<0.01 compared with HRE
3.3.5.4 Location of patients prior to admission, at discharge and at 4 weeks, 8 weeks and 6 months.

The location of patients prior to admission and at specified times following surgery is presented in Tables 3.9 - 3.10.

As shown in Table 3.9, fifty percent of HRA patients were admitted to hospital from their own homes compared with 80.4 percent of the corresponding LRA group. Only 14.3 percent of HRA patients returned to home compared with 47.8 percent of LRA patients (p<0.05 HRA vs LRA). In the emergency patients, only 46.1 percent of the HRE group were admitted from home compared with 63.2 percent of the corresponding LRE group. Of these patients 7.7 percent of the HRE group were discharged to home compared with 31.6 percent of the LRE group, (p<0.05).

A significant number of patients, particularly from the high risk groups, were discharged to rehabilitation/convalescent hospitals, (Table 3.9). When all patients were considered together 71 percent of the high risk group compared with 26 percent of the corresponding low risk group went on to further rehabilitation (HRA vs LRA p<0.01). Of the emergency patients only, 77 percent of HRE group compared with 37 percent of the LRE group were discharged to convalescence, (HRE vs LRE p<0.05).

Of the HRA and HRE patients 36 percent and 46 percent respectively were still in convalescence at 4 weeks, compared with 11 and 21 percent in the LRA and LRE groups, (HRA vs LRA p<0.05; HRE vs LRE p<0.05), (Table 3.10). By 6 months 71.7 and 47.4 percent of the low risk groups (LRA and LRE) compared with 28.6 and 23.1 percent of the high risk groups (HRA and HRE) were living independently at home, (HRA vs LRA p<0.05; HRE vs LRE p<0.05), (Table 3.10).
<table>
<thead>
<tr>
<th>Location</th>
<th>ALL PATIENTS</th>
<th></th>
<th>EMERGENCY PATIENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
</tr>
<tr>
<td>Percentage of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>returned to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home (independent)</td>
<td>50.0</td>
<td>14.3</td>
<td>49.8*</td>
<td>46.1</td>
</tr>
<tr>
<td></td>
<td>40.0</td>
<td>80.4</td>
<td></td>
<td>7.7</td>
</tr>
<tr>
<td>Warden controlled</td>
<td>21.4</td>
<td>7.1</td>
<td>2.2</td>
<td>0.0</td>
</tr>
<tr>
<td>accommodation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Care of relative</td>
<td>14.3</td>
<td>0.0</td>
<td>6.5</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Residential home</td>
<td>14.3</td>
<td>7.1</td>
<td>8.7</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.7</td>
</tr>
<tr>
<td>Convalescence</td>
<td>0.0</td>
<td>71.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26.0**</td>
<td>77.0</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01 compared with HRA

tp<0.05 compared with HRE
Table 3.10  Clinical Outcome. Location of all patients and emergency (FN5) patients only, at 4 weeks, 8 weeks and 6 months following surgery according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ALL PATIENTS</th>
<th></th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
<td>HRE (n = 13)</td>
</tr>
<tr>
<td>Percentage of patients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>returned to:</td>
<td>4W</td>
<td>8W</td>
<td>6M</td>
</tr>
<tr>
<td>Home (independent)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.4</td>
<td>21.4</td>
<td>28.6</td>
<td>67.4*</td>
</tr>
<tr>
<td>Warden controlled accommodation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>21.4</td>
<td>14.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Care of a relative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Residential home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>28.6</td>
<td>21.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Convalescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36.0</td>
<td>7.0</td>
<td>7.0</td>
<td>11.0*</td>
</tr>
</tbody>
</table>

* p<0.05 compared with HRA
† p<0.05 compared with HRE
3.3.5.5 Activities of daily living (ADL)

Changes in the ADL scores are shown in Figure 3.16 and the Appendix B, (Table 3ix). There was an improvement in the ADL score within the LRA group from one to eight weeks (p<0.01) but no corresponding improvement was noted in the HRA group. The difference in the ADL change between the LRA and HRA groups from one to eight weeks was statistically significant (p<0.001). For the period from one week to 6 months both groups (HRA and LRA) demonstrated a similar change or improvement in independence (p<0.01, both cases) but the improvement in the LRA group in the period from one week to six months was similar to that achieved at 8 weeks indicating that full independence had been achieved in this group by 8 weeks. However, the improvement in activities of daily living of the HRA group did not start to occur until the period from eight weeks to six months.

When only the emergency patients were considered, an improvement in the ADL scores occurred in both the HRE and LRE groups from one week to eight weeks but this was only statistically significant in the LRE group (p<0.05), and differences between groups did not reach statistical significance. Finally, for the time period from one week to 6 months similar changes or improvements in the ADL scores were recorded in both the HRE and LRE groups (p<0.05).
Figure 3.16 Change in Activities of Daily Living after Surgery

a) All patients

Values are medians with 25th and 75th percentiles in brackets

* \( p < 0.001 \) vs HRA

b) Emergency patients

Values are medians with 25th and 75th percentiles in brackets

* \( p < 0.001 \) vs HRA
3.4 DISCUSSION

3.4.1 Nutritional status of the study group on admission

In the present study a 4 percent incidence of apparent malnutrition was identified in the elective (THR) patients and a 41 percent incidence in emergency (FNF) patients, on admission to two orthopaedic wards at the Royal Surrey County Hospital, based on patients having three or more abnormal values for specified anthropometric and biochemical values. It is clear from these findings that the emergency patients represent a more vulnerable group than the elective patients, in terms of nutritional status.

The use of the term "apparent malnutrition" is employed because there are no universally acceptable gold standard tests that conclusively establish the presence of malnutrition. Comparison with other studies presents further difficulties, because various and heterogenous hospital patient groups have been examined. Furthermore, some studies have reported incidence figures for malnutrition by taking the percentage of patients with only one abnormal parameter of nutritional status, (Seltzer et al, 1979; Thompson et al, 1984). In other studies, a minimum number of abnormal indices had to be present before that patient was considered to be malnourished, (Zador and Truswell, 1987).

Indeed, there are few published figures for malnutrition which might afford a direct comparison with those found in the present study. Although Jensen et al, (1982), determined the incidence of nutritional depletion in 129 orthopaedic patients undergoing surgical procedures, the average age of the patients was 41 years, (range, 17-79 years). However, it is interesting to note that the lowest incidence of nutritional depletion was identified in patients undergoing total hip-replacement surgery (28.6%) followed by the elective surgical group (35.3%) and then patients with multiple trauma and femoral fractures (58.6%). The figure for malnutrition quoted for total hip replacement surgical patients at 28.6 percent was much higher than the 4 percent incidence of malnutrition found in the present study. This may have partly been because the majority of data was collected postoperatively by Jensen et al, (1982) and not on admission as in the present study. Thus, low values for serum proteins in Jensen's study in the total hip replacement patients may have been due to the metabolic response to trauma.

Indeed, in another study of 84 patients admitted for elective surgery the level of malnutrition was 12 percent (Zador and Truswell, 1987). Patients in that study
were assessed within 48 hours of admission and only those who had two or more abnormal measurements, three or more borderline measurements, or one abnormal and two borderline measurements were considered malnourished. It is interesting to note that in a study of 82 orthopaedic patients by Dreblow et al, (1981), 39 patients (48 percent) had one or more abnormal indices but only 4 patients (5 percent) had three findings suggestive of protein-calorie malnutrition on admission. Of those examined 49 percent were admitted for elective surgery whereas 29 percent underwent a surgical procedure directly related to trauma. However, the mean age of this group was 52.2 years compared with a mean age of 77.7 years in the present study.

A more recent survey of nutrition was carried out on 501 elderly patients, newly admitted to long-term medical care, (Larsson et al, 1990). Protein energy malnutrition was defined as the presence of three or more abnormal parameters. Of the patients examined, 28.5 percent showed evidence of malnutrition on admission. This incidence of malnutrition is higher than was observed in the present study for patients admitted for elective surgery but is lower than that found in patients admitted for surgery for fracture neck of femur patients in whom the incidence was found to be 41 percent.

Thus, the differences in the figures for the incidence of malnutrition are likely to be due to a number of factors: variation in the clinical group, including age; social class of patients; nutritional parameters measured and the definition of malnutrition used; the use of different anthropometric norms and reference ranges.

As discussed, the incidence of malnutrition found in the present study is based on admission values only. A higher prevalence of malnutrition is often quoted in studies in which patients are assessed at some point during their hospital stay rather than on admission. When patients were grouped according to pre and post-operative status, Hill et al, (1977), found the highest incidence of malnutrition in those patients who had undergone major surgery more than seven days previously. Thus, if data from post-operative and long stay patients were included, the percentage of malnourished patients would probably have been higher in the present study.

Comparisons may also prove inconclusive because of the differing social circumstances of the various study groups. Patients recruited to the present study were drawn from areas not generally thought to be disadvantaged. Whilst patients varied in their social and living circumstances, none appeared to be
notably disadvantaged. In that sense, it was somewhat surprising to observe such a high incidence of malnutrition. Many other surveys (Bistrian et al, 1976) reporting a high prevalence of malnutrition, have also studied patients drawn from middle-class areas indicating that an adequate income is no guarantee of an optimal nutritional health. Many other factors can affect nutritional status, particularly in the elderly such as bereavement, physical or mental problems, and poor nutritional knowledge, irrespective of income. However, the findings of a study by Dickhaut et al, (1984), did indicate that a higher incidence of malnutrition was more likely to be found in hospitals which admitted patients from poorer areas.

As discussed, the way in which malnutrition is diagnosed varies from study to study and inevitably leads to widely fluctuating figures for the incidence of malnutrition. The use of only one abnormal index of malnutrition as the basis for publishing incidence figures in Dreblow’s study (1981) explains the high percentage of malnutrition quoted. Although in spite of using a number of tests in a study of 40 hip fracture patients a high incidence of malnutrition was still found on admission (Foster et al, 1990).

The discrepancies in the quoted prevalence of malnutrition may depend partly on the anthropometric and biochemical standards which are applied to data. Indeed, the application of anthropometric and biochemical values derived from studies of younger populations are inappropriate for elderly people leading to over-estimates of malnutrition, (Volkert, 1992). For these reasons care was taken in the present study to select appropriate reference ranges and to use rigorous cut-off points of the fifth percentile for each variable, when estimating malnutrition (Morgan et al, 1986).

However, an abnormality of any measurement used to assess nutritional status can be attributed to a number of causes other than poor nutrition. This further emphasises the importance of not using single tests to estimate malnutrition. The use of three or more abnormal values, as in the present study, should be encouraged but it is important to recognise that this may still not be adequate. For example, serum albumin concentrations are often depressed in the immediate post-operative period and in other clinical situations and so cannot be relied upon as an indicator of malnutrition. Low haemoglobin values may be the result of excessive blood loss during injury or surgery. Many workers criticise the use of anthropometric norms such as the triceps skinfold and mid arm muscle circumference as nutritional indicators because of their imprecision and because they may not reflect whole body nutritional status. These problems
were considered throughout the course of the present study and selection of the range of measures aimed to take account of this weakness.

Thus, whilst the parameters used to identify nutritional depletion in the present study can be criticised, they represent an improvement over other procedures which have been used for estimating malnutrition. Furthermore, the incidence figures derived from using this procedure clearly indicate the nutritional vulnerability of the emergency FNF patients compared with the THR patients. It should be emphasised at this point that the high risk group HRA, includes HRE patients and further that the HRA group is comprised of mostly emergency patients (13/14). Thus, HRA and HRE are not distinct and separate groups but rather HRE is a subgroup of HRA. This is an important point to consider throughout the discussion of results.

It should also be noted that patients from the HRA and HRE groups had significantly lower body weights, TSF, MUAC, MUAMC measurements and haemoglobin and serum albumin values. However, these differences were to be expected as these values were used in the risk allocation procedure. However, this did not apply in the case of mental function and handgrip strength, both of which were lower on admission in the high risk groups. A more detailed discussion of possible reasons for this finding are discussed below.

The other questions which logically follow from this discussion of the nutritional status on admission of patients in the present study relate to: how the nutritional status of the group changes during the remaining post-operative period in hospital and at home; whether indices of malnutrition are correlated with post-operative outcome. These points are discussed below, (Section 3.4.3 and 3.4.4).

3.4.2 Social and medical characteristics on admission

One of the aims of this study was to determine whether, in elderly orthopaedic patients, there are specific social and medical factors which might contribute to the poor nutritional status on admission.

In the emergency (FNF) patients identified as being high risk by the anthropometric and biochemical indicators applied on admission, a higher prevalence of social and medical factors known to be linked with poor nutritional status was found. These included a higher proportion of patients: living alone; unable to shop and cook for themselves; suffering depression; and with poor
dentition. These and other risk factors for malnutrition in the elderly have been identified by many other workers (Davies and Knutson, 1991). It should be noted here that some of the factors may themselves be a consequence of malnutrition. In a study of malnutrition in healthy adults where body weight was reduced by one quarter, besides the obvious loss of body tissue and muscle strength, subjects became depressed, apathetic, introverted and lost mental concentration, (Keys, 1950).

The most marked difference between the high and low risk nutritional groups was for the prevalence of a history of falls. The majority of patients in the high risk groups reported frequent falls, whereas this was the case for only a small minority of patients in the low risk groups.

The reasons for the markedly higher prevalence of frequent falls in patients categorised into high nutritional risk groups are not known at present. The data suggest that the factor(s) responsible for the increased tendency to fall in this group is also responsible for their poor nutritional status. It is also possible that poor nutrition is responsible for the increased tendency for falls in this group. The mechanism underlying the relationship between fall injury and nutritional status in the present group of patients requires further study. However, in a study of undernutrition, hypothermia and injury in elderly women by Bastow et al, (1983b), the incidence of fracture of the femoral neck was found to increase more during the winter months in undernourished elderly patients than in their normally nourished counterparts. The study also showed that the undernourished tended to suffer accidents indoors and to be hypothermic on admission, whereas the normally nourished had their accidents out of doors and were normothermic. These observations led to the hypothesis that chronic undernutrition might be associated with defects of thermoregulation, predisposing to hypothermia in the cold weather. Ataxia and diminished mental function might then result in an increased risk of accident. Certainly in this study there was a tendency for the high risk emergency fracture patients to be recruited in the months of January and February following indoor falls.

It has been suggested that a deficiency of thiamine with resultant confusion may be a factor contributing to the frequent occurrence of falls in the elderly, (Older and Dickerson, 1982). This observation is supported to some extent in this study in that the mental function scores on admission in the high nutrition risk groups were lower than in the corresponding low risk groups, although this only reached a level of significance in the HRA vs LRA comparison. It must therefore be remembered that HRA and LRA groups differ in their proportions of
emergency and elective patients. It could therefore be argued that this was in part due the circumstances of their fall. Goodwin, (1989), also found an association between nutritional status and cognition in a healthy, free living population with no evidence of either malnutrition or dementia. Low levels of vitamin C, B12, folate and riboflavin were associated with poor scores on tests of cognitive function in 270 healthy elderly. Relatively subtle changes in nutritional status therefore may be responsible for part of the decline in cognitive function seen in elderly populations and this in turn may lead to an increased tendency to fall. Conversely it may be that relatively small changes in cognitive function adversely influence nutritional status in elderly subjects.

These findings confirm those of other reports, in that those women who experience fractures of the hip are usually those people who are just managing to remain independent and self-sufficient, (Office of Health Economics, 1990).

The findings of the present study also suggest that a knowledge of certain social and medical data in combination with standard anthropometric and biochemical measurements would assist in the identification of patients requiring nutritional support.

### 3.4.3 Nutritional outcome following surgery

A distinguishing feature of this study was the long-term follow-up of patients. If changes in the nutritional status of patients are to be investigated fully, time is an important factor. Nutritional changes occur relatively slowly and so an investigation of the relationship between nutritional status and clinical outcome should span the likely recovery period.

The changes in the serial anthropometric measurements (TSF and MUAMC), suggest there are differences in the body compositional changes between the high risk groups, (HRA and HRE), compared with the low risk groups (LRA and LRE). The data obtained suggest that the high risk patients lose very little weight, but where weight loss does occur the losses appear to be due to loss of fat (as indicated by TSF measurements). Furthermore, the high risk patients did not regain fat, at least not during the 6 month follow-up period. The fact that there were no losses of MUAMC suggest that patients may be more resistant to losses of lean body tissue, losses of which are known to occur following surgery and be associated with reduced mobility.
On first consideration these data may appear to be the opposite of what might be expected i.e. greater weight and lean tissue losses in the more vulnerable low weight patients. It is suggested however that the resistance to lean tissue losses may reflect the adaptation to chronic malnutrition of the high risk patients. If this is the case then it appears that they are able to metabolise body fat to provide an energy substrate, whilst retaining protein (lean tissue) in order to maintain somatic structure and function. The opposite appears to be true in the low risk patients. The data suggest that the weight gained by low risk patients after discharge reflects a gain in body fat, rather than lean body mass. Thus, the low risk groups lose weight and then regain it, but the gains are made up of fat (TSF) and not muscle (MUAMC). These findings indicate that more work may be needed to compare how subjects of low or normal body weight respond to surgery and to examine the long-term effects of this on body composition. Further, it would be interesting to investigate whether body compositional changes following surgery are the same in adults of all ages, or whether the changes observed in the present study are specific to the elderly. If these changes in body composition were specific to the elderly this would have important implications in terms of the effects of repeated surgery and /or injury in the elderly. Indeed, this tendency to gain fat but not muscle after weight loss may further explain why various anthropometric standards have been found to be inappropriate for use with the elderly. Most importantly, the differences in anthropometric changes between groups of patients with different starting body weights observed in this study suggest that such patients may differ in the way they respond to injury and recovery. However, it must be noted that the tendency of the high risk groups to retain muscle mass may also be due, in part, to use of mobility aids such as frames and sticks for a longer period than the low risk groups. The use of such aids necessitates that the muscles in the upper arm are exercised and in the present study changes in body composition have been inferred from simple upper arm measurements. Clearly a larger study is required in which more specific measures of body fat and lean body tissue are employed to determine whether the changes observed are real and whether they reflect whole body changes or are simply a reflection of walking aid usage in these groups.

The determination of biochemical parameters such as serum albumin and retinol binding protein was carried out as part of the study, as circulating plasma protein concentrations may reflect body protein reserves. Changes in these values may help to explain the changes found in MUAMC described above. When all patients were considered together it was found that the LRA group showed a large negative change in serum albumin from admission to discharge.
This was much less marked in the HRA and HRE group and the LRE group showed no change at all. An important factor in the interpretation of these findings is the timing of the sampling of blood used for analysis. Blood samples were obtained on admission prior to surgery. As albumin levels are known to be depressed following injury or trauma, values in the emergency patients would be expected to be low when taken on admission prior to surgery. Furthermore, serum albumin determinations performed on bloods taken at discharge would be expected to be depressed, especially as the duration of stay in the acute hospital was only 17.5 days in the FNF group. Thus, it is not surprising that either only small negative changes or indeed none at all, were observed in the emergency patients between admission and discharge (HRE and LRE). In other words the serum albumin levels recorded at admission and at discharge would both be expected to be low, because the former would be affected by the injury and the latter by surgery. This is in marked contrast to the bloods taken from THR patients who had been admitted for planned elective surgery. The admission pre-surgical albumin values of these patients would be expected to be normal, whereas the discharge bloods would give values which reflected effects of recent surgery. The larger negative change found in the LRA group is explained therefore by the greater number of elective THR patients in this group. Because of these circumstances the extent to which the estimation of plasma proteins in this study might be expected to correlate with the changes in MUAMC observed from admission to discharge, is difficult to judge.

The albumin levels increasingly begin to recover in the LRA and LRE group although this is more marked in the LRE group from admission to 8 weeks and from admission to 6 months. This recovery was also observed in the HRA and HRE from admission to 6 months, but not from admission to 8 weeks when negative changes in serum albumin values were recorded. The recovery in serum albumin values seen in the low risk groups is not matched by increases in lean tissue (MUAMC). It is worth noting that the observation of nutritional and biochemical changes in the present study was only possible because of the length of follow-up which was undertaken with these patients. Very few studies to date have involved such a long-term follow-up after discharge, so that comparisons with other data are limited.

3.4.4 Clinical outcome following surgery

A primary aim of this Chapter has been to ascertain whether patients identified as being at high nutritional risk do less well in terms of their clinical outcome.
The present study monitored the clinical outcome of THR and FNF patients for a period of 6 months. Before proceeding with the discussion of results it should be noted however that some of the differences in clinical outcome found between HRA and LRA groups only (Table 3.9-3.14) are probably the result of differences in the proportions of the elective and emergency admissions within these risk groups (THR:HRA-1/14; LRA-27/46) and reflect clinical rather than nutritional differences.

However, the emergency (FNF) patients do represent an homogeneous clinical group and differences in clinical outcome such as convalescence time found between HRE and LRE groups are likely to reflect the different nutritional status found on admission. Therefore in this discussion more emphasis is placed on the likely significance of the clinical outcome differences between the LRE and HRE groups.

Of the high nutritional risk emergency patients (HRE), 25 percent died compared with 19 percent in the corresponding low risk group (LRE). The mortality observed in the two emergency groups therefore is not different. This compares with a mortality of 25 percent observed in FNF patients who, on admission, were described as being "very thin", (Bastow et al, 1983a). Similarly, Lockie, (1990), also found that around 25 percent of women with a fractured hip die within 6 months. Foster et al, (1990), reported that 12.5 and 27.5 percent of hip fracture patients had died at 3 and 11 months respectively. Cummings, (1985), found that 12 to 20 percent more die within the first year than might be expected on the basis of age alone and Melton, (1987), found that most of this excess mortality occurs in the first four to six months after the fracture. In another study of fractured neck of femur patients it was found that only 73 percent of those aged 75 and over at the time of the fracture were still alive after one year compared with that expected of 83 percent. However, it is difficult to estimate the relative contribution of hip fracture to mortality since hip fractures can in themselves be seen as an indicator of poor health. Indeed, women who experience fractures of the hip are usually those women who are only just managing to remain independent and self sufficient, (Office of Health Economics, 1990). Emergency hip fracture patients in the present study often had a variety of co-existing conditions, such as a recent history of falls indicating poor balance and muscular weakness. Further, the occurrence of the fracture itself may precipitate adverse events associated with trauma and stress.

It has been found that the longer the period spent on the floor following the fall the greater the likelihood of developing pressure sores and pneumonia, (Woolf et
Furthermore, dehydration and hyponatraemia after prolonged periods of waiting for help to arrive, together with existing anaemia and nutritional deficiencies render patients more vulnerable to the trauma of falling, (Foster, 1990). Emergency surgery, and the subsequent immobilisation in bed may be accompanied with increased risks of venous thrombosis and pulmonary embolism leading to higher mortality, (Melton, 1987). Although information regarding the length of time spent on the floor was not available in this study, of the women who died or were at high risk, many were being treated for chest and urinary infections, pressure sores, wound infections and ulcers. One patient died from a pulmonary embolism, following admission for clinical depression during which she sustained a broken ankle following a total hip replacement. Another patient also suffered from a venous thrombosis of the leg. The mortality observed in the group as a whole (including THR patients) was 23 percent in the high nutritional risk group in which the majority of patients were emergency admissions (HRA/FNF:13/14) and 9 percent in the low nutritional risk group in which the majority of patients were undergoing elective surgery (LRA:THR-27/46). It is therefore clear from this discussion that patients admitted for fractured neck of femur are more likely to suffer mortality in the 6 months following surgery.

Patients from the high risk emergency group had a significantly longer stay in convalescent hospital (28 days HRE vs 0.06 days LRE). Similar results to those above were obtained when both FNF and THR patients were considered together. There was no difference in the length of stay in the acute hospital between the high and low risk groups, (16.5;16 days HRA vs LRA; 18;17 days HRE vs LRE). It is difficult to make comparisons between these figures and those from other studies. For example, the OPCS, (1987) found that there were considerable differences in mean duration of stay for fractured neck of femur patients as hospital in-patients, between different regional health authorities in England and Wales, ranging from 20.9 to 35.8 days. However, in 1985 the mean duration of stay of women with FNF as hospital in-patients was 33 days in South West Thames Regional Health Authority, (OPCS, 1987). This contrasts to 18 and 17 days in the FNF groups (HRE vs LRE) in this study at a hospital in the same region. This may reflect a new policy to transfer patients requiring further rehabilitation to geriatric beds in convalescent hospitals, rather than keeping them in acute orthopaedic hospital beds which are much more expensive. In an analysis of the stages of care during hospital stay, the Working Party found that 10 percent of bed days were spent waiting a theatre session, 51 percent recovering from surgery without complications and 28 percent waiting to leave the orthopaedic ward, despite being declared medically and
surgically fit to do so. The findings in this thesis suggest that the THR patients were operated on the day of admission or on the following day. In the FNF patients there was a mean wait of 2 days in high risk group and 1 day in the low risk group. Also in the majority of cases patients were transferred to geriatric beds without delay following a period of hospital stay of 15-16 days.

Further savings could only be made therefore by reducing post-operative complications and by reducing the extended period spent in convalescent hospitals. In addition there are the costs of out patient appointments, community nursing and social services for hip fracture patients. The reduced quality of life for both the patient and their relatives should also be taken into account. Examining some of these issues the King's Fund Report, (1992), produced evidence that special care in feeding malnourished patients improves recovery rates, decreases complications, reduces length of stay and hence costs. They estimated that the cost of keeping a patient in hospital was £150 a day and that by ensuring proper nutrition of patients and thereby reducing the length of stay, a total saving of £266 million per year could be saved even taking into account the extra cost of supplements and the nursing care involved in their delivery.

This estimate assumes that provision of nutritional support is straightforward. Although nasogastric feeding of "very thin" FNF patients reduced the length of stay in hospital, (Bastow et al, 1983a), a significant number of patients in this study attempted to remove their feeding tubes. Furthermore, some physicians and nursing staff, consider nasogastric feeding invasive for old and frail patients. Additional energy and protein intake can also be achieved by the use of sip-feed supplements. Supplement drinks are only acceptable to a proportion of elderly people and long-term compliance to these products can only be achieved, however, when intake is closely supervised, (Williams et al, 1989; Driver et al, 1990). The improvement of oral food intake is likely to be more acceptable to the patient. However, in spite of good quality food being offered to patients in sufficient quantities, studies continue to show that the voluntary intake of many patients is still inadequate to meet their needs (Dickerson et al, 1985).

Obviously a reduction of the total stay in hospital and convalescence in the high risk groups from 44 and 45 days (HRA; HRE) to 19 and 30 days in the low risk groups (LRA;LRE) would provide enormous savings even though these represent geriatric bed costs. The extent to which nutrition could reduce the duration of stay in this particular group of patients and indeed in the other elderly orthopaedic patients is still unclear.
It is clear that patients in the high risk groups as well as having an increased duration of stay compared with low risk groups also have poorer mobility. Approximately half of the high risk group (HRE) were still using frames six months following surgery. Only 20 percent of the HRE patients were using no mobility aids at six months. Miller analysed the outcomes of 360 patients with hip fractures at 6 months following surgery; he found that only 51 percent of patients had returned to the ambulatory status they had enjoyed prior to surgery (1978). One year after the injury, not only had 27 percent of the patients died but 22 percent could not walk.

The loss of mobility observed in the present study has also been found to result in increased dependence on others and an increased probability of being admitted to an institution. Thus, although 46 percent of the high nutritional risk emergency patients (HRE), compared with 63 percent of the low nutritional risk patients (LRE) were admitted from their own homes, at six months only 7.7 and 31.6 percent (HRE vs LRE) had returned to them. Clearly the outcome of the LRE patients with regard to their ability to return to their own home is better than the HRE patients, but the extent to which nutrition is responsible for this is unknown.

Finally the ability of patients in the high risk group to function independently, and carry out normal activities of daily living was also reduced. Clearly, if patients were not able to walk properly their ability to undertake self care would be also compromised.

### 3.5 CONCLUSIONS

Of the twenty-eight patients admitted for total hip replacement surgery 4 percent were found to be malnourished compared with 41 percent of the thirty-two patients admitted for emergency surgery for fractured neck of femur. The incidence of malnutrition was therefore much more common in the emergency patients in the present study.

Comparisons regarding the incidence of malnutrition with that of other studies is not productive because of the variations in the patient groups and procedures used to assess malnutrition. This finding reinforces the need for a so-called "gold standard" of malnutrition to be agreed upon. However, the large difference in the incidence of malnutrition which was found between the emergency and elective patients reflects the greater vulnerability of the FNF
patients. It is recommended that procedures should be implemented to try to identify patients who would benefit from nutritional support.

Further support for this recommendation comes from the analysis of the social and medical admission data for the high risk groups (largely comprised of FNF) patients. The data confirm that the women who sustain fractures are often those who are only just managing to remain independent. The most marked difference observed between the low and high risk groups was for the prevalence of a positive history of falls in the high risk groups. Depression, living alone, unable to cook and shop and poor dentition were also more common. Such patients therefore appear to need greater community support if they are to remain independent.

Indeed, the nutritional and clinical course of the high risk patients in the present study indicates that women judged to be in poor nutritional status on admission: spend longer in hospital and convalescence; take longer to return to mobility and independence and in many cases are still unable to return to their own homes 6 months following surgery.

A most interesting finding of the present study, were the differences between the high and low risk groups in terms of changes in body composition. These changes were only observed because of the length of follow-up justifying the stated need to observe patients in the long-term. These data suggest that the low risk groups lose weight and then regain it as fat and not muscle. In contrast the high risk groups lose very little weight but when they do the losses are related to fat. Furthermore, the high risk patients did not re-gain weight at least up to 6 months. The fact that there were no losses in MUAMC measurements suggest that the high risk patients are more resistant to losses in lean body tissue. It is suggested that this may be due to adaptation to chronic malnutrition of the high risk patients. Another explanation for the high risk groups to retain muscle mass may be due to the prolonged use of walking aids. It is recommended therefore that a larger study is required to compare how subjects of low or normal weight respond to surgery and to examine the long-term effects of this on body composition.
CHAPTER 4

DEVELOPMENT OF A PREDICTIVE MODEL FOR DETERMINING INDIVIDUAL PATIENTS AT RISK OF POOR CLINICAL OUTCOME
4.1 INTRODUCTION

There has been much interest expressed in the need for accurate nutrition screening devices for specific groups of patients. Particular attention has been directed towards the use of nutritional markers as prognostic indicators of clinical outcome. A recent government report on the nutrition of elderly people recommended that parameters of nutritional status with prognostic significance in ill, elderly patients should be determined (DH, 1992). For some time certain measures of nutritional status have been identified as predictors of increased hospital morbidity and mortality secondary to protein calorie malnutrition in various patient groups, (Kaminski et al, 1977, Meakins et al, 1977). Studies such as these have increased the awareness of the prevalence and clinical effects of untreated malnutrition, as well as highlighting the need for the nutritional support of at-risk patients.

Elderly female orthopaedic patients represent a clinical group who can often require nutritional support. In the present study apparent malnutrition was found in a significant proportion of such patients on admission to hospital as described in Chapter 3. Forty-six percent of emergency fractured neck of femur patients (FNF), and 4.3 percent of total hip replacement patients were evidently malnourished. Malnutrition was identified in those women admitted with three or more abnormally low values for specified anthropometric and biochemical measurements. The patients in this study with abnormal values for weight, TSF and MUAMC, haemoglobin and serum albumin were those who were: older, usually living alone; suffering from a recent bereavement; needing help with shopping and cooking and reported to have had a history of falls, depression and poor dentition. Such observations have been noted by others such as Davies, (1990) who concluded that malnutrition in the elderly is as much a socio-economic as a medical problem.

The findings of the study described in Chapter 3 indicated that there are identifiable social and medical factors which predispose patients to nutritional risk. Hence, it might be expected that a knowledge of these factors, in conjunction with objective tests of nutritional status could be used to develop a
nutrition risk screening tool for elderly female orthopaedic patients. Such a tool would assist in the identification and treatment of malnutrition in this specific clinical group and thereby contribute to significant clinical improvements in terms of morbidity and mortality. In addition, nutritional depletion can, through an increase in complications, lead to the possibility of prolonged and expensive medical care. Chandra, (1985) reported that the elderly as a whole accounted for 25 percent of the total health care costs in the U.K., with a large proportion due to post-surgical complications, many of which are considered to be caused by malnutrition. In the present study poorer rates of recovery and longer convalescence times were observed in those patients considered to be at high nutritional risk. Therefore the identification and prevention of malnutrition is potentially an important treatment strategy of the hospitalized older adult, (DH, 1992). The aim of the study presented here was to develop a predictive equation for the identification of nutritionally at risk elderly females undergoing orthopaedic surgery.

Whilst it is known that nutritional status is an important determinant of operative morbidity and mortality, pre-operative identification of patients at increased risk is fraught with difficulties. Protein energy malnutrition is a complex patho-physiological process and as such, no proper definition of it exists. In an attempt to resolve this problem the values of various nutritional markers have been related to the incidence of adverse clinical events. For example, Dempsey et al., (1988), demonstrated that the effects of malnutrition are not just indicators of malnutrition, but are also linked to clinical outcome.

This introduction therefore considers the different approaches ranging from the use of single measures, three or more measures and multivariate models for defining the prevalence of malnutrition on the basis of outcome, and critically evaluates their usefulness in practice.

Numerous studies have defined various measures of nutritional status which, when abnormal, are statistically related to an increased morbidity or mortality in large series of patients, (Buzby et al, 1980). It could be said that the problem is not one of inadequate measures, rather it is the choice of the most appropriate nutritional marker for application in a particular clinical setting. However, there are two aspects to consider in relation to choice. Firstly, malnutrition may occur in conjunction with, or be secondary to, some other primary illness making it difficult to separate the relative impact of nutritional and non-nutritional factors on a particular measure. Indeed, this led McLaren, (1988), to suggest that the prevalence of hospital malnutrition has been over-estimated because particular nutritional markers have been used out of context. This is especially relevant to...
the elderly hospital population. Secondly, the choice of an appropriate nutritional marker(s) is difficult in the absence of any absolute criteria for defining malnutrition which would provide a standard against which to judge the sensitivity and specificity of nutritional indicators. The value of a diagnostic test lies in its ability to detect patients with protein energy malnutrition (its sensitivity) and to exclude those patients with satisfactory nutritional status (its specificity).

Before selecting appropriate marker(s) that are clinically applicable and acceptable, Buzby and Mullen, (1984), suggested the following as characterising the ideal marker for identifying protein calorie malnutrition:

- Consistently abnormal in patients with protein-calorie malnutrition, demonstrating high sensitivity
- Consistently normal in patients without protein-calorie malnutrition, demonstrating high specificity
- Nutrition specific, i.e. unaffected by non-nutritional factors
- Normalized by nutritional support and demonstrating high sensitivity to nutrition depletion.

As discussed above, non-nutritional factors can be a major variable affecting the interpretation and clinical relevance of nutritional markers. Hence, it is unlikely that any single marker would satisfy all four criteria. The critical evaluation of such markers is hampered further by poorly designed studies which have been used to evaluate nutritional support so that high sensitivity to nutritional repletion has not always been rigorously demonstrated (Taylor and Goodinson-McLaren, 1992).

Although there is no universal agreement as to which specific measures most accurately define protein-energy malnutrition, Buzby and Mullen, (1984), suggest the inclusion of at least the following parameters:

- Body weight, weight loss
- Static energy reserve (fat stores)
- Static protein reserve (muscle stores)
- Circulating protein status
- Immune status
In spite of the general acceptance that multiple measures of nutritional status are preferable, numerous single measures of nutritional status have been shown to have prognostic significance in various clinical situations.

Biochemical tests, for example, are traditional measures of nutritional status; depression of these measures during malnutrition has been well documented, and restoration with refeeding has been reported. A number of studies have demonstrated their potential value predicting, in the absence of disease, poor clinical outcome. Kaminski et al, (1977), observed that patients with a depressed serum transferrin (less than 170 mg/dl) on hospital admission, had a significantly increased risk of sepsis and a 2.5-fold increase in mortality. An almost five-fold increase in morbidity and a five-fold increase in mortality was observed in patients whose serum albumin levels were less than 3.5 g/dl, (Seltzer et al, 1979). Reinhardt et al, (1980) reported that albumin concentration has an inverse linear relationship to hospital mortality. However, serum albumin concentration is an example of a test which can be useful in diagnosing protein-calorie malnutrition in specific settings, but highly misleading results can be obtained where there is an acute inflammatory or injury response, (Carpentier et al, 1982).

Measurements of immune status, such as the delayed hypersensitivity skin test, as a criterion for malnutrition have been widely discussed. As a nutritional parameter it has been criticised because it is also affected by non-nutritional factors. However, malnutrition is associated with an increased incidence of skin test anergy and nutritional repletion may correct immunologic deficits. A greater mortality in anergic patients than in reactive patients, (74 percent versus 5 percent), was demonstrated in a large series of patients, (Meakins et al, 1977). In another study, patients with anergy had a significantly higher mortality than those with normal skin reactivity, (Harvey et al, 1981). In a study of elderly patients Ek et al, (1990), found that anergic patients had higher mortality and more pressure sores than the reactive group. Nutritional supplementation was associated with an increase in skin reactivity. In contrast, Forse et al, (1981), described an overlap in the response to the skin test between normally nourished and malnourished individuals and concluded that the skin test does not accurately assess an individual’s nutritional state, although it might be useful in epidemiological studies.

Other simple single measures of nutritional status have been shown to have high prognostic sensitivity, for example, low pre-operative body weight predicted death with a sensitivity of 88 percent, (Hickman et al, 1980), whilst abnormal
muscle function determined by handgrip dynamometry was 90 percent sensitive in predicting post-operative complications (Klidjian et al, 1982).

The use of specific measures of nutritional status as predictors of increased morbidity and mortality, secondary to protein calorie malnutrition in different patient groups, may appear convincing and certainly attractive. These studies appear to have provided an objective means of identifying groups of patients at increased risk of nutritionally based complications. However, they are only statistically valid for selected, large surgical patient populations and, as discussed by Forse et al, (1981) in relation to immunological tests, their use should probably be confined to epidemiological studies. Certainly clinical interpretation of these nutritional markers is difficult for individual patients. The clinical importance of an abnormal nutritional parameter in the presence of one which is apparently normal has not been clarified. The relative importance of individual nutritional markers has not been established, nor the actual magnitude of the risk they represent. A study by Mullen et al, (1979), examined the value of sixteen nutritional and immunological variables in predicting subsequent outcome in surgical patients. They found only three nutritional factors correlated with outcome, namely: serum transferrin, serum albumin and delayed hypersensitivity reactivity. Boraas et al, (1982), found that, in addition to serum albumin and serum transferrin, prealbumin and retinol binding protein were also useful in discriminating between patients who survived without complications and those who suffered complications and subsequently died, in an unselected population. Detsky et al, (1982), carried out a study involving the use of both objective and subjective assessments on fifty-nine surgical patients on admission and monitored their subsequent outcome in terms of post-surgical infection rate. They found no single objective measurement could statistically separate patients who were at high risk of infection from those at low risk. As well as questioning the validity of single measures as a means of assessing risk in a heterogeneous population, the particular problems in their use in an elderly orthopaedic group needs careful consideration. In addition the outcome measures used to evaluate the predictive power of nutritional assessment procedures require further evaluation. Almost without exception outcome has been measured in terms of those patients who died compared with those who did not. However, mortality may be due to non-nutritional causes. In other words, many nutritional predictors of outcome are really just morbidity predictors. Furthermore, as an outcome measure, mortality is limited. It would be more useful to monitor outcome measures which reflect the overall quality of life of the patient following surgery.
In summary, the conclusion of the above review is that no single test of nutritional status meets all the criteria proposed by Buzby and Mullen, (1984), as listed above. One of the major concerns is that non-nutritional factors are significant variables affecting possibly both the results of tests and their interpretation. Of course this does not imply that information is not needed on the adequacy of the patients diet and on those patients who require nutrition support. As Goode, (1981), suggested: "simple bedside impressions of nutritional status, or change with therapy are invariably erroneous and are to be deprecated". It is recommended that no single abnormal parameter is used in isolation, but rather in a combination of at least three parameters. The weaknesses inherent in using any single test are overcome by using several measures in combination, but caution should be employed in the use of standard reference tables of normal values and serial measurements.

Many workers have used three or more parameters to evaluate nutritional status. Ek et al, (1990), evaluated the nutritional state of 482 elderly patients newly admitted to a long-term medical ward. He assessed patients using anthropometry, serum protein analyses and the delayed hypersensitivity skin test in an attempt to investigate the correlation between anergy, malnutrition and clinical outcome. Protein energy malnutrition, (PEM), was defined as three or more subnormal criteria, one in each of the three categories of measurement. The prevalence of PEM was 28.5 percent and 38.5 percent when anergy was excluded as a criterion. PEM was more common in women and increased with age. Dreblow et al, (1981), found that patients with only three or more abnormal measurements or a serum albumin concentration of less than 3.5 g/dl had a longer than average hospital stay. The use of three or more parameters to evaluate nutritional status was used in the present study, (Chapter 3). Whilst this approach is useful for epidemiological studies of large groups of patients and offers an improvement over the use of single measures, as well as incorporating the use of relevant elderly reference data, it provides no means of quantifying risk for individual patients.

Mullen et al, (1979), acknowledged the need to develop a method to determine the magnitude of risk of nutritionally based complications. They developed a model (an equation) based on the simultaneous assessment of several nutritional markers thereby partially correcting for errors introduced by the insensitivity and/or lack of specificity of particular markers. In addition, defining malnutrition as a nutritional deficit which, when present, is associated with adverse clinical outcome, overcomes the lack of standard for diagnosing malnutrition i.e. a patient is malnourished if nutritional status affects clinical outcome.
In recognition of the need to include a variety of measurements and indicators, Mullen et al., (1979), constructed a multivariate prognostic nutritional index (PNI). In developing the PNI, 161 non-emergency patients admitted for major intra-abdominal or intra-thoracic surgery were assessed and their clinical course monitored until death or discharge. The following variables of nutritional status were measured on admission: anthropometrics; secretory proteins; immunologic function and personal data. Complications monitored included: death, septicaemia, intra-abdominal sepsis and fistula formation. The mean values of the variables measured on admission were compared in order to identify those variables which predicted outcome. A stepwise regression procedure was used to select the variables of most influence. These were found to be serum albumin, serum transferrin, triceps skinfold and delayed hypersensitivity. Discriminant analysis was then performed in order to construct a linear model relating risk of operative morbidity and mortality to baseline nutritional status as reflected by the four predictive variables. The number predicted by the model was referred to as a PNI. Patients at higher risk of morbidity and mortality were found to be those with a PNI of greater than 50 percent, where PNI was given by:

\[
PNI\% = 158 - 16.6(\text{ALB}) - 0.78(\text{TSF}) - 0.2(\text{TFN}) - 5.8(\text{DH})
\]

where:
- ALB is the serum albumin (g/dl);
- TSF is the triceps skinfold thickness (mm);
- TFN is serum transferrin (mg/dl);
- DH is delayed hypersensitivity skin test grading (Grade 0, non-reactive; Grade 1, 5mm reactive, Grade 2, > 5mm reactive);
- PNI is the risk of complications.

The validity and clinical effectiveness of the PNI was evaluated prospectively in several patient populations admitted for elective gastrointestinal surgery, (Buzby et al., 1980). The validity of the PNI in other clinical settings has also been evaluated. The model was useful in separating 100 cancer patients who underwent major non-emergency surgery, into high and low risk groups (Smale et al., 1979). However, whilst the PNI was found to be useful in predicting risk in patients undergoing elective surgery, this was not found to be the case in patients undergoing acute abdominal surgery, (Jones et al., 1983). Eisenberg et al., (1981), in a study of 46 critically ill post-operative patients found no significant difference between survivors and non-survivors for post-operative PNI values calculated within 48 hours of admission. These results demonstrate the
importance of evaluating the PNI prior to its application with patient populations which are substantially different from those in which the indices were originally developed.

Although much enthusiasm is expressed in the literature regarding the improved validity of objective measurements and outcome prediction using the PNI, it is apparent that a number of difficulties have arisen regarding its utility. Much of the work in relation to the PNI has been based upon selected populations of gastrointestinal surgical patients.

A further difficulty associated with the application of such a screening procedure is the acceptability and practicality of undertaking certain assessment procedures for individual patients within particular clinical groups. Social and medical data are rarely included in nutritional assessments primarily because they tend to be designed with a younger population in mind where acute illness rather than chronic ill-health, poverty and isolation is more often the major cause of malnutrition. The findings presented in Chapter 3 suggest that, for elderly patients, social and medical factors may be of greater significance. Furthermore, the collection of such data is relatively straightforward, avoiding invasive procedures, and therefore more acceptable to the patient. Nursing histories recorded on admission frequently include socio-medical data and therefore much of the data required might already be available from the notes.

The transferability of PNI models from one patient group to another clearly is limited. For example, PNI's derived from patients undergoing gastrointestinal surgery are likely to be inappropriate for predicting the outcome of elderly orthopaedic patients for a number of reasons. Body composition and biochemistry is affected by age as well as nutritional requirements. As mentioned previously social and medical factors may be of greater importance regarding elderly patients. In addition, the existing PNI's are based on simple and perhaps inappropriate clinical outcome criteria collected in the short term, such as mortality and post-operative infection rates which, by definition, restricts their potential usefulness. For example in the study by Mullen et al, (1979) patients were classified into three groups according to outcome: alive with no complications; alive with complications; and dead. Sullivan et al, (1990), in a study of 110 patients newly admitted to a geriatric rehabilitation unit, adopted a similar system for grouping outcome variables. Complications were classified into the following groups: death; any complication; major complications; any infectious complication; and major septic complications. However, in a retrospective analysis of the outcomes of 360 patients with
fractures of the hip, only 51 percent showed return to pre-injury ambulatory status; one year after injury 27 percent of the patients had died and 22 percent were non-ambulatory, (Miller, 1978). Foster et al., (1990), examined the outcome of 40 patients with hip fracture. At 3 months, only 37.5 percent of patients had returned to their premorbid ambulatory status; 42.5 percent had exhibited a deterioration in ambulatory status or independence; 12.5 percent had died; 7.5 percent were lost to the follow-up. Clearly in the elderly orthopaedic patient these are the measures which need to be considered when determining outcome. The multivariate analytical approaches used by various workers have not included outcome variables specifically related to mobility and independence even though they are important aspects of recovery in hip fracture patients. Another factor which was observed in the data reported in Chapter 3 is that women judged to be in poor nutritional health on admission stay longer in the acute hospital and have prolonged periods of convalescence.

In the present study an objective was the development of a predictive model (an equation) for female elderly orthopaedic patients using more appropriate outcome criteria as discussed above. It has been noted that many of the prognostic instruments have used infection as a major outcome variable and this again has usually been because the PNI’s are derived from gastrointestinal patients where abdominal sepsis is a major complication. However, infection was not observed to be a major complication of the present study (Chapter 3). Extended duration of stay, poor return to full mobility, lack of ability to self care and death following surgery were major complications of patients identified as being poorly nourished on admission.

The implication of the above is that in the development of a predictive model (or PNI) for use in elderly orthopaedic patients a more comprehensive and subtle set of outcome criteria based on an analysis of data collected in the long term was needed. A major limitation of other models is that patients’ well-being is usually studied for a relatively short period of time, e.g. until death or discharge in the case of Mullen’s study, (1979). It was felt that data gathered over a longer period of time following surgery would detect the less obvious effects of nutritional deficiencies which would not be apparent in the short term. As a means of achieving this aim a total outcome scoring procedure was devised based on the data presented in Chapter 3 and described below.

In response to these considerations further work was undertaken to tackle the limitations of PNI’s, such as those developed by Mullen et al, (1979), and in particular to develop a predictive model more applicable to the elderly female
orthopaedic population. The development of a clinically applicable, multiparameter model to identify patients at risk of nutrition related poor outcome was therefore undertaken. An important original feature of the present study was the use of key objective, clinical and anthropometric admission variables together with subjective data such as social/functional nutritional markers.

4.2 AIMS

The aims of this element of the research were as follows:

Stage I:

To determine the relative value of various nutritional and social/ medical admission markers in terms of predicting post-operative morbidity, mortality and restoration of previous functional abilities for elderly females undergoing surgery for total hip replacement or fractured neck of femur.

To develop a clinically applicable, multiparameter model able to identify elderly patients at increased risk of nutrition related complications following surgery, and to allow a quantitative estimate of this risk.

Stage II:

To validate this model using data collected in a further series of patients from the same clinical group.

4.3 METHODS AND STUDY POPULATION

The study was carried out in two Stages. Stage I involved the development and calibration of a multiparameter predictive model for elderly female orthopaedic patients. The validity of the model developed in Stage I was evaluated in the Stage II population.
4.3.1 Study group

In both Stages the study group comprised elderly female patients who were admitted to two orthopaedic wards at the Royal Surrey County Hospital (Guildford) for surgery for total hip replacement (THR-elective), or for emergency surgery for fractured neck of femur (FNF-emergency), (Table 4.1). All female patients over the age of 60 years admitted for hip surgery were eligible for recruitment into the study, with the exception of confused or senile patients. Ethical consent for the study was obtained from the Hospital Ethics Committee and all patients gave their consent to participate and to be visited for the purpose of long-term follow-up. Details of the patient groups in Stage I and II, are given in Table 4.1 and discussed below.

4.3.1.1 Stage I study group

Seventy three patients admitted on weekdays between January 1988 and December 1989 were assessed within 48 hours of admission and the subsequent clinical outcome monitored for a period of 6 months. The results of the follow-up of 60 of these patients have been presented in Chapter 3. Data from a further thirteen patients were subsequently obtained and were also included in the Stage I study group for the purpose of developing the model. Fifty-three percent of the 73 patients were admitted for emergency surgery for fractured neck of femur, whilst 47 percent were admitted for total hip replacement surgery.

4.3.1.2 Stage II study group

The Stage II study group comprised 22 patients admitted on weekdays between January 1992 and March 1992. These patients were assessed on admission and monitored for a period of 3 months. Fifty-nine percent of patients were admitted for surgery for fractured neck of femur and 41 percent for elective hip replacement. The proportion of patients admitted for elective and emergency surgery was similar therefore in Stages I and II of the study.
<table>
<thead>
<tr>
<th></th>
<th>Stage I (n = 73)</th>
<th>Stage II (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hip replacement (THR) (%)</td>
<td>47</td>
<td>41</td>
</tr>
<tr>
<td>Fractured neck of femur (FNF) (%)</td>
<td>53</td>
<td>59</td>
</tr>
</tbody>
</table>
4.3.2 Design of study

A summary of the overall study design is presented in Figure 4.1. The same experimental protocol was used in both Stages and is described in detail in Chapter 3 and summarised in Figure 3.1. However, it should be noted that Stage I patients were followed up for 6 months, whereas because of limitations on the part-time investigator’s time it was only possible to follow up patients in Stage II for 2-3 months.

4.3.3 Data collection

A number of admission parameters were examined in order to develop and test the model. These fall into two categories:

4.3.3.1 Stage I and II objective data

Admission measurements of anthropometric, biochemical and functional parameters were recorded. A detailed description of the methods used is presented in Chapter 2.

4.3.3.2 Stage I and II subjective data

A detailed history of social and medical factors was taken on admission. This established rapport with, and knowledge of patients. For the purpose of analysis a checklist of 20 questions, (SAS), was constructed covering risk factors known to affect the nutritional status of older people such as living conditions, social circumstances and psychological well-being. The number of positive responses formed the basis of the Subjective Assessment Score (SAS), (Appendix C, Figure 4.1). The logistics of the study dictated that the development of the predictive model be commenced prior to the full analysis of the data collected in Stage I of the study, (Chapter 3). Therefore, the subjective assessment score, (SAS), was based upon factors described above which were originally proposed by Exton-Smith, (1971). Interestingly these do not include some of the factors identified in Chapter 3 as being apparently related to nutritional status, namely: a history of recent falls, patient requires help with cooking, depression (other than major life events), and totally dependent upon others for meal provision. As discussed in Chapter 3, it is not known whether these factors are the cause or consequence of poor nutritional status and therefore it was felt that the scope of the SAS was sufficient for the purpose, but clearly there is a need for more detailed sensitivity analysis and revision.
Figure 4.1 Overall design of the study

STAGE I (n=73)

ADMISSION DATA

Nutritional assessment
Social/Medical history
Mental Function

↓

2-3 MONTHS

Clinical outcome data:
Mobility
Visick (ADL)
Duration of stay
Convalescence
Mental function
Mortality

↓

SIX MONTHS

Clinical outcome data (as above)

↓

TOTAL CLINICAL OUTCOME SCORE DERIVED

↓

TOTAL CLINICAL OUTCOME SCORES CALCULATED FOR STAGE I POPULATION

↓

DEVELOPMENT OF THE MULTIPARAMETER MODEL USING DATA DERIVED FROM STAGE I ADMISSION AND OUTCOME DATA

↓

STAGE II (n=22)

Admission Data (as above)

↓

2-3 MONTHS

Clinical outcome data (as above)

↓

TOTAL CLINICAL OUTCOME SCORES CALCULATED FOR STAGE II POPULATION

↓

VALIDATION OF THE MULTIPARAMETER MODEL
The admission data variables tested for their predictive power in the development of the model were as follows:

- age
- body weight
- triceps skinfold thickness
- mid upper arm circumference
- mid upper arm muscle circumference
- serum retinol binding protein
- serum albumin
- haemoglobin
- plasma creatinine
- white cell count
- handgrip strength
- mental function test
- subjective assessment score

4.3.3.3 Stage II - objective/subjective and clinical outcome data-deviations from the Stage I methodology

Although admission measurements of objective and subjective parameters were recorded and clinical outcome criteria monitored using the same procedures as in Stage I, a number of unavoidable differences in the experimental protocol did arise during the course of the Stage II data collection. These were as follows:

- the collection of blood samples on admission was dependent upon medical staff time and became unreliable, due to a change over of junior medical staff in the middle of recruitment. Serum albumin and retinol binding protein determinations could not be used as only 5/22 patients had pre-operative bloods taken;

- a number of subjects in Stage II "refused" to participate in the reading test (which forms part of the overall mental function test) affecting the total score achieved by some patients;

- the period of follow-up was only 2-3 months compared with 6 months in the Stage I study.
These deviations from the original protocol were an inevitable consequence of the part-time nature of the field work, but were not considered to be critical and are noted in the discussion.

4.3.3.4 Stage I and II - clinical outcome data and development of total clinical outcome score, (TCOS)

A range of clinical outcome criteria were monitored and recorded following surgery. Data were collected on:-

- mortality
- mobility
- activities of daily living (Visick score)
- duration of stay in acute hospital
- duration of stay in convalescence
- total duration of stay

The procedures for monitoring clinical outcome criteria listed above are described in Chapter 2. In an attempt to maximise the sensitivity, (ability to predict patients with poor clinical outcome), of the model, a Total Clinical Outcome Score (TCOS) was derived using the criteria listed above, (Figure 4.2). These clinical outcome criteria are particularly relevant to the clinical group being studied and extend the range of factors to reflect not only mortality but also quality of life in the clarification of poor and good outcome. Four indices of outcome were used to derive the TCOS with the highest weighting given to outcomes which were considered to reduce the quality of life. Mortality is the worst possible outcome and was accordingly given the highest weighting. The other scores were formulated as a result of discussions with an orthopaedic consultant surgeon and aim to reflect those outcomes most likely to compromise quality of life following surgery. However, it must be noted that the final scoring system was arrived at by arbitrary decision and no attempt has been made to validate it. The simultaneous use of four indices was used to give as complete a picture as possible in relation to outcome. Thus, the second highest weighting was given to a Visick score of four. The Visick score is a 6-point functional status tool used to assess independence and mobility of patients once they have returned home, as discussed in Chapter 2. A score of 4 is allocated to patients who are completely disabled, confined to bed or chair and unable to carry out any selfcare. The third highest score was assigned to patients who were using walking frames.
Figure 4.2 Total clinical outcome score

<table>
<thead>
<tr>
<th>MORTALITY (AFTER SIX MONTHS)</th>
<th>WEIGHTED SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>The patient died</td>
<td>30</td>
</tr>
<tr>
<td>The patient was alive</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOBILITY (AFTER SIX MONTHS)</th>
<th>WEIGHTED SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>The patient using frame</td>
<td>8</td>
</tr>
<tr>
<td>The patient using crutches</td>
<td>7</td>
</tr>
<tr>
<td>The patient using stick/s</td>
<td>6</td>
</tr>
<tr>
<td>The patient fully mobile</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACTIVITIES OF DAILY LIVING (AFTER SIX MONTHS)</th>
<th>WEIGHTED SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visick score of 4 or 5</td>
<td>10</td>
</tr>
<tr>
<td>Visick score of 3</td>
<td>8</td>
</tr>
<tr>
<td>Visick score of 2</td>
<td>6</td>
</tr>
<tr>
<td>Visick score of 1</td>
<td>4</td>
</tr>
<tr>
<td>Visick score of 0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONVALESCENCE/DURATION OF STAY</th>
<th>WEIGHTED SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total duration of stay greater than 40 days</td>
<td>10</td>
</tr>
<tr>
<td>Total duration of stay greater than 30 days</td>
<td>8</td>
</tr>
<tr>
<td>Total duration of stay greater than 20 days</td>
<td>4</td>
</tr>
<tr>
<td>Total duration of stay less than 20 days</td>
<td>0</td>
</tr>
</tbody>
</table>

Clearly some patients may use a frame but still be capable of self care. The combination of a score for mobility and Visick thus reflects this situation more accurately and indicates the overall quality of life.

This system was used to score subjects from Stage I of the study and the calculated outcome values were then displayed as a frequency distribution. Analysis of this distribution enabled a cut-off value to be determined for poor and good outcome, (Figure 4.3).
Figure 4.3  The frequency distribution of total clinical outcome scores from Stage I study group.
As indicated above the patients in Stage I of the study were thus divided into two groups, namely good and poor outcome, based on the histogram of the TCOS values, (Figure 4.3). A value of 17.5 was assessed as being a reasonable value above which outcome was judged to be poor and below which outcome was classified as being good. It was recognised that this classification is a simplification of the measure of successful outcome, but it was felt appropriate for this stage of the model development. Future work could focus on the prediction of a range of relative outcomes and a refinement of the definition of the TCOS.

Using the total clinical outcome score and applying the calculated cut-off point, patients from Stage I were divided into two groups: good outcome and poor outcome.

This grouping was used as the basis for carrying out the discriminant analysis so that the most predictive admission variables could be identified (in other words the admission measures which were seen to discriminate between good and poor outcome). A model was then developed relating clinical outcome to baseline admission data, where the outcome index obtained quantifies the risk of poor recovery for individual patients as described in 4.3.4 below.

4.3.4 The use of discriminant analysis in the development of the model

Discriminant analysis is a useful technique when data is classified into two groups, (good vs poor outcome) and one or more functions of quantitative measurements are required to help discriminate among the groups, (Klecka, 1990). The method is used for predicting which group a new case is most likely to fall into, and/or to obtain a minimum number of useful discriminating variables.

The aims of the discriminant analysis method can be summarised as follows:

- to arrange patients into one of two groups (in this case, good outcome vs poor outcome) on the basis of independent variables (in this case, admission characteristics);
- to identify which variables are most powerful in discriminating between groups and to develop a predictive model;
- to validate the accuracy of the model using the data from Stage II.
Discriminant analysis was used in order to develop a model which predicted the TCOS, or a value within an equivalent range, from a number of variables measured on admission. The particular technique was selected as it allows investigation of the differences between two or more groups of objects (patients in this case), with respect to a number of variables. The technique has been applied widely in the social sciences and in general terms allows the determination of:

- which variables are useful in predicting group allocation;
- how these variables should be combined mathematically to produce an equation to predict the most likely outcome;
- and the accuracy of the derived equation.

The variables adopted may be measurements or levels of support, (ie, scores) provided that:

- there are at least two groups;
- there are at least two cases per group;
- the total number of discriminating variables must be at least two less than the number of cases;
- no variable is derived from one or more other variable included in the model;
- the covariance matrices for each group should be approximately equal. This allows a simplification of the formulae used to calculate the discriminant function and certain tests of significance;
each group is drawn from a population with a multivariate normal
distribution with respect to the discriminating variables. Such a
distribution exists when each variable has a normal distribution
about fixed values on all others. This enables the precise
computation of tests of significance and probabilities of group
membership. Such a distribution may not be present in a small
sample size such as the one being studied. When the rule is
broken, the computed probabilities are not precise, but they are
still of value if interpreted with caution.

The following variables were confirmed as being normally distributed at the 5
percent significance level:

- age
- subjective assessment score
- body weight
- triceps skinfold
- mid upper arm circumference
- mid upper arm muscle circumference
- handgrip strength
- haemoglobin

Non-normally distributed variables included:

- mobility score
- duration of stay in acute hospital
- duration of stay in convalescence
- total duration of stay
- mental function score
- Visick score

From the summary it can be seen that not all the variables conformed with the
requirements of discriminant analysis. However, it was accepted by Klecka,
(1990), that when small samples are used it may not be possible to satisfy this
assumption. However, he indicated that, whilst the computed probabilities may
not be precise, if used with caution the results would still be useful. Therefore,
discriminant analysis was employed and interpreted in the light of the degree of
compliance with the underlying assumptions of the technique.
4.3.5 Comparison of Stage I and Stage II study groups - statistical methods

The data collected on admission and at the last visit (6 months in Stage I; 2-3 months in Stage II) were analysed to determine whether there were any significant differences between corresponding variables in Stage I and II study groups.

Initially the admission and final visit values were analysed using the Kolomogrov-Smirnov goodness of fit test to determine whether the distribution of the cases was normal for each parameter. Normally distributed values are represented by their means (SD); non-normally distributed variables by medians (with 25th and 75th percentile ranges).

Patients were then classified according to their expected outcome (good outcome vs poor outcome) by applying admission values to the derived model. Differences in clinical and nutritional outcome between the two groups were tested.

Differences in mean values were tested for significance by the Student t-test. Differences in median values between groups were identified by analysis of variance (Kruskal-Wallis) and their significance tested by Mann-Whitney U analysis. A result of $p < 0.05$ was taken as the level of statistical significance.

The prognostic significance of the model was ascertained by calculating the sensitivity, specificity and overall predictive value, (OPV), using the following equations:

\[
\text{Sensitivity} \ (\%) = \frac{\text{true positives (tp)}}{\text{tp} + \text{false negatives (fn)}} \times 100
\]

\[
\text{Specificity} \ (\%) = \frac{\text{true negatives (tn)}}{\text{tn} + \text{false positives (fp)}} \times 100
\]

\[
\text{OPV} \ (\%) = \frac{\text{tp} + \text{tn}}{\text{number of predictions}} \times 100
\]
4.4 RESULTS

4.4.1 Statistical analysis of admission characteristics of Stage I and II study groups

The admission variables: age, weight, triceps skinfold, mid upper arm circumference, mid upper arm muscle circumference, handgrip strength, mental function and haemoglobin for the Stage I and II study groups were analysed for all patients (Table 4.2). The purpose of this comparison was to establish whether the patients groups in Stages I and II could be judged as being drawn from a similar population.

There were no significant differences in the mean age of the two study groups [mean (SD) 77.9 (7.8) vs 78.2 (9.3) years]. The mean values for body weight were also similar [59.0 (13.2) vs 59.7 (13.3) kg]. Similarly there were no significant differences in anthropometric values: TSF [13.8 (5.1) vs 14.4 (5.2) mm]; MUAC, [29.1 (4.9) vs 27.4 (6.2) cm]; MUAMC [24.7 (3.7) vs 23.9 (4.3) cm]. The mean values for handgrip strength and haemoglobin also were not significantly different from each other [HGS: 3.4 (2.6) vs 3.0 (2.3) mm Hg; HB: 12.6 (1.8) vs 12.5 (1.7) g/dl].

However, there were significant differences in the median values for mental function scores between Stage I and II study groups [medians (25; 75 percentile) 100 (86.9; 100) vs 90 (70.0; 100.0) %]

Summarising, a comparison of the admission values of the mean and median values for age, bodyweight, haemoglobin, TSF, MUAC, MUAMC and handgrip strength indicated that the patients from Stage I and II were derived from a similar population group whereas there appeared to be significant differences in mental function between the two groups. As discussed in Section 4.5.2 the differences could be attributed to difficulties encountered with the reading test in Stage II.
Table 4.2 Admission values for age, body weight, triceps skinfold, mid upper arm circumference, mid upper arm muscle circumference, handgrip strength, mental function and haemoglobin in Stage I and II study groups

<table>
<thead>
<tr>
<th>Admission Data</th>
<th>Stage I (n=73)</th>
<th>Stage II (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>77.9 ± 7.8 (61 - 93)</td>
<td>78.2 ± 9.3 (61 - 92)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>59.0 ± 13.2 (36.8 - 90.3)</td>
<td>59.7 ± 13.3 (43.2 - 83)</td>
</tr>
<tr>
<td>Triceps skinfold thickness (mm)</td>
<td>13.8 ± 5.1 (6.2 - 28.4)</td>
<td>14.4 ± 5.2 (4.8-25)</td>
</tr>
<tr>
<td>Mid upper arm circumference (cm)</td>
<td>29.1 ± 4.9 (20.1 - 39.0)</td>
<td>27.4 ± 6.2 (11.2 - 37.9)</td>
</tr>
<tr>
<td>Mid upper arm muscle circumference (cm)</td>
<td>24.7 ± 3.7 (18.0 - 32.3)</td>
<td>23.9 ± 4.3 (16.6 - 30.1)</td>
</tr>
<tr>
<td>Handgrip strength (mmHg)</td>
<td>3.4 ± 2.6 (0 - 11)</td>
<td>3.0 ± 2.3 (0 - 8.1)</td>
</tr>
<tr>
<td>Mental function score %</td>
<td>100.0 (86.9; 100)</td>
<td>90.0* (70.0; 100)</td>
</tr>
<tr>
<td>Haemoglobin g/dl</td>
<td>12.6 ± 1.8 (6.5 - 18.1)</td>
<td>12.5 ± 1.7 (8.9 - 15.5)</td>
</tr>
</tbody>
</table>

* p<0.01 compared with Stage II

Note: Normally distributed data presented as mean ±SD (and range)
Data not normally distributed presented as medians (25th; 75th percentiles)
4.4.2 Statistical analysis of nutritional and biochemical characteristics in Stage I and II study groups at the final visit.

Mean and median values for nutritional and biochemical variables at the final visit for both study groups are presented in Table 4.3. There were no significant differences observed in weight, TSF, MUAC and MUAMC between the two groups. Significant differences were observed in handgrip strength and mental function at the final visit.

The mean values for weight [58.2 (13.2) vs 58.9 (16.9) kg]; TSF [15.9 (6.8) vs 13.6 (5.2) mm]; MUAC [28.4 (6.7) vs 27.8 (5.0) cm] and MUAMC [23.5 (3.0) vs 23.5 (3.5) cm] were not significantly different.

Significant differences were found in the mean values for handgrip strength [4.9 (3.6) vs 3.1 (2.3) mmHg] and in the median values for mental function [100 (98.9; 100) vs 95 (82.5; 100) %].

4.4.3 Clinical outcome of Stage I and II study groups

There was a mortality of eleven percent (8 patients) recorded in the Stage I study group after 6 months compared with five percent (1 patient) in Stage II after 2-3 months, (Table 4.4). The difference did not reach statistical significance and is probably due to the period of follow-up being shorter in Stage II.

The median values of the following outcome measures were not significantly different, (Table 4.4) for the duration of stay in the acute hospital [16 (7;44) vs 21 (14;59) days]; convalescence [0 (0;24) vs 7 (0;31) days] and total time in hospital [22 (15;44) vs 21 (14;59) days]. However, there was a large difference in the median values of the duration of stay in the acute hospital and in the variability as shown from the percentile values. This is probably a reflection of the small sample size of the Stage II study group.

Finally, Table 4.4 also shows that 30 percent of patients in the Stage I study were not able to return home at 6 months (final visit), whereas 45 percent of patients in the Stage II study group had not returned to home 2 to 3 months following surgery (final visit). The difference in the length of the follow-up period negates comparison; however there was no significant difference between the two groups in this respect.
Table 4.3 Nutritional and biochemical values for body weight, triceps skinfold, mid upper arm circumference, mid upper arm muscle circumference, handgrip strength and mental function at the final visit for Stage I and Stage II study groups

<table>
<thead>
<tr>
<th></th>
<th>Stage I (n=73)</th>
<th>Stage II (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>58.2 ± 13.2</td>
<td>58.9 ± 16.9</td>
</tr>
<tr>
<td></td>
<td>(37.7 - 92.2)</td>
<td>(22.2 - 85.5)</td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>15.9 ± 6.8</td>
<td>13.6 ± 5.2</td>
</tr>
<tr>
<td>thickness (mm)</td>
<td>(5.8 - 36.3)</td>
<td>(2.9 - 21.3)</td>
</tr>
<tr>
<td>Mid upper arm</td>
<td>28.4 ± 6.7</td>
<td>27.8 ± 5.0</td>
</tr>
<tr>
<td>circumference (cm)</td>
<td>(20.0 - 41.0)</td>
<td>(18.1 - 36.8)</td>
</tr>
<tr>
<td>Mid upper arm muscle</td>
<td>23.5 ± 3.0</td>
<td>23.5 ± 3.5</td>
</tr>
<tr>
<td>circumference (cm)</td>
<td>(16.9 - 30.0)</td>
<td>(17.2 - 30.1)</td>
</tr>
<tr>
<td>Handgrip strength</td>
<td>4.9 ± 3.6</td>
<td>3.1 ± 2.3*</td>
</tr>
<tr>
<td>(mmHg)</td>
<td>(0 - 12.5)</td>
<td>(0 - 7.9)</td>
</tr>
<tr>
<td>Mental function score</td>
<td>100.0</td>
<td>95.0**</td>
</tr>
<tr>
<td>(%)</td>
<td>(98.9; 100)</td>
<td>(82.5; 100.0)</td>
</tr>
</tbody>
</table>

* p<0.01; ** p<0.005 compared with Stage I

Note: Normally distributed data presented as means ±SD (range)

Data not normally distributed presented as medians (25th; 75th percentiles)
Table 4.4 Clinical outcome of Stage I and Stage II Study groups for mortality, duration of stay in hospital, and convalescence and return to home

<table>
<thead>
<tr>
<th></th>
<th>Stage I (n=73)</th>
<th>Stage II (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality %</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Duration of stay in acute</td>
<td>16 (7; 44)</td>
<td>21 (14; 59)</td>
</tr>
<tr>
<td>hospital (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of stay in</td>
<td>0 (0.0; 24)</td>
<td>7 (0; 31)</td>
</tr>
<tr>
<td>convalescence (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time in hospital</td>
<td>22 (15; 44)</td>
<td>21 (14; 59)</td>
</tr>
<tr>
<td>(days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients not able to return</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>to own home (%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4.4 Development of a predictive model

From the Stage I data it was found that the following variables (of those which were practical to use) were most powerful in terms of predicting poor outcome. These are listed below in order of their relative influence on the prediction model:

- age
- mental function test
- haemoglobin
- handgrip strength
- triceps skinfold measurement
- subjective assessment score (SAS)
- mid upper arm circumference

Other variables tested had no influence on clinical outcome and did not increase the predictive power when included in the model. It was found from the Stage 1 data that some factors were more closely related to nutritional status and clinical outcome, while others did not significantly discriminate nutritional risk as determined by body weight, serum albumin and haemoglobin. The questions found to be most useful were combined to form a simple tick-list questionnaire called a subjective assessment questionnaire, (SAS), described in Appendix C, Figure 4.i. This approach was developed further and the number of positive responses recorded to give a subjective assessment score (SAS). The score for individual patients projects a measure of subjective indices of risk.
A discriminant function was derived using the SPSS-PC statistical package, using the cut-off point, previously described for the TCOS. The value predicted by the equation is defined herein as the Prognostic Outcome Index (POI):

\[
\text{POI} = 0.000121 \times (\text{SAS})^3 - 0.000242 \times (\text{MFT})^2 - 0.091508 \times \text{HB} + 0.000008 \times (\text{AGE})^3 - 0.115735 \times \text{HGS} + 0.000500 \times (\text{MUAC})^2 + 0.041050 \times \text{TSF} - 1.107360
\]

Where:

- \text{SAS} = \text{subjective assessment score on admission}
- \text{MFT} = \text{mental function test score on admission (\%)}
- \text{HB} = \text{haemoglobin value on admission (g/dl)}
- \text{AGE} = \text{age on admission (yrs)}
- \text{HGS} = \text{handgrip strength on admission (mmHg)}
- \text{MUAC} = \text{mid upper arm circumference on admission (cm)}
- \text{TSF} = \text{triceps skinfold measurement on admission (mm)}

The range of the POI was set between -4 and 4, i.e. equivalent to 0-30. The division point for indicating "poor" or "good" outcome (outcomes rated with respect to the total weighted outcome score) was set at +0.26 equivalent to 17.5 in the 0-30 range. A patient obtaining a value greater than 0.26 would be predicted to have a poor outcome in the long term. Conversely patients with an index of less than 0.26 would be predicted to have a good long-term outcome.

The value of a predictive model lies in its ability to detect patients whose outcome is likely to be poor, (its sensitivity) and to exclude those whose outcome is subsequently good (specificity) as well as the overall predictive value, (OPV), as defined in Section 4.3.5. These indices were calculated by
identifying patients whose outcomes had been misclassified i.e. those patients whose actual outcome differed from that predicted, (Table 4.5).

A summary of the admission values used in the model to predict outcome for individuals is given in Appendix C, Table 4.ii. Similarly, the outcome variables used to calculate the Total Clinical Outcome Score for patients is given, together with the predicted and actual outcome, in Appendix C, Table 4.iii. Using this information it was possible to determine the sensitivity, specificity and overall predictive value of the model when applied to the Stage I data. The sensitivity of the model was 89 percent, the specificity 91 percent and the OPV 89 percent, (Table 4.6). The model accurately predicted the long-term outcome of 89 percent of the patient group and falsely predicted poor outcome for only 9 percent of patients.

4.4.5 Validation of the model using data from Stage II study group

Using admission variables and those at the final visit the predicted outcomes were calculated. These data and the "actual" outcomes are presented in Table 4.7. When applied to the Stage II data the model was found to have a sensitivity of 100 percent, a specificity of 60 percent and OPV of 73 percent, (Table 4.8). The model had accurately predicted poor outcome in all patients whose outcome was subsequently found to be compromised, but it had falsely predicted poor outcome in 40 percent whose outcome was in fact good. The overall predictive value of the model was found to be 73 percent. The summaries of admission and outcome values used to calculate individual scores are presented in Appendix C, Tables 4.iv and 4.v.
<table>
<thead>
<tr>
<th>STAGE I</th>
<th>ADMISSION VARIABLES</th>
<th>FINAL VISITS VARIABLES</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Number</td>
<td>SAS</td>
<td>MFT</td>
<td>AGE</td>
</tr>
<tr>
<td>1</td>
<td>5.5</td>
<td>96*</td>
<td>82</td>
</tr>
<tr>
<td>4</td>
<td>3.0</td>
<td>22*</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>8.0*</td>
<td>52*</td>
<td>69</td>
</tr>
<tr>
<td>14</td>
<td>6.0</td>
<td>100</td>
<td>93*</td>
</tr>
<tr>
<td>33</td>
<td>4.0</td>
<td>100*</td>
<td>78*</td>
</tr>
<tr>
<td>34</td>
<td>4.0</td>
<td>87</td>
<td>75*</td>
</tr>
<tr>
<td>37</td>
<td>4.0</td>
<td>100</td>
<td>86*</td>
</tr>
</tbody>
</table>

* Variables most likely to cause misclassification
Table 4.6  Sensitivity, specificity and overall predictive value of the model: Stage I

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity %</strong></td>
<td>( \frac{\text{true positives (tp)}}{\text{tp + false negatives (fn)}} \times 100 )</td>
<td>89%</td>
</tr>
<tr>
<td></td>
<td>( \frac{24}{24 + 3} \times 100 = 89% )</td>
<td></td>
</tr>
<tr>
<td><strong>Specificity %</strong></td>
<td>( \frac{\text{true negatives (tn)}}{\text{tn + false positives (tp)}} \times 100 )</td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td>( \frac{39}{39.4} \times 100 = 91% )</td>
<td></td>
</tr>
<tr>
<td><strong>Overall predictive value %</strong></td>
<td>( \frac{\text{tp} + \text{tn}}{\text{no. of predictions}} \times 100 )</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td>( \frac{24 + 39}{71} \times 100 = 73% )</td>
<td></td>
</tr>
</tbody>
</table>
**Table 4.7  Misclassifications: Stage II patients whose predicted outcome (using model) differed from the actual outcome (observed)**

<table>
<thead>
<tr>
<th>Case</th>
<th>ADMISSION VARIABLES</th>
<th>FINAL VISIT VARIABLES</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAS</td>
<td>MFT</td>
<td>AGE</td>
</tr>
<tr>
<td>7</td>
<td>6.0</td>
<td>80*</td>
<td>77</td>
</tr>
<tr>
<td>8</td>
<td>7.0*</td>
<td>70*</td>
<td>81*</td>
</tr>
<tr>
<td>12</td>
<td>11.0*</td>
<td>90</td>
<td>82*</td>
</tr>
<tr>
<td>18</td>
<td>5.0</td>
<td>70*</td>
<td>78</td>
</tr>
<tr>
<td>20</td>
<td>8.0*</td>
<td>70*</td>
<td>88*</td>
</tr>
<tr>
<td>21</td>
<td>10.0*</td>
<td>100</td>
<td>85*</td>
</tr>
</tbody>
</table>

* Variables most likely to cause misclassification
Table 4.8 Sensitivity, specificity and overall predictive value of the model: Stage II

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>OPV %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\frac{tp}{tp + fn} \times 100$</td>
<td>$\frac{tn}{tn + fp} \times 100$</td>
<td>$\frac{tp + tn}{\text{no. of predictions}} \times 100$</td>
</tr>
<tr>
<td></td>
<td>$\frac{7}{7 + 0} \times 100 = 100%$</td>
<td>$\frac{9}{9 + 6} \times 100 = 60%$</td>
<td>$\frac{7 + 9}{22} \times 100 = 73%$</td>
</tr>
</tbody>
</table>
4.5 DISCUSSION

A predictive outcome model capable of achieving a high overall predictive value has been developed. Calibration and validation were done using two independent, but similar, patient groups. The model represents a significant improvement over previous work in that, in addition to anthropometric values, it takes into account important non-nutritional variables such as age, mental function, and social medical factors, all of which significantly affect outcome in the clinical group studied.

The sensitivity of the model was 89 percent in the Stage I study group. This degree of accuracy could be expected as the model had been developed on data drawn from this group. Similarly the specificity of the model was also good; only 9 percent of patients were incorrectly predicted to have a poor outcome when in fact they had a good outcome. The OPV is high at 73 percent. This indicates that the model is a very powerful test comparing well with similar models. For example, Leite et al, (1987) found a sensitivity of 72 percent for the PNI using a cut-off of more than 20 points compared with a sensitivity 78 percent using 40 points as the cut-off (Buzby et al, 1980). The sensitivity and specificity of the predictive outcome model is also greater than those recorded for single nutritional tests related with post-operative complications.

In the second population, (Stage II), the instrument was strongly sensitive (100 percent) but not as specific (60 percent). Forty percent of patients were predicted to have a poor outcome when in fact outcome was good. The most likely reason for this finding was that outcome was only evaluated up to 8-12 weeks. If the period of follow-up had been longer, (i.e. 6 months), the condition of patients might have improved and the test would not have predicted so many false positives.

This reduction in the percentage of cases accurately predicted is also expected as the model was being tested on a similar but nevertheless different population within the same type of patient cohort. In general this level of accuracy is encouraging and compares favourably with that of other predictive models. However, whilst some indication of the validity of the model has been obtained it is acknowledged that a larger and more rigorous validation study is required using data from patients followed up for 6 months.

The model fulfils certain of the criteria needed for an ideal marker of PEM as laid down by Buzby and Mullen, (1984), and it overcomes two major problems
experienced in the interpretation of single markers. Thus, the simultaneous use of seven values must go some way towards correcting for errors introduced by the insensitivity and lack of specificity of single values. By including a number of indicators these may reflect various aspects of the nutritional status, have different latent periods, and are influenced by differing factors. Furthermore, by defining malnutrition as a nutritional deficit which when present is associated with adverse clinical outcome has overcome the lack of standard for diagnosing malnutrition. With regard to the former point it could be argued that to have developed a model containing seven variables has reduced its acceptability. However, although the PNI developed by Mullen et al, (1979) requires that only albumin, transferrin, TSF and delayed hypersensitivity need to be measured, nevertheless these tests are much more invasive, potentially costly to administer and require clinicians to undertake the screening. The interesting point about the model developed in this study is that many of the seven parameters are in fact non-nutritional so that it may be argued that the model is not a nutritional index at all. Indeed, Buzby and Mullen, (1984) have suggested the inclusion of body weight, fat stores, muscle stores, circulating protein status and immune status be included in the definition of PEM. However, as discussed already, this model was developed for a very different population for whom some of these values such as body weight are difficult to measure whereas the subjective assessment score is easy to measure and probably reflects nutritional status just as well. It should be noted that the model developed is non-linear compared with other similar PNI’s, (Buzby et al, 1980). In addition, it could be argued that the PNI of Mullen et al, (1979), which includes two serum protein measures may also be strongly affected by non-nutritional factors which cause abnormal serum protein values.

As discussed above the sensitivity and specificity of this model compares well with other similar models. Katelaris et al, (1986), studied the predictive ability of a battery of nutritional measures, including the PNI and clinical assessment by surveying patients admitted for elective surgery. Using a value of 30 percent the PNI was the most sensitive test, correctly identifying 83 percent of patients who suffered major complications while maintaining a specificity of 73 percent. Clinical assessment however, identified only 50 percent of the patients who subsequently had major complications although they did this with higher specificity (89 percent), (Katelaris et al, 1986). Similarly, Pettigrew et al, (1984) only achieved a sensitivity of 50 percent for clinical assessment and at the same time showed that surgeons of different experience had different ability at predicting post-operative morbidity. Furthermore, the subjective nature of clinical assessment makes it an unsatisfactory method for selecting patients for
nutritional support according to Katelaris et al, (1986). In spite of these findings clinical assessment remains the oldest, simplest, and probably the most widely used method of nutritional status and preferred by some workers. For example, Detsky et al, (1984), compared seven techniques of nutritional assessment in terms of their ability to predict a nutritional associated complication. The best combination of sensitivity (82 percent) and specificity (72 percent) was achieved using clinical or subjective global assessment. However, the second best combination (88 percent and 45 percent) was found by using either the PNI or creatinine-height index. Volkert et al, (1992) also conclude that clinical judgement is of great value for the assessment of malnutrition in geriatric patients and that clinical assessment was a better predictor of 18-month mortality than all other commonly used nutritional parameters. A criticism of stepwise techniques of analysis relates to the problem associated with individual objective measurements found to be highly correlated with each other. This can lead to some parameters being dropped inappropriately from equations when they may have important effects. Furthermore, the precision with which the weightings can be estimated can be low according to Baker et al, (1982). This has lead workers to believe that the use of PNI’s for both prediction and inference is flawed due to the likelihood of finding correlation among objective measurements, (Baker and Detsky et al, 1982). However, this problem was not encountered in the present study as none of the parameters examined and subsequently used in the equation were correlated with each other (see correlation matrix Appendix C Table 4.vi). However, it is still interesting to note that the most frequently used indicators of nutritional risk or depletion used by nurses are also those obtained in direct contact with patients that is, the indicators obtained visually. Using this approach nurses identified 46 percent of patients as malnourished compared with 76 percent when specific criteria were applied, (Collinsworth and Boyle, 1989).

4.5.1 Prognostic variables and the model

In the development of the predictive model, all objective and subjective variables of nutritional status were examined for discriminating power. The most discriminating admission variables were in order of their relative influence: age, mental function, haemoglobin, handgrip strength, triceps skinfold, subjective assessment score and mid upper arm circumference in order of their correlation with outcome.

Age is easy to record and was found to be the most powerful discriminator of outcome, more than all other admission parameters investigated. This illustrates
the difference between a model derived from elderly subjects and one developed specifically for gastrointestinal surgical patients such as the PNI, (Mullen et al, 1979) which did not even include age as a variable. Indeed, Miller, (1978), found age and pre-operative cerebral dysfunction increased the probability of death and non-ambulation in a study of 360 patients with hip fracture.

It was interesting to find that Mental Function was the second most influential variable in determining outcome. However, this was of some concern as significant differences were observed in the Stage I and II study groups as discussed below. Also of importance was that the score was not normally distributed, thus violating one of the conditions of the discriminant analysis procedure and therefore leading to a reduction in the confidence in the results. It should be noted that it was not expected that the MFT scores would be normally distributed given the nature of the test. Further as discussed in the introduction to discriminant analysis Section 4.3.4 non-normality of the data does not completely invalidate the method. MFT was found to be responsible for a number of the mis-classifications of outcome. However, omitting MFT from the model resulted in a dramatic loss of discriminative power. For these reasons it remained as a admission variable despite its problems. It is also interesting that the findings of Chapter 3 showed that a low MFT and the tendency to fall was strongly linked with nutritional risk.

Haemoglobin, HGS and TSF were the next most discriminating variables. They are all objective measures with normal distributions and were therefore considered to be reliable admission variables. This assumption was confirmed on examination of the mis-classification of patients which showed they played little part in the wrongly grouped cases. Haemoglobin is also routinely recorded prior to surgery and values are easily available in patients’ notes at no extra cost.

In the case of TSF, whilst it was included in this model it is interesting to note that it played a much less important role than in the PNI developed by Mullen et al, (1979). This illustrates the distinctive nature of PNI’S with respect to specific clinical groups.

Subjective assessment criteria were found to discriminate outcome confirming the view that the social and living circumstances of older people reflect nutritional status and therefore relate to poor outcomes following surgery.
The least discriminating admission parameter of those include in the model was MUAC and was similar to other anthropometric variables in that it was objective and showed a normal distribution. Furthermore, it appeared to exert very little influence over misclassifications in either study.

Although creatinine and white cell counts are carried out routinely on admission these variables unlike haemoglobin did not prove to be discriminating.

The most interesting factor to emerge from the discriminant analysis of admission variables is that the dominant predictive factors were largely "non-nutritional" and therefore it could be said that these were acting as general predictors of risk. However, the interrelation between nutritional status, primary disease, morbidity and mortality is complex, multifactorial and analytically difficult according to Buzby et al. (1980). Non-nutritional factors undoubtedly play a role in the development of morbidity and mortality. However, it is difficult to define and separate the relative importance of nutritional and non-nutritional factors, (see section 4.5.5.).

4.5.2 Differences between the Stage I and II patient groups

Ideally the calibration and validation of the model should be based on two similar, but independent sets of data. Indeed, any statistical model strictly is only applicable within the range of data upon which it was developed. Comparison of the two study groups established that patients were drawn from a similar population and further the Stage I and II study groups, comprised the same proportion of emergency and elective patients. No significant differences were found in age, weight and other anthropometric variables or in haemoglobin and handgrip strength measurements. However, significant differences were found in the results of the mental function test. This is attributed to the fact that some patients, particularly in Stage II, were resistant to completing the reading list section of the test. Variations in the degree of cooperation between the two groups and the relative sizes of the groups themselves are thought to be the main reasons for the difference.

Small differences in the two patient groups were to be expected and indeed it could be argued that this might constitute a better test of the model.

In view of the importance of the MFT in model is it clear that in any future work particular care must be taken to ensure the reliability and consistency of this
test, and if necessary modify it in order to make it more acceptable to the patients.

A further point which should be noted relates to the homogeneity of the study groups. Patients admitted for emergency hip surgery may be at greater risk of poor outcome than those admitted for total hip replacement. In other words, the emergency and elective patients may represent different clinical groups. However, if either of the groups had been omitted it would not have been possible to recruit sufficient patients for the study. It was hoped that the difference would not interfere greatly with the development of the model. Nevertheless, the difference between admission types is a factor which should be taken into consideration in interpreting the results. Had it been possible to include a far greater number of participants in the study a separate model could have been developed for the emergency hip surgery patients and the total hip replacement patients. The benefits of separate models could then be assessed.

As stated in the results, there were no significant differences between the two study groups in terms of mortality, duration of stay in hospital or convalescence or in the number of patients who had been able to return home by the final visit.

4.5.3 Total clinical outcome score

In previous studies involving the development of PNI's, outcome has been measured in terms of mortality and infection rates. These factors might be of over-riding interest to the clinician, but the patient may have other concerns, such as an improvement in the quality of life following surgery particularly in relation to their ability to walk without pain and being able to carry out everyday activities. In an attempt to remedy the restrictive approach of previous PNI’s the TCOS was developed using a more comprehensive set of criteria to reflect quality of life, namely: mortality; mobility; activities of daily living (Visick score); and total duration of stay. It is particularly important that for the patients in this study these outcome criteria are relatively easy to measure.

Mortality is considered to be the worst possible outcome and is accorded the highest score. Furthermore, it is firmly diagnosed and always recorded. However, it should be noted that mortality may have nothing to do with surgery or the nutritional status of the patient. Thus, the actual cause of death is often unknown or disputed and it may well be a reflection of underlying disease, social, economic, environmental or personal factors or simply old age which are independent of nutritional status.
Much emphasis has been placed on a consideration of the quality of life in the development of the TCOS. It could be argued however that there are many other factors which reflect the quality of life. Depression, for example will have a profound effect on recovery and on the desire to eat. However, a depression rating was not included in the outcome score because such psychological tests were beyond the resources of the study, although a mental function test was performed. Thus, malnourished patients become depressed, anxious, irritable, apathetic, introverted and lose mental concentration, (Keys et al, 1950) leading to a vicious circle of reduction in food intake. Indeed, evidence exists that there is a significant relationship between depression and poor survival prognosis in severely traumatised patients and that cognitive training improves the rehabilitation of elderly female orthopaedic patients, (Gunther, 1991). The apathy and lethargy which result from depression inevitably influence the time taken to mobilise.

Morbid complications were not incorporated into the TCOS. Pulmonary complications for example remain the most important cause of post-operative morbidity and mortality. Although the incidence of pneumonia after operations outside the chest and abdominal cavity is said to be negligible it is also noted that respiratory complications are of importance in older patients and in those with malnutrition (including obesity), chronic respiratory disease, a history of smoking and who have had an anaesthetic lasting longer than 2 hours, (Windsor and Hill, 1988).

The scoring of outcomes as well as the incorporation of particular outcome measures into the TCOS were formulated as a result of careful thought and informed judgement. Hence, any TCOS is inevitably subjective. As no established systems are in place to evaluate outcome for elderly female orthopaedic patients, there is no means of comparing the present system with others for determining its suitability.

In this study only two categories of outcome were used, namely good and poor. Whilst this was felt to be appropriate for the initial development of the model it was recognised that refinements could be made in the model by adopting more categories of outcome. This would be possible with the techniques employed although a larger group of patients would be required. Future developments should consider the desirability of having more grades of outcome and the implications regarding the required patients numbers.
Whilst the TCOS was designed to facilitate the separation of the long-term outcome into good and poor, it could also find application in the medical audit of female orthopaedic hip surgery patients.

4.5.4 Clinical applicability of the model

The prime consideration when developing a predictive model is its validity, i.e., its sensitivity and specificity. However, it is just as important to develop a model which is clinically applicable; otherwise it will not be used.

The parameters to be measured must be acceptable to patients who have recently been admitted. They should also be straightforward and simple to perform.

The measures found to be most discriminating which were incorporated into the model are as discussed above, age, mental function, haemoglobin, handgrip strength, triceps skinfold, subjective assessment score and mid upper arm circumference.

Whilst age is obviously easy to determine, some problems were encountered administering the mental function test. These were overcome to a degree by explaining the reasons for screening. However, difficulties appear to be associated with the reading list element of the test and it may worth exploring how the test could be made more acceptable to the type of patients in this group.

Haemoglobin estimations are routinely performed on all surgical patients and in the majority of cases the values are available in patients’ notes.

Handgrip strength is measured using a dynamometer and is a very straightforward procedure to perform. Difficulties might arise in patients with arthritic or injured hands, although this did not pose problems in this study.

As a measure, TSF is subject to operator error although in the hands of a skilled technician its reliability is improved having a coefficient of correlation of about 6 percent, (DH, 1992). The changes in skin compressibility in older people have not been properly investigated. The triceps skinfold measurement only offers a rough guide to body fatness and should only be used with other parameters, as it is here. Furthermore, nurses are not familiar with the test. In a recent study to determine which nutritional indicators were used by nurses to assess elderly
patients, the lack of use by nurses of upper arm circumference and skinfold thickness was explained by lack of knowledge of the values or how to obtain them, (Collinsworth and Boyle, 1989). Clearly some form of training would be required to improve the reliability of test.

The subjective assessment score, SAS, is a simple checklist of questions (Appendix 4.i). Much of the data in the SAS is collected during nursing histories and would be available from the notes.

Finally, the mid upper arm circumference is measured using a non-extensible tape measure and once the mid point of the arm has been correctly identified the MUAC is easy to measure.

A number of measures were excluded from the discriminant analysis process such as body weight, serum albumin and retinol binding protein because the parameters were found to be difficult to obtain reliably in a sufficient number of patients.

Although body weight is much favoured by some workers, its use with recently admitted fracture patients is impractical and therefore had to be omitted. Body weight was identified as the most frequently used parameter by nurses to assess nutritional status, (Collinsworth and Boyle, 1989); the experience of the present study was that nurses found weighing patients difficult and time-consuming, compounded by the lack of appropriate weighing scales on wards.

In the Stage 1 patient group, bloods were analysed for the estimation of serum albumin and retinol binding protein. However, it was not possible to obtain bloods for analysis in Stage II of the study for reasons already explained. Furthermore, in order for these values to be determined routinely a very sound case would have to be made to obtain resources from health managers.

4.5.5 Comparison of the model with other prognostic models

As discussed above the most dominant predictors of risk which were identified, and then incorporated into the model, were largely "non-nutritional". The fact that the discriminating variables appeared to be simply general predictors of risk suggests that either the clinical state, including age of the patient on admission, is more important than nutritional status, or that poor clinical outcome may only be very weakly dependent upon poor nutritional status. Indeed, it could be argued that the model developed assesses pre-injury status, rather than
nutritional status. Nevertheless it fulfils the requirement of identifying individuals who may be more likely to benefit from nutritional support.

In the emergency fractured neck of femur patients variables such as age, mental function, haemoglobin and handgrip strength may give an indication of the severity of the injury. Older people are more likely to undergo long periods alone and unattended following falls and therefore suffer more stress and trauma. This in turn may increase mental confusion and give rise to poor handgrip strength. If there has been a loss of blood it may be reflected in a poor value for haemoglobin.

Obviously, TSF and MUAC are nutritional indices but these parameters exerted much less influence over outcome than the measures discussed above.

The subjective assessment score reflects nutritional vulnerability but also incorporates other factors such as age, living alone, chronic illness.

It could be argued that many nutritional predictors of outcome are really only morbidity predictors. Inspection of the equation shows how much power there is in the measurement of age emphasising the importance of developing age-related models of assessment/prediction. It is interesting to see that TSF and MUAC are the only truly nutritional parameters which appear in the equation. Some of the power of the variables, particularly mental function haemoglobin and handgrip strength, may simply be a reflection of the severity of the injury sustained by patients. Is this predictive equation a nutrition index therefore, or is it an index of non-nutritional factors that nevertheless influence the duration of stay, return to independence, mobility and mortality? Since nutritional and non-nutritional factors are so closely related it could be a combination of the two. Clearly many non-nutritional factors in addition to nutritional status influence clinical outcome in female orthopaedic surgical patients and the predictive model presented may simply be a reflection of this fact. However, a model is presented which may assist in the identification of patients who are at increased risk of post-operative morbidity and mortality, (whether or not this risk is nutritionally-based).

It is said that the ideal outcome indicator is 100 percent sensitive and specific to an agreed and clearly defined end-point and that it is universally available and consistently comparable as well as benefiting individual patients, (Pearson, 1987). Such indicators are said to be rare and irretrievable; supposedly sophisticated routine hospital data systems are in practice unable to track down
re-admission rates or even to obtain prompt lists for in hospital mortality, (Sanderson, 1987). Indeed, without more advanced record keeping systems longer term results such as mobility following hip replacement cannot be identified. In this sense even if the predictive outcome index is simply a morbidity index and only very weakly dependent on poor nutritional status this type of approach may still have some utility.

4.6 CONCLUSION

For the first time a predictive index has been developed for elderly female orthopaedic patients to predict which patients would benefit from nutritional support, which in addition incorporates socio-economic as well as nutritional and clinical data. This meets the recommendation of a recent recommendation to develop prognostic parameters of nutritional status for the ill elderly, (DH, 1992). When applied to a further 22 patients this index provided an accurate estimate of outcome. Whilst an attempt has been made to validate the model using a similar cohort of patients, a larger study would be required complete the validation of this instrument.
CHAPTER 5

SUMMARY DISCUSSION AND CONCLUSIONS
CHAPTER 5 SUMMARY DISCUSSION AND CONCLUSIONS

5.1 OVERVIEW

This thesis has described a study of the nutritional status of a specific group of elderly patients and an investigation of possible links between nutritional status and clinical outcome. The study comprised:

- a critical review of methods of nutritional status assessment techniques
- a study of the changes in nutritional status indicators in the selected patient group, from admission until six months after discharge from hospital
- a study of long-term clinical outcome in a selected patient group
- the development of an equation relating nutritional status to clinical outcome

The novel features of this study are the extended period of patient follow-up and the development of the equation relating nutritional status to outcome. Particular points of interest arising from the work include:

- the need for a more precise definition of nutritional status in general, and malnutrition in particular, for specific patient groups
- the nature of long-term anthropometric changes in patient groups in relation to their nutritional status on admission
- the importance of socio-economic factors in the identification of patients likely to be nutritionally at risk
- the relationship between nutritional status and the predisposition to falls in patients admitted with a fractured neck of femur

The above points are expanded in the following summary discussion, the structure of which follows the order of the Chapters.
5.2 NUTRITION OF THE OLDER ADULT

Chapter 1 reviewed the current literature on the assessment of the nutritional status of the elderly and identified that there is an urgent need for more studies to be conducted regarding both the nutritional status and the nutritional requirements of this section of the population. Evidence has been found indicating that the prevalence of malnutrition in clinical and subclinical forms has been increasing in the elderly. There is a need for studies to provide more reliable guidelines regarding the definition of optimal nutritional status in older people. Anthropometric and biochemical standards derived from appropriate populations of healthy elderly people are required, as well as criteria relating to specific patient groups.

Until more precise definitions have been formulated caution should be exercised in the use and interpretation of the various terms used to describe nutritional status in the literature. Even in the limited number of studies of the prevalence of malnutrition in elderly populations in the community, the comparison of results is difficult. Fidanza, (1991), emphasised this point stating:

"quality control and standardization of methodology in nutritional epidemiology studies are essential items, particularly in the comparison of results".

Whilst manuals of nutritional status assessment exist for younger groups of the population, (Fidanza, 1991), no such reference publication exists for the elderly. Standardised procedures for the nutritional assessment of older people should be formulated, (particularly for anthropometry and biochemical methods). In addition, a specification of the efficacy of the methods, (i.e. reproducibility and validity), is required. At present it is evident that researchers rely on the available literature as a reference source in the assessment of nutritional status. This leads to individual and varying approaches being adopted. The consequence is that the results are not comparable and provide little or no help to practising clinicians. Thus, whilst the scientific community urge clinicians to recognise the features of malnutrition and the need for management and prevention, very little consistent information is readily available to them. In relation to the clinical features of malnutrition alone, it has been said that the syndromes of specific nutrient deficiencies described so well in the young are rarely seen in the elderly, (MacLennan, 1985); this highlights the need for more research to be conducted regarding nutrition in the elderly.
The literature review also revealed the limited data on the prevalence of nutritional problems in the elderly population in the UK. Furthermore, a lack of consistency exists in the reporting of prevalence figures for malnutrition, particularly in hospital studies, due to the heterogeneity of the patient groups studied and the variations in the definitions of malnutrition used.

The present study demonstrated the complexity of nutritional status assessment, and its interpretation in older patients, and hence the difficulty in the construction of precise definitions.

### 5.3 RISK ALLOCATION PROCEDURE

In this study the criteria used to identify patients with a poor nutritional status was chosen to be the presence of three or more abnormally low values for specified anthropometric and biochemical measurements on admission, (body weight, TSF, MUAMC, serum albumin, haemoglobin). Abnormally low values were those values below the fifth percentile derived from the healthy elderly population studied by Morgan et al, (1986), except for haemoglobin, where the local laboratory value for the fifth percentile for the healthy adult population was used.

The procedure was then used to allocate patients to the high nutritional risk group and was reasonably successful in identifying a group of patients whose outcome was subsequently found to be impaired. Using this approach apparent malnutrition was identified in 41 percent of the FNF patients and 4 percent in the THR patients. When assessed using the outcome data the sensitivity was found to be 39 percent, the specificity 70 percent and the overall predictive value 72 percent.

The measurements employed were easy to obtain, especially the anthropometric values. Haemoglobin values were available in all the medical notes with few exceptions. The determination of serum albumin necessitated an additional blood sample and was therefore the most difficult measure to obtain.
A number of criticisms could be made of the risk allocation procedure regarding the measurements and reference values used, for example:

- The use of serum albumin as an index of undernutrition may only be strictly applicable to the screening of healthy, active elderly patients. In the ill patient, hypoalbuminaemia is not sufficiently specific to confirm a diagnosis of undernutrition.

- Haemoglobin values are usually sensitive, but not specific for malnutrition, especially where blood losses may have preceded the measurement. However, a diagnosis of malnutrition in the absence of anaemia should be questioned, (Lehmann, 1989). Thus, anaemia (determined by a haemoglobin value of 10 g/dl) was found in 98 percent of elderly malnourished patients in a study by Mitchell and Lipschitz, (1982).

- Triceps skinfold is thought to be an inaccurate reflection of fat stores in elderly women due to the centralization and internalization of body fat with ageing. Although the measurement of skinfolds in the elderly is difficult and compressibility of skinfolds may further affect the reliability, anthropometric values are still important as basic descriptive information provided that appropriate reference standards are used.

- As MUAMC is partly determined by TSF, any error in the skinfold measurement will be reflected in the circumference value.

Clearly, as the reference values for the risk allocation procedure, with the exception of the haemoglobin, were based on those of Morgan et al, (1986), the procedure was dependent upon the validity and definitions used in Morgan’s study. Furthermore, if anthropometric data do not conform to the assumption of a normal distribution the percentile cut-off points used are subject to error.

The anthropometric data were confirmed as being normally distributed. The reference values were the most appropriate for the present study at the time of the analysis of the data and despite the above limitations the risk allocation procedure, gave an estimate of apparent malnutrition which was no less, and in some cases a more rigorous, means of estimating malnutrition than that quoted in other studies.
As mentioned above the prevalence of malnutrition was much greater in the emergency FNF group than in the elective THR group. It is noteworthy that the high risk group (HRA) consisted of emergency FNF patients only, with the exception of one THR patient. This was not anticipated at the outset of the study, nor was there documented evidence available to indicate this. However, the findings of the study suggest clearly that the FNF and THR patients differed in their nutritional status on admission. As the study progressed, and the investigator gained experience, it became clear that FNF and THR patients represented two distinct populations. However, the original protocol was retained and it was ensured that sufficient FNF patients were recruited to allow separate analysis of this group, as well as analysis of the original study population. Any future studies of a similar nature should note that the collection of detailed follow-up data is extremely time consuming. The length of the follow-up period and the travelling time required to visit patients in the community dispersed widely within the catchment requires considerable resource. The apparent difference in the nutritional status between the emergency and elective patients despite involving similar surgery illustrates the importance of designing studies where patient populations are as homogeneous as possible.

The procedure developed provided a useful and clinically applicable method of allocating patients on admission into high and low nutritional risk groups. The method used could, for example, be applied in studies of the effects of nutritional supplementation, where rapid and easily interpreted tests are required to allocate patients into high and low nutritional risk groups. The subsequent long-term follow-up in the community then provided longitudinal data on the clinical course of the specific group of orthopaedic patients, and provided a means of quantifying long-term clinical outcome.

5.4 NUTRITIONAL STATUS OVER TIME

The investigation of the possible relationship between nutritional status and clinical outcome required the use of a range of clinical outcome criteria. It was found that there is very little documented data regarding the changes in patients following discharge in terms of their nutritional status and clinical outcome. Few, if any, studies included the monitoring of a variety of clinical outcome parameters over an extended period. However, prolonged recoveries were observed by Jensen et al, (1982). They observed that not only did morbidity and mortality increase, but that mortality continued in members of the study.
group for a long period after injuries which normally would not be considered severe.

Adverse clinical outcome only became apparent in the present study well into the recovery stage when normally many patients would have been lost to the follow-up process. The poor recovery found in the patients classified on admission to have low nutritional status may have been due to either pre-existing primary malnutrition or to malnutrition secondary to pre-existing disease. Other evidence presented in Chapter 3 indicates that primary malnutrition may result from the adverse social and living conditions which were found to predominate in the patients classified as being at high nutritional risk. The influence of socio-medical factors will continue and perhaps increase into the recovery stage.

Clearly, if changes in the nutritional status and the relationship to clinical outcome are to be investigated fully, time is an important factor. The results of this study confirmed that the impact of injury and surgery on the objective measures of nutritional status only became evident after the patients were discharged, and so clearly any investigation of the relationship between nutritional status and clinical outcome must span the likely recovery period.

5.4.1 Body composition changes

The collection of long-term follow-up data in this study was amply justified, in particular regarding the changes in body composition observed over time and the differences observed between the high and low nutritional risk groups. Analysis of the data revealed that following discharge the high risk patients lost fat but not muscle. This contrasts with the low risk patients who gained fat but lost muscle. This observation suggests that the patients classified as being at high nutritional risk who were usually of very low body weight, were more resistant to losses in lean body tissue. A possible explanation for this is that it may be a result of a prior adaptation to chronic malnutrition.

The implication of these results is that more work is needed to compare how elderly subjects of low or normal body weight respond to surgery/injury and to examine the long-term effects on body composition. Further, it would be interesting to observe whether the body compositional changes following surgery found in the present study are specific to older people. If these changes are specific to the elderly this would have important implications in terms of the effects of repeated surgery and/or injury in the elderly, and suggest possible
therapeutic interventions including physiotherapy and hormone treatment (e.g. growth hormone).

5.4.2 Response to injury in older people

In addition to further investigations of changes in body composition more information is needed regarding the metabolic effects of illness, injury and surgery in old people and how these are affected by nutritional status. Horan et al, (1988), investigated ageing and the complexity of the ebb and flow phases of the response to injury involving the neuroendocrine, metabolic and reticuloendothelial systems. Their findings suggest that older people do not fail to mount an adequate response to their injuries. However, recovery from the chronic effects of injury are impaired in the elderly. The present study also suggests that it is during the rehabilitation phase of recovery that differences in body compositional response became evident.

There is evidence for peripheral insulin resistance in FNF patients which has been associated with a prolonged rise in plasma cortisol and with immobility, (Frayn et al, 1983). Interestingly, the predisposition to insulin resistance suggests a greater disturbance in skeletal muscle metabolism than in younger patients, and it might be expected that a larger net breakdown of protein would be the result. However, the very limited data available in the literature suggest that the protein catabolic response is decreased in elderly patients, because of their smaller muscle mass and adaptation to reduced nutrient intakes, (Stableforth, 1986). This area is controversial and therefore warrants further investigation.

An alternative explanation for the body compositional changes and the apparent tendency of the patients at high nutritional risk to retain muscle mass may also be related to the prolonged use of walking aids recorded in the high risk patients compared with those in the low risk groups. The use of mobility aids such as frames and sticks necessitates that the muscles in the upper arm are exercised and this is a particularly difficult confounding variable because the changes in body composition in the present study have been inferred from upper arm anthropometric measurements. Furthermore, some of the patients classified at high nutritional risk who returned to their own homes were dependent on their own resources for various household tasks necessitating mobilisation.

Clearly a larger study would be required in which more specific measures of body fat and lean body tissue were employed to determine whether the changes
observed in the present study are real and whether they reflect whole body changes, or are simply a reflection of walking aid usage in these groups. It is suggested that methods such as bioelectric impedance should be included in any further studies as it is a surrogate measure of the relative proportions of whole body fat and lean body tissue, and has been validated in older people against underwater weighing. The technique is inexpensive, non-invasive, and requires no special operator skills, (DH, 1992).

5.4.3 Plasma proteins and body protein depletion

It might have been expected that the changes observed in circulating plasma proteins carried out as part of the study would have helped to confirm the lean body compositional changes inferred by the MUAMC measurements. However, the results of serum albumin and retinol binding protein estimations were inconclusive. The fact that hypoalbuminaemia, for example, is a consequence of the acute-phase response means that low serum albumin concentrations can be considered equally to be a response to infection and environmental stress. The inconclusive nature of the serum albumin determinations in the present study therefore may have been due to the timing of the initial blood sample or alternatively to the difference in the blood profiles of emergency and elective patients. It could be argued that the small negative or negligible changes observed in the emergency patients between hospital admission and discharge were due to their admission in an injured state. As stated earlier albumin levels are known to be depressed following injury or trauma; therefore values in the emergency patients would be expected to be low on admission. Furthermore, serum albumin levels would be expected to remain depressed on discharge, especially as the average duration of stay was only 17.5 days for the emergency patients. In contrast, the pre-surgical albumin values for non-emergency THR patients would be expected to be normal, whereas the discharge bloods would give depressed values reflecting the effects of recent surgery.

The findings of the present study indicate that the measurement of serum albumin may not be useful for the determination of the nutritional status of elderly patients who have suffered injury. This is in conflict with other workers who concluded that serum albumin is the best predictor of malnutrition in any age group, (Mitchell and Lipschitz, 1982). Friedman et al, (1985) dispute the usefulness of serum albumin in the diagnosis of undernutrition in the elderly. This view is again supported by Kemm and Allcock, (1984), who found in their study that serum albumin was not sufficiently specific for hospital patients. However, they considered that it may be useful as a screening test in the
community to distinguish between undernourished patients and well-nourished patients at all ages. MacLennan, (1985), concluded that the specificity of the test is inadequate to distinguish undernutrition from other causes of reduced albumin in sick elderly hospital patients with inflammation, chronic illness, infection, ascites, liver disease, oedema or open wounds.

There may be some value in estimating the insulin-like growth factor-1 (IGF-1) as an alternative indicator of nutritional status particularly with respect to protein. In a study of malnourished hospital patients by Unterman et al, (1985), values of IGF-1 were on average 38 percent of the normal observed. Further, the more malnourished patients exhibited greater reductions in IGF-1 levels than in serum albumin, transferrin, and lymphocyte counts. The response to nutritional repletion was found to be greatest in terms of the IGF-1 measure.

With the benefit of hindsight the advantages and disadvantages of different measures of nutritional status can be assessed, although it is apparent that all methods have limitations. The rationale for the choice of methods was discussed in Chapter 2, and the methods used were, in general, found to be adequate as a means of determining nutritional status.

5.5 NUTRITIONAL STATUS AND CLINICAL OUTCOME

As well as monitoring the changes in nutritional status with time, a further feature of the study was to determine whether patients identified as being at high risk nutritionally did less well in terms of clinical outcome in the longer-term.

Poor clinical outcome was found to be related strongly to low nutritional status. A 25 percent mortality was observed in patients classified as being at high nutritional risk. At 4 weeks following discharge the mortality rate of the high risk group was not very different from that of the low risk group, whereas at 6 months the differences were greater, hence justifying the long-term follow-up. The mortality figures observed in the present study are similar to those found in other studies. The present study confirmed the view that, in general, women who experience fractures of the hip are only just managing to remain independent and self-sufficient, and that these women would benefit from more support in the community prior to their admission, as well as during their recovery. The emergency hip fracture patients in the present study had a variety of co-existing conditions, such as a history of recent falls, indicating poor
balance and muscular weakness. Furthermore, the fracture itself may precipitate secondary clinical conditions associated with trauma and stress.

Women judged to be in poor nutritional status on admission, both in the group as a whole and within the FNF group only, spent longer in hospital and convalescence, took longer to return to mobility and independence, and in many cases were still unable to return to their own homes at 6 months following surgery. Whilst it is clear that emergency patients do less well in terms of outcome, it cannot be concluded, without qualification, that poor nutritional status was responsible for poor outcome. Any underlying disease and the effects of stress as a result of accident may have contributed to the observed morbidity and mortality. The only way of quantifying the contribution of poor nutrition would be to supplement at random half of the high risk group and then compare their outcome with that of the control group. Indeed, a supplement study was set up in response to the findings of the present study.

5.6 THE INFLUENCE OF SOCIAL AND MEDICAL ADMISSION FACTORS ON OUTCOME

The influence of specific social and medical factors was explored in Chapter 3. As noted above those women in the high nutritional risk group were the FNF patients who in general were only just managing to maintain an independent existence prior to admission. The most marked difference observed between the low and high nutritional risk groups within the FNF group was a greater reported frequency of recent falls in the high risk patients in the period prior to admission. Other common features in the high risk group were depression, recent bereavement, living alone, poor dentition and being unable to cook and shop unaided. Such patients clearly need greater community support if they are to avoid the falls leading to admission to hospital and to remain independent.

It is possible that the needs of this group could be identified during the GP health checks for the over 75's, as part of the overall protocol currently used to assess health. Body weight and some simple anthropometric measurements could be taken for those women having the above risk factors. Appropriate community support could be deployed and a record of weight and simple anthropometry taken to provide baseline information for future reference.
5.6.1 Cause and prevention of falls

It was noted above that falls might be prevented if more community support were made available to those women deemed to be at risk. Further, anthropometric measurements would confirm the presence of thinness in these at risk women. The fact that thin elderly females have impaired thermoregulation compared with better nourished women was noted by Fellows et al, (1985). Defective thermoregulation may lead to hypothermia which in turn may lead to confusion, ataxia, falls and hence fractures, (Bastow et al, 1983b). It is interesting to note therefore, that anthropometric values for FNF patients in the present study are lower than even the lowest estimates for other reference populations, (Vir and Love, 1980; Burr et al, 1984; McEvoy et al, 1982). The patients in the present study were drawn from non-institutionalised populations and are comparable with healthy elderly populations studied by these other workers. Mansell et al, (1990), took standard anthropometric measurements in a study of three groups of elderly females, namely (i) fractured neck of femur patients, (ii) healthy community subjects, and (iii) those admitted to acute medical and geriatric wards. They also found that fractured neck of femur patients were thinner than both healthy controls and the unselected female medical in-patients. These differences were most apparent in anthropometric indices dependent on body fat; it was postulated that this may be significant in terms of the aetiology of fractured femur.

Fractured neck of femur only occurs below a certain threshold of bone density, Riggs et al, (1986). A degree of osteoporosis is therefore a necessary, but not sufficient, condition for fracture. Bone mineral density falls with age. A low maximum bone mass attained in adulthood, an early menopause, and an enhanced rate of post-menopausal bone loss predispose women to fractures. Nutrition has an influence on skeletal mass as thin women tend to have an earlier menopause, an increased rate of post-menopausal bone loss and may have achieved a lower peak bone mass in early adulthood. Thinness is known therefore to be a risk factor for osteoporosis, RCP, (1989). Thus, nutrition may not only be involved in the development of osteoporosis; it may be implicated also in precipitating a fracture of the femur in thin patients whose thermoregulation mechanisms may be impaired.

The data derived from the social and medical history taken on admission confirmed that, in general, FNF patients had not undergone recent weight loss, ie, they probably had been thin for a number of years. Furthermore, the low MUAMC measurements observed in this group suggest a reduced muscle mass.
and hence decreased strength with which to resist a fall. It would seem that anthropometry could also be used to identify which women would most benefit from post-menopausal therapy for the prevention of osteoporosis and associated fractures. However, it is not known to what extent thinness alone precipitates falls. Chronic illness and disability also will result in reduced intakes of food and malnutrition.

5.7 THE DIETARY NEEDS OF PATIENTS FOLLOWING SURGERY

The latest government report on the nutrition of the elderly, (DH, 1992), recommends that:-

"the impact of acute and chronic illness on the nutritional requirements of the elderly needs comprehensive study"

The Department of Health report on nutrition and the elderly also acknowledges the on-going failure to assess current nutritional status and to ameliorate poor diet. They recommend that assessment of nutritional status of elderly people admitted to hospital should be a routine aspect of recording patient history and of physical examination, (DH, 1992).

However, a further problem is that, despite being offered more than they want, elderly people may still not be eating enough. This may be because underlying disease, as well concurrent metabolic abnormalities, increase the need for nutrients and induces structural changes in the gastrointestinal tract.

Whilst the dietary intake of food by elderly hospitalised patients may be sufficient to maintain body weight under the day to day conditions of low energy expenditure, it may not be enough to make up for the episode of catabolism induced by injury or illness in fractured neck of femur patients. Formal nutritional therapy, including supplements if necessary, should be instituted for undernourished elderly during hospital admission, especially following trauma and surgery, (DH, 1992). It would have been interesting to measure, in the context of the present study, the prevalence of malnutrition on discharge to determine whether this had increased during the hospital stay. Although cumulative weight loss may be an inevitable consequence of the stress and trauma associated with fractures, the fact that poor nutritional status affects outcome has been confirmed in the present study. However, irrespective of whether being under-weight in these circumstances affects
clinical outcome and well-being, the possibility that a patient’s nutritional needs are not being met in hospitals is of concern.

It was notable that of the 22 patients studied as part of Stage II of the study, only two were identified by the medical staff as having either a low body weight or a poor appetite. It is understood that the dietitian was not alerted for either patient. These same two patients were identified as being at high nutritional risk using the predictive model for identifying individuals at nutritional risk described in Chapter 4. A further eleven patients were allocated to the high nutrition risk category using this procedure indicating a total of 13/22 patients or 59 percent may have been suffering some degree of malnutrition. Despite a number of studies having demonstrated the benefit of nutritional supplementation for high nutritional risk patients, it would appear that the identification of such patients is poor and subsequent action limited.

It is of interest to consider the reasons why patients are not being referred to dietetic services. In general, dietitians are always reactive to referrals, but often lack the resources to be pro-active. According to the risk allocation procedure used in this study, nearly a fifth of patients admitted to hospital over a three month period were apparently in need of nutritional support, but did not receive it. This may have been due to either any identification procedures in use being inadequate, or resource constraints on the dietitians resulting in their being unable to deliver dietary supplementation.

The Royal College of Physicians report on fracture neck of femur patients, (1989), also emphasises the importance of post-operative care. It states that: "the objective of post-operative care should be to maximise the potential of each patient in the shortest possible time and with the minimal discomfort." Prevention of further falls and fractures is desirable and the majority of patients require some medical supervision during the recovery stage. The report concluded that committed nursing care is critical to the recovery of hip fracture patients and that, among other factors, this should include adequate fluid and nutritional input. This point was further emphasised in the recent government report on the elderly, (DH, 1992). This report stated that in the longer-term every encouragement should be given to patients to eat more solid food, especially after returning home.
5.8 NUTRITIONAL ASSESSMENT FOR REFERRAL

The present study confirms the need for a more systematic approach to nutritional assessment for the purposes of referral. The use of specific nutritional markers for individual patients is difficult. The clinical importance of one abnormal nutritional parameter, when others are apparently normal, has not been clarified.

According to Fidanza, (1991), the purpose of nutritional status assessment is:-

"to ascertain if an individual is optimally nourished with a view to formulating and instigating appropriate action where necessary to improve or restore the level of nutritional health."

He suggests that to this end it may only be necessary to describe an individual as:-

"adequately nourished  -  no action required
marginally nourished  -  monitor further
poorly nourished     -  institute remedial action"

However, the cut-off points of these categories are subjective and depend upon the scale of the problem, and the resources available for action. Of course these issues relate to any method of assessment.

5.9 DEVELOPMENT OF A PREDICTIVE MODEL

In order to provide some means of quantifying risk for individual patients, a predictive model was developed as part of the present study, as described in Chapter 4. The advantage of this approach is that by defining malnutrition in relation to outcome, the lack of standards for diagnosing malnutrition is overcome, i.e. a patient is malnourished if the nutritional status is predicted to affect outcome. An original feature of this particular multiparameter predictive model was the use of clinical and anthropometric admission variables, together with subjective data such as social/functional indices. The model was developed specifically for female elderly orthopaedic patients and based on a comprehensive set of outcome criteria collected over 6 months following discharge.
The model developed had a sensitivity of 89 percent and a specificity of 91 percent for the study group for which it was developed. Had the risk allocation procedure, (Chapter 3), been used to predict outcome, the equivalent values would have been a 39 percent sensitivity and a 70 percent specificity. From these results it could be concluded that the outcome prediction model is a better tool for assessing nutritional status on admission than the risk allocation procedure employed in Chapter 3.

Validation of the outcome prediction model was undertaken on a second population, although the population was smaller (n = 22), and the follow-up period was only 3 months due to time constraints. Despite these differences the model was highly sensitive at 100 percent for the second population, but not as specific at 60 percent. Whilst these results provide a reasonable level of confidence in the model, it is acknowledged that a larger and more rigorous validation study is required with the same follow-up period of 6 months.

The relative importance of various nutritional and socio-medical admission data, in terms of predicting post-operative morbidity and mortality and the restoration of previous functional abilities was also determined for the specific patient group studied. The admission variables found to be most discriminating in order of their influence on outcome prediction were: age; mental function; haemoglobin; handgrip strength; triceps skinfold; subjective assessment score; and mid upper arm circumference. Hence, the dominant predictive factors were largely non-nutritional, but are measures of functional capacities. This finding is in agreement with the concept described by Ferro-Luzzi, (1988), who suggested that energy nutritional status is a dynamic condition which might be described as the extent to which improvements can be made in terms of functions and capacities, (such as disease response, work capacities and performance, social and behavioral functions), by changes in energy balance. Ferro-Luzzi advocates a move away from anthropometry and the traditional approaches used to assess energy status to a more functional assessment. However, the relationship between nutritional status, the response to disease, the return to independence and mobility or mortality clearly is likely to be multi-factorial and therefore complex. The separation of nutritional from non-nutritional affects is difficult, as is the identification of their relative importance. Interestingly, the most influential factor of rapid and effective rehabilitation was the mental test score, together with good evidence of a good pre-fracture level of independence in a study by the RCP, (1989). Other important factors were quoted as being hydration and nutrition.
Ultimately, the resolution of some of these issues lies in the implementation of a large-scale randomised controlled trial of nutritional supplementation. The observed clinical outcome would be compared with that predicted by the equation (or a refinement of it). The patients predicted to have had poor outcomes would be analysed to assess whether those who had received supplements showed significantly better outcome status than those not supplemented. Having undertaken the present study it is clear that the separation of the FNF patients from the THR patients would have been appropriate had it been possible to recruit and follow-up a greater number of such patients. It is recommended that future work be focused on such carefully specified groups.

It should be noted that a small scale supplement study of elderly female orthopaedic patients has been undertaken by a member of the research group with preliminary findings already published, (Driver et al, 1990). The subsequent findings confirmed that nutrition is indeed a contributing factor affecting clinical outcome. For example, it was found that those patients receiving an extra 500 Kcals and 20g of protein per day for a period of 6 weeks had significantly shorter stays in convalescence and gained significantly more weight at 6 months than the non-supplemented group. There was also a trend towards lower mortality rates at 6 months, although this did not reach statistical significance, (Driver, unpublished).

As stated in the discussion, the relationship between nutritional status and the predisposition to falls requires further study. A community observation study of elderly females identified as "fallers" or "non-fallers" in which a range of nutritional assessment parameters are evaluated in the two groups would enable the influence of nutritional and health status to be clarified.

Finally, it must be emphasised that the predictive model developed in the present study represents only the first step in the development of a more quantitative and scientific means of identifying at-risk patients in the clinical group studied. Further work is required to refine the assessment of outcome and the equation relating this to nutritional and socio-medical factors. Furthermore, practical applicability must be evaluated under conditions of routine clinical use. Even so the relationship between nutritional status, health and well-being, and the ability to recover from acute illness and injuries, may be so interactive that separation between the effects of poor nutrition and the effects of illness itself may prove elusive even to the most conscientious investigator.
APPENDIX A

SUPPLEMENTARY INFORMATION TO CHAPTER 2
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Figure 2.i Mental function test
Figure 2.ii Social and medical admission history: checklist of questions
Figure 2.iii Activities of daily living: modified Visick index
Figure 2.iv Summary of nutritional assessment parameters collected for each subject
CLIFTON ASSESSMENT PROCEDURES FOR THE ELDERLY (CAPE)

Cognitive Assessment Scale

Name: .....................................................................

Current address/placement: ..................................................

Date of birth: ................................................................. Occupation: ...............................................

Information/Orientation

Name: ............................................................... Hospital/Address: ..................................................... Colour of British Flag:

Age: ...................................................................... City: .............................................................. Day: .........................................................

D.o.B. ...................................................................... P.M.: ............................................................. Month: .....................................................

Ward/Place: .............................................................. U.S. President: ........................................................ Year: ..........................................................

I/O Score .......

Mental Ability

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MAb Score .......

Psychomotor

Time: ............... Errors: .............

Pm Score .......

Scoring

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<td>N/C</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Add Bonus 2 if 60 secs or under;
1 if 120 secs or under

Assessed by: .......................................................... Date: ...............................................

Page 173
CAS Reading List

free
saying
plain
picture

hostage
twisted

sponge
shoulder

knowing
physical
decent
comprehend

atmosphere
precocious
Figure 211 Social and Medical History: Checklist questions

Patient's name: ..............................................

Place a tick against any statement which applies to the patient

The Patient

1. Lives alone
2. Lives alone and has regular visitors less than twice per week
3. Lives in a residential home
4. Is over 60
5. Is over 80
6. Is over 90
7. Has experienced a major life crisis in the last 12 months
   (eg moving house/divorce/separation/bereavement)
8. Has no regular hobbies or pastimes
9. Is unable to walk more than 400 yds unaided
10. Leaves the house less than twice a week
11. Has had no regular visits during hospitalisation

The Patient has:

12. Failing vision (other than normal use of spectacles)
13. Cancer
14. Diabetes Mellitus
15. Gastrointestinal disease
16. Bronchitic disease
17. Physical disability which impairs dexterity/mobility
18. Mental disability which prevents normal communication
19. Osteoarthritis
20. Undergone surgery in the past 6 months
21. Been bedridden for more than 3 months
22. A history of frequent falls
23. Poor dentition; ill-fitting dentures

Been admitted for:

24. Surgery
25. Radiotherapy
26. Chemotherapy
The Patient

27 Could be described as thin
28 Could be described as very thin
29 Has a small appetite
30 Has lost more than 7 lbs (without dieting) in the past 2 months
31 Avoids a particular food/group of foods due to intolerance
32 Has restricted their diet in the past 6 months in order to lose weight
33 Has impaired sense of taste/smell

Has frequent episodes of:
34 Nausea
35 Vomiting
36 Diarrhoea
37 Constipation

38 Eats alone more than 4 days a week
39 Eats less than 5 cooked meals per week
40 Regularly skips meals, eg breakfast

Never eats the following:
41 Red meat
42 White meat or fish
43 Milk or dairy products
44 Eggs
45 Drinks less than 3.5 pints of milk per week
46 Eats less than 3 servings of fruit juice a week or less than 3 servings of vegetables a week
47 Uses laxatives more than twice a week
48 Expresses a lack of interest in food and food preparation
49 Is totally dependent on others for meal provision
50 Has expressed episodes of apathy or depression

FOR PATIENTS LIVING IN THEIR OWN HOMES/INDEPENDENTLY

The Patient

51 Requires help with shopping
52 Requires assistance with preparation/cooking of food
53 Requires, but does not receive, sufficient assistance with above activities
54 Does not have easy access to food stores/supermarkets
55 Relies on public transport/walking for shopping
56 Relies on others to get shopping
**Modified Visick index**

The patient is assessed by the study nurse and assigned a grade according to the following criteria.

0. Fully active, able to carry on all pre-disease performances without restriction (Karnofsky 90-100) (1).

1. Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work (Karnofsky 70-80).

2. Ambulatory and capable of all self-care but unable to carry out any work activities. Up and about > 50% of waking hours (Karnofsky 50-60).

3. Capable of only limited self-care, confined to bed or chair > 50% of waking hours (Karnofsky 30-40).

4. Completely disabled, cannot carry on any self-care. Totally confined to bed or chair (Karnofsky 10-20).

5. Dead.
Figure 2.iv Summary of nutritional assessment parameters collected for each subject

Preadmission living arrangement

Preadmission functional status
- Able to shop and cook for self
- Able to walk unaided
- Housebound
- History of Falls
- Depression

Preadmission nutritional status
- Appetite
- History of weight loss
- Thin/very thin
- Avoidance of certain food groups
- Loss of sense of smell/taste
- Dentition
- Episodes of nausea, vomiting, diarrhoea or constipation

Age

Medical Data
- Total number of medications on admission to RSCH
- Reason admitted to RSCH (THR or FNF)
- Prosthesis
- Number of active problems on admission to RSCH
- Diagnoses

Socioeconomic variables
- Previous occupation
- Marital status
- Recent bereavement
- Living alone
Admission laboratory tests
  Serum Albumin
  Retinol Binding Protein
  Haemoglobin
  Creatinine
  White Cell Count
  Total Lymphocyte Count

Admission anthropometric measurements
  TSF
  MUAC
  MUAMC

Serial nutritional measurements
  Serum Albumin
  Retinol Binding Protein
  TSF
  MUAC
  MUAMC

Weight indices
  Weight loss in previous 2 months
  Usual weight
  Weight changes up to 6 months after surgery

Discharge functional status
  Mental competence
  Activities of Daily Living Score
  Mobility

Postdischarge living arrangement

Mortality

Clinical Outcome
  Falls
  Infection
  Readmission
  Pressure sores/ulcers
APPENDIX B

SUPPLEMENTARY INFORMATION TO CHAPTER 3
### Table 3.i
Body weight values in hospital, at 4 weeks, 8 weeks and 6 months post discharge for all patients and in patients admitted for emergency surgery (FNF) only, according to nutritional risk categorisation

### Table 3.ii
Anthropometric measurements at admission, discharge, 4 weeks, 8 weeks and 6 months post discharge in all patients and in patients admitted for emergency surgery (FNF) only, according to nutritional risk categorisation

### Table 3.iii
Handgrip strength values at admission, at discharge, 4 weeks, 8 weeks and 6 months post discharge in all patients and in emergency (FNF) patients only according to nutritional risk categorisation

### Table 3.iv
Biochemical values at admission, discharge, 8 weeks and 6 months post discharge in all patients and in patients admitted for emergency surgery (FNF) only, according to nutritional risk categorisation

### Table 3.v
Changes in body weight values from hospital to 6 months post discharge following surgery for all patients and emergency (FNF) patients according to nutritional risk categorisation

### Table 3.vi
Changes in anthropometric measurements from admission to 6 months post discharge following surgery for all patients and for emergency (FNF) patients only, according to nutritional risk categorisation

### Table 3.vii
Changes in handgrip strength from admission to 6 months post discharge following surgery for all patients and for emergency (FNF) patients only according to nutritional risk categorisation

### Table 3.viii
Changes in biochemical values from admission to 6 months post discharge following surgery for all patients and for emergency (FNF) patients only according to nutritional risk categorisation
Table 3.ix  Changes in clinical outcome. Activities of daily living following discharge from 1 week to 4 weeks; 1 week to 8 weeks; and 1 week to 6 months after surgery in all patients and in emergency patients (FNF) only, according to nutritional risk categorisation.
<table>
<thead>
<tr>
<th>Body Weight</th>
<th>ALL PATIENTS</th>
<th>EMERGENCY PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(kg)</td>
<td>ERA (n=14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td>Hospital</td>
<td>43.7 (38.1; 48.0)</td>
<td>63.5*** (58.3; 70.9)</td>
</tr>
<tr>
<td>4 weeks</td>
<td>41.0 (40.0; 45.9)</td>
<td>62.1*** (55.8; 70.2)</td>
</tr>
<tr>
<td>8 weeks</td>
<td>41.4 (40.2; 44.0)</td>
<td>62.7*** (56.1; 71.2)</td>
</tr>
<tr>
<td>6 months</td>
<td>42.3 (40.2; 43.8)</td>
<td>65.5*** (56.4; 70.9)</td>
</tr>
</tbody>
</table>

*** p<0.0001 compared with ERA; †† p<0.0002; ††† p<0.0001 compared with HRE
Table 3.ii (a) Anthropometric measurements at admission, discharge, 4 weeks, 8 weeks and 6 months post discharge in all patients according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Values at various time intervals</th>
<th>ALL PATIENTS</th>
<th>HRA (n = 14)</th>
<th>LRA (n = 46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TSF</strong></td>
<td><strong>MUAC</strong></td>
<td><strong>MUAMC</strong></td>
<td><strong>TSF</strong></td>
</tr>
<tr>
<td>Admission</td>
<td>8.2 (7.1;10.9)</td>
<td>22.9 (21.8;24.3)</td>
<td>20.2 (19.1;20.9)</td>
</tr>
<tr>
<td>Discharge</td>
<td>7.7 (6.2;9.5)</td>
<td>22.0 (20.9;22.7)</td>
<td>19.3 (18.5;20.5)</td>
</tr>
<tr>
<td>4 weeks</td>
<td>8.8 (6.7;10.9)</td>
<td>23.3 (20.9;23.5)</td>
<td>19.0 (18.1;20.0)</td>
</tr>
<tr>
<td>8 weeks</td>
<td>7.6 (6.3;10.9)</td>
<td>22.3 (21.1;24.0)</td>
<td>19.7 (18.8;20.6)</td>
</tr>
<tr>
<td>6 months</td>
<td>8.1 (6.4;12.6)</td>
<td>22.2 (21.4;23.9)</td>
<td>19.3 (18.7;21.3)</td>
</tr>
</tbody>
</table>

*** P<0.0001 compared with HRA

Table 3.ii (b) Anthropometric measurements at admission, discharge, 4 weeks, 8 weeks and 6 months post discharge in patients admitted for emergency surgery (FNF) according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Values at various time intervals</th>
<th>EMERGENCY PATIENTS</th>
<th>HRE (n = 13)</th>
<th>LRE (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TSF</strong></td>
<td><strong>MUAC</strong></td>
<td><strong>MUAMC</strong></td>
<td><strong>TSF</strong></td>
</tr>
<tr>
<td>Admission</td>
<td>8.4 (7.1;11.0)</td>
<td>22.9 (21.6;24.6)</td>
<td>20.1 (19.1;21.1)</td>
</tr>
<tr>
<td>Discharge</td>
<td>8.0 (6.7;9.9)</td>
<td>22.0 (20.7;22.5)</td>
<td>19.3 (18.4;20.0)</td>
</tr>
<tr>
<td>4 weeks</td>
<td>8.8 (6.5;11.0)</td>
<td>22.0 (20.8;23.6)</td>
<td>19.0 (17.8;20.0)</td>
</tr>
<tr>
<td>8 weeks</td>
<td>8.0 (6.3;11.4)</td>
<td>22.0 (20.9;24.0)</td>
<td>19.6 (18.7;20.6)</td>
</tr>
<tr>
<td>6 months</td>
<td>8.1 (6.7;12.8)</td>
<td>22.0 (21.2;23.9)</td>
<td>19.2 (18.7;20.9)</td>
</tr>
</tbody>
</table>

† P<0.005; †† P<0.0002; ††† P<0.0001; a P<0.02 compared with HRE
<table>
<thead>
<tr>
<th>Handgrip strength (mm Hg)</th>
<th>All patients</th>
<th>Emergency patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
</tr>
<tr>
<td></td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
</tr>
<tr>
<td>Median (25th; 75th percentile)</td>
<td>Median (25th; 75th percentile)</td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>HGS</td>
<td>HGS</td>
</tr>
<tr>
<td></td>
<td>(2.00; 4.5*)</td>
<td>(1.5; 3.0)</td>
</tr>
<tr>
<td></td>
<td>(0.87; 3.60)</td>
<td>(0.75; 3.75)</td>
</tr>
<tr>
<td>Discharge</td>
<td>HGS</td>
<td>HGS</td>
</tr>
<tr>
<td></td>
<td>(2.5; 4.7*)</td>
<td>(2.0; 2.5)</td>
</tr>
<tr>
<td></td>
<td>(0.88; 5.60)</td>
<td>(0.75; 5.0)</td>
</tr>
<tr>
<td></td>
<td>(0.88; 5.60)</td>
<td>(1.5; 7.5)</td>
</tr>
<tr>
<td>4 weeks</td>
<td>HGS</td>
<td>HGS</td>
</tr>
<tr>
<td></td>
<td>(1.0; 6.0**)</td>
<td>(1.0; 5.0)</td>
</tr>
<tr>
<td></td>
<td>(0.13; 3.40)</td>
<td>(0.0; 3.0)</td>
</tr>
<tr>
<td></td>
<td>(3.1; 7.0)</td>
<td>(1.5; 7.0)</td>
</tr>
<tr>
<td>8 weeks</td>
<td>HGS</td>
<td>HGS</td>
</tr>
<tr>
<td></td>
<td>(3.0; 6.0***)</td>
<td>(2.7; 5.2†)</td>
</tr>
<tr>
<td></td>
<td>(0.0; 4.0)</td>
<td>(0.0; 4.0)</td>
</tr>
<tr>
<td></td>
<td>(4.0; 8.0)</td>
<td>(1.1; 8.0)</td>
</tr>
<tr>
<td>6 months</td>
<td>HGS</td>
<td>HGS</td>
</tr>
<tr>
<td></td>
<td>(3.5; 6.2**)</td>
<td>(3.0; 5.0)</td>
</tr>
<tr>
<td></td>
<td>(0.0; 5.0)</td>
<td>(0.0; 4.5)</td>
</tr>
<tr>
<td></td>
<td>(4.4; 9.1)</td>
<td>(4.0; 10.7)</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001 compared with HRA  
†p<0.05; ††p<0.01 compared with HRE
3.iv (a) Biochemical values at admission, discharge, 8 weeks and 6 months post discharge in all patients admitted for surgery according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Biochemical values at various time intervals</th>
<th>HRA (n = 14)</th>
<th>LRA (n = 46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum albumin (g/l)</td>
<td>Retinol binding protein (mg/l)</td>
<td>Retinol binding protein (mg/l)</td>
</tr>
<tr>
<td>Admission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.5 (35.0;45.5)</td>
<td>46.0 (34.8;57.0)</td>
<td>43.0 (40.5;48.0)</td>
</tr>
<tr>
<td>Discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.0 (37.0;44.5)</td>
<td>59.0 (37.5;77.5)</td>
<td>41.0 (37.0;45.0)</td>
</tr>
<tr>
<td>8 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42.0 (34.3;45.3)</td>
<td>45.0 (34.0;52.0)</td>
<td>44.0 (40.0;46.0)</td>
</tr>
<tr>
<td>6 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.0 (41.8;47.0)</td>
<td>40.5 (34.5;48.3)</td>
<td>43.5 (42.0;46.3)</td>
</tr>
</tbody>
</table>

* p<0.05 compared with HRA

3.iv (b) Biochemical values at admission, discharge, 8 weeks and 6 months post discharge in patients admitted for emergency surgery (FNF) according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Biochemical values at various time intervals</th>
<th>HRE (n = 13)</th>
<th>LRE (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum albumin (g/l)</td>
<td>Retinol binding protein (mg/l)</td>
<td>Retinol binding protein (mg/l)</td>
</tr>
<tr>
<td>Admission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.5 (35.0;45.0)</td>
<td>46.0 (34.8;57.0)</td>
<td>43.0 (39.0;47.0)</td>
</tr>
<tr>
<td>Discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.5 (39.0;45.3)</td>
<td>66.0 (37.3;78.8)</td>
<td>39.0 (37.0;47.0)</td>
</tr>
<tr>
<td>8 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42.0 (33.5;43.5)</td>
<td>46.0 (40.8;52.0)</td>
<td>43.0 (40.0;45.0)</td>
</tr>
<tr>
<td>6 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.0 (41.0;48.0)</td>
<td>42.0 (36.0;50.0)</td>
<td>42.0 (41.0;46.0)</td>
</tr>
</tbody>
</table>
Table 3.5  Changes in body weight values from hospital to six months post discharge following surgery for all patients and emergency (FNF) patients according to nutritional risk categorisation

<table>
<thead>
<tr>
<th></th>
<th>ALL PATIENTS</th>
<th></th>
<th>EMERGENCY PATIENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HRA (n = 14)</td>
<td>LRA (n = 46)</td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
</tr>
<tr>
<td><strong>Body weight (kg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital → 4 weeks</td>
<td>0.3</td>
<td>-0.9</td>
<td>0.0</td>
<td>-1.1</td>
</tr>
<tr>
<td></td>
<td>(-1.6; 2.4)</td>
<td>(-2.1; 0.8)</td>
<td>(-1.6; 2.7)</td>
<td>(-2.3; -0.2)</td>
</tr>
<tr>
<td>Hospital → 8 weeks</td>
<td>0.0</td>
<td>-0.9</td>
<td>0.0</td>
<td>-0.9</td>
</tr>
<tr>
<td></td>
<td>(-1.5; 3.4)</td>
<td>(-2.3; 1.3)</td>
<td>(-2.1; 4.0)</td>
<td>(-2.3; 1.9)</td>
</tr>
<tr>
<td>Hospital → 6 months</td>
<td>0.4</td>
<td>1.3</td>
<td>0.0</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>(-1.5; 3.5)</td>
<td>(-1.6; 2.2)</td>
<td>(-2.1; 4.3)</td>
<td>(-1.8; 1.8)</td>
</tr>
</tbody>
</table>
### Table 3. vi (a) Changes in anthropometric measurements from admission to six months post discharge following surgery for all patients according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Values</th>
<th>Admission to 6 months post discharge</th>
<th>HRA (n = 14)</th>
<th>LRA (n = 46)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Δ TSF</th>
<th>Δ MUAC</th>
<th>Δ MUAMC</th>
<th>Δ TSF</th>
<th>Δ MUAC</th>
<th>Δ MUAMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission -&gt; discharge</td>
<td>-0.2</td>
<td>-0.4</td>
<td>-0.2</td>
<td>-0.7</td>
<td>-0.3</td>
<td>-0.1</td>
</tr>
<tr>
<td></td>
<td>(-1.5; 0.4)</td>
<td>(-0.7; -0.2)</td>
<td>(-1.0; 0.0)</td>
<td>(-2.0; 0.5)</td>
<td>(-0.9; 0.1)</td>
<td>(-0.8; 0.3)</td>
</tr>
<tr>
<td>Admission -&gt; 8 weeks post discharge</td>
<td>-0.9</td>
<td>-0.8</td>
<td>-0.3</td>
<td>1.0*</td>
<td>-1.5</td>
<td>-1.8*</td>
</tr>
<tr>
<td></td>
<td>(-3.3; 0.5)</td>
<td>(-1.2; 0.1)</td>
<td>(-1.5; 0.0)</td>
<td>(-0.7; 3.5)</td>
<td>(-2.5; -0.5)</td>
<td>(-2.8; -1.0)</td>
</tr>
<tr>
<td>Admission -&gt; 6 months post discharge</td>
<td>-1.5</td>
<td>-0.4</td>
<td>-0.1</td>
<td>2.4***</td>
<td>-1.4</td>
<td>-1.8**</td>
</tr>
<tr>
<td></td>
<td>(-1.9; 0.6)</td>
<td>(-1.7; 0.08)</td>
<td>(-1.3; 0.5)</td>
<td>(-0.2; 3.0)</td>
<td>(-2.3; -0.6)</td>
<td>(-2.8; -0.9)</td>
</tr>
</tbody>
</table>

*p < 0.002; ** p < 0.007; *** p < 0.0003 compared with HRA

### Table 3. vi (b) Changes in anthropometric measurements from admission to six months post discharge following surgery for emergency (FNF) patients according to nutritional risk categorisation

<table>
<thead>
<tr>
<th>Values</th>
<th>Admission to 6 months post discharge</th>
<th>HRE (n = 13)</th>
<th>LRE (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (25th; 75th percentile)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Δ TSF</th>
<th>Δ MUAC</th>
<th>Δ MUAMC</th>
<th>Δ TSF</th>
<th>Δ MUAC</th>
<th>Δ MUAMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission -&gt; discharge</td>
<td>-0.3</td>
<td>-0.5</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.1</td>
</tr>
<tr>
<td></td>
<td>(-1.7; 0.2)</td>
<td>(-0.7; -0.2)</td>
<td>(-1.0; 0.0)</td>
<td>(-1.9; 0.8)</td>
<td>(-0.8; 0.1)</td>
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<td>(-2.4; -0.2)</td>
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† p < 0.03 †† p < 0.01 compared with HRE
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<td>LRA (n = 46)</td>
<td>HRE (n = 13)</td>
<td>LRE (n = 19)</td>
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<td>1.0* (0.0; 2.4)</td>
<td>0.0 (0.0; 1.3)</td>
<td>1.5 (-0.25; 3.0)</td>
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<td>1.5* (0.0; 3.0)</td>
<td>-0.25 (-1.1; 1.0)</td>
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<td>Admission to 6 months</td>
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<td>1.0* (0.0; 3.5)</td>
<td>0.0 (-1.0; 0.25)</td>
<td>2.5‡ (0.12; 5.3)</td>
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* p<0.05 compared with HRA  † p<0.05;  ‡ p<0.01 compared with HRE
### Table 3.viii (a) Changes in biochemical values from admission to six months post discharge following surgery for all patients according to nutritional risk categorisation

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<td>Admission to discharge</td>
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<td>1.5 (-17.0;11.0)</td>
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<tr>
<td>Admission to 6 months</td>
<td>2.0 (0.0;4.0)</td>
<td>-1.0 (-4.0;19.0)</td>
<td>1.5 (-2.8;4.0)</td>
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* p<0.03 compared with HRA

### Table 3.viii (b) Changes in biochemical values from admission to six months post discharge following surgery for emergency (ENF) patients according to nutritional risk categorisation

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<th>LRE (n = 19)</th>
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<td>8.5 (-4.8;40.5)</td>
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<td>Admission to 6 months</td>
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<td>-1.0 (-4.0;19.0)</td>
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Table 3.9: Changes in clinical outcome. Activities of daily living following discharge from 1 week -> 4 weeks; 1 week -> 8 weeks and 1 week -> 24 weeks after surgery in all patients and in emergency patients (PNF) patients only, according to nutritional risk categorisation.

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<th>Changes in activities of daily living (using a modified, Visick Index) from:</th>
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<th>EMERGENCY PATIENTS</th>
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<tr>
<td>1 week -&gt; 8 weeks</td>
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<td>1 week -&gt; 24 weeks</td>
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</table>

* p<0.001 vs HRA
APPENDIX C SUPPLEMENTARY INFORMATION TO CHAPTER 4

Figure 4.i Subjective assessment questionnaire/score, (SAS)
Table 4.ii Admission values used to predict the outcomes of individuals from Stage I
Table 4.iii Total clinical outcome scores for individuals from Stage I (6 months)
Table 4.iv Admission values used to predict the outcomes of individuals from Stage II
Table 4.v Total clinical outcome scores for individuals from Stage II (8-12 weeks)
Figure 4.vi Correlation matrix
Figure 41 Subjective Assessment Questionnaire (SAS)

Patient name:

Please place a tick against any statement which applies to the patient:-

1. Lives alone
2. Aged over 90 years
3. Has experienced a major life event during the last 12 months (e.g., bereavement, moving residence, divorce, separation)
4. Has no regular hobbies or interests
5. Suffers from cancer
6. Suffers from diabetes mellitus
7. Suffers from gastrointestinal disease
8. Has been admitted for surgery
9. Has poor dentition or ill-fitting dentures
10. Could be described as thin
11. Could be described as very thin
12. Has restricted their diet within the last 6 months in order to lose weight
13. Has frequent episodes of constipation
14. Eats alone more than 4 days a week
15. Eats less than 5 cooked meals per week
16. Regularly skips meals such as breakfast
17. Never eats red meat
18. Never eats milk or dairy products
19. Never eats eggs
20. Relies on others to do shopping
Table 4ii: Admission values used to predict the outcomes of individuals from Stage I

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<th>Patient No</th>
<th>SAS</th>
<th>MFT (%)</th>
<th>AGE (Yrs)</th>
<th>HGS (mmHg)</th>
<th>MUAC (cm)</th>
<th>Hb g/dl</th>
<th>Model Score</th>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
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Table 4v  Total clinical outcome scores for individuals from Stage II (8-12 weeks)

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REFERENCES


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**AUTHOR'S PUBLICATIONS**


