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Hand Grip Strength (HGS) as an indicator of nutritional status in patients in a rural hospital

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HGS as an Indicator of Nutritional Status in Patients in a Rural Hospital

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Abbreviations:

APD	Accredited Practising Dietitian
BDH	Bega District Hospital
BMI	Body Mass Index
DAA	Dietitians Association Australia
HGS	Hand Grip Strength
ISAK	International Society for Advancement of Kinanthropometry
LOS	Length Of Stay
MUAMA	Mid Upper Arm Muscle Area
Med Pass	A system for delivering ONS to inpatients along with the delivery of medications.
MNT	Medical Nutrition Therapy
MST	Malnutrition Screening Tool
MUAC	Mid Upper Arm Circumference
NRS	Nutrition Risk Screening
NUM	Nursing Unit Manager
ONS	Oral Nutrition Supplement (supplementary drink)
PEM	Protein Energy Malnutrition
PG-SGA	Patient Generated – Subjective Global Assessment
SGA	Subjective Global Assessment
SNSW LHD	Southern New South Wales Local Health District
TSF	Triceps Skin Fold

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Abstract

Introduction: Handgrip strength (HGS) has been proposed as a simple, economical and objective measure of nutritional status. This study aimed:

1. To evaluate the use of handgrip strength by dynamometer in the detection of malnutrition in a group of patients 60 years and older in Bega District Hospital.
2. Produce practice guidelines for the measurement of HGS in this group of patients.

Methods:

Study design: Cross sectional analytical

Subjects: 96 surgical and medical patients aged 60 years or older in an 80 bed rural hospital.

Outcome measures: Handgrip measures were taken in the dominant and non-dominant hand with patients either seated in a chair or reclined in bed. Both malnutrition risk and actual diagnosed malnutrition were compared to the maximum and mean of three HGS measurements. Malnutrition risk was identified using the standard methods of direct observation and the Malnutrition Screening Tool (MST). Malnutrition diagnosis was made using the Patient Generated- Subjective Global Assessment (PG-SGA).

Results:

There were significant associations between malnutrition risk and muscle weakness, as indicated by HGS, for the mean of three measurements in both the left ($P = 0.029$) and right hand ($P = 0.017$), and in the dominant hand ($P=0.015$). Overall, the results suggest that the mean of the three HGS measurements for the dominant hand is the most accurate when assessing nutritional status. Sensitivity analysis indicated that combining direct observation, MST and HGS (using 85% cut off point for normative data) gave a sensitivity of 88.5% when screening for malnutrition.

There were no significant associations between malnutrition diagnosis and HGS in the 30 participants who were assessed by PG-SGA.

Conclusion:

Handgrip strength enhanced the standard malnutrition screening process. The fact that this study did not find an association between malnutrition diagnosed by PG-SGA and HGS may be a feature of the small proportion of malnourished patients, bias in sampling or that HGS alone is not a sensitive enough tool in this group of people.

Implications for practice:

Hand grip strength should be used in conjunction with other assessment tools and clinical judgement.

Further research is needed to support this work and assist in quantifying significant change in HGS over time in relation to dietetic care.

Keywords:

Protein energy malnutrition, under nutrition, muscle, hand grip strength, rural hospital.

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Executive Summary

Why was this study performed?

Malnutrition is occurring at high rates in some Australian hospitals. Occasionally malnutrition may go undetected on admission or malnutrition screening does not occur in a timely manner. Even when diagnosed, malnutrition is difficult to monitor, as any improvement is subtle and consequently not observable in the short term. Handgrip strength has been proposed as a quick and objective measure of nutritional status but it is not used significantly within the hospital system because there are no clear guidelines for measuring HGS for nutritional status in sick patients or interpreting the measurement.

How was this study conducted?

Patients on medical and surgical wards at Bega District Hospital (BDH) aged 60 years and over had their HGS tested in combination with a standard hospital screening for malnutrition.

What was found?

- This study found that using direct observation and Malnutrition Screening Tool (MST) alone, 69% of malnourished patients were identified at risk of malnutrition. Using direct observation, MST and an 85% cutoff for mean HGS in the dominant hand, 88% of malnourished patients were identified. Use of HGS improved the sensitivity of malnutrition screening.
- This study found an association between malnutrition risk and muscle weakness as indicated by HGS. Someone at risk of malnutrition (by MST and direct observation) was 3.4 (95% CI 1.2-9.9) times more likely to exhibit weakness in their dominant hand as judged by the mean of three HGS measurements.
- This study did not find an association between weak HGS and malnutrition diagnosed by Patient Generated – Subjective Global Assessment.

What does this mean?

- Handgrip strength is a simple objective indicator of functionality that improves the sensitivity of screening for malnutrition. HGS should be used in conjunction with other assessment tools and clinical judgment.
- The results from this study are supportive of using the mean of the three measurements for the dominant hand when assessing nutrition status.
- That this study did not find an association between diagnosed malnutrition and HGS could be a feature of low numbers, bias of sampling or that HGS is not sensitive enough to detect malnutrition in this sample.

Where to from here?

- Share the information with this HETI report and by writing up the study as a QI activity. Poster presentation and publication in a peer review journal – "The use of functionality as measured by HGS in screening for malnutrition".

- Write up practice guidelines and aim to make HGS part of the screening and monitoring process at key stages within BDH. Dietitians are able to do HGS on selected patients but staffing levels are not able to support the routine screening for malnutrition. Seek the addition of an allied health assistant position to complement the dietitians and nursing staff so as to ensure a timely process for malnutrition screening (MST, height, weight and HGS) and monitoring.

- Consult with other workers in nutrition support to achieve a position statement on HGS and its use in malnutrition management within health care facilities. The values can be included on transfer of care forms in the same way that body weights and blood pathology results are listed, providing an objective measure of a patient's status and encouraging monitoring from facility to facility.

- Consider inter professional approach to malnutrition assessment with input from physiotherapists for testing of functionality that goes beyond HGS.

Further Research:

1. **Sensitivity and specificity of hand grip strength (HGS) in screening for malnutrition in hospital inpatients aged 60 and over**. Seeking a similar sample size and involving University of Wollongong student dietitians who will be having a combined clinical and research placement at BDH 2014 – proposal stage only.

2. If HGS can be introduced routinely into practice this would enable further evaluation. **Retrospective study evaluating HGS in patients screened at increased risk of malnutrition** and tracking how their HGS responds to re-feeding.
- Further analysis to support the use of the mean of the dominant hand measurements as a guide to making a judgment regarding nutrition status.
- Further data collection to test for an association between malnutrition (diagnosed by PG-SGA) and reduced HGS.
- Establishing clinically significant change levels in the mean HGS. Will the maximum HGS achieved in the screening stage offer a significant change to aim for when re-feeding?
- Establishing the effects of comorbidity on HGS.

3. **Evaluate the use of dynamometer for patients with hand problems** by trialling the use of a bulb dynamometer.

4. **Introduce HGS for patients receiving renal dialysis at BDH.** To evaluate quality of life or vitamin D status and muscle function in conjunction with the visiting renal specialist and nursing staff.

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Introduction

Hospital malnutrition

Nutritional status is an integral part of health and the fact that malnutrition can occur in a developed country with good standards of health care is confronting. Malnutrition in hospital facilities may occur quickly for a variety of reasons. With a process of timely screening and rescreening it should be easily identifiable and consequently treatable.

Background

Definitions for malnutrition have received much attention. A generally accepted view defines malnutrition as a deficiency or excess or imbalance of energy, protein or other nutrients causing measurable adverse effects on tissue or body form, function and clinical outcome (Elia, 2000).Malnutrition can occur with over-eating as well as under-eating. This research will focus primarily on protein energy malnutrition (PEM) or under-nutrition, which can occur in both underweight and overweight people. Key PEM elements are inadequate intakes of protein and energy associated with decrease in lean body mass (muscle) and possible loss of fat mass. PEM has widespread effects on the body and impacts on both physical and psychological function. Corish (Corish, 1999) in a paper discussing nutritional assessment, cited multiple complications associated with malnutrition including poor wound healing, higher post-operative infection risk, adverse functioning of the gastrointestinal tract, immune, cardiovascular and respiratory systems, increased mortality rate and longer convalescence with more frequent readmission to hospital. Quality of life has been shown to decline with poor nutritional status in gastrointestinal disease (Norman, Kirchener, Lochs, & Pirlich, 2006; Norman, Smoliner, et al., 2008). In a study of pressure ulcers and malnutrition in a Queensland hospital (Banks, 2008) found that malnutrition was associated with increased risk for a higher stage and higher number of pressure ulcers. The British Association for Parenteral and Enteral Nutrition has estimated the cost for disease related malnutrition in Britain for 2003 was approximately 7.3 billion pounds which was greater than the cost of treating obesity and obesity related disease (Russell, 2007).

Although few inpatients have protein energy malnutrition as a primary diagnosis, it occurs frequently in acute settings because of illness or surgery and associated increased requirements for protein and calories in combination with a decreased intake of protein and calories. In a study conducted in the Hunter New England region over 5 small rural hospitals, Seldon (2009) found prevalence rates for malnutrition to be 39% for patients over the age of 60years.

Although it is established that PEM arises from an inadequate intake of both protein and energy there is a need to fully define other aspects of the aetiology of PEM. The American Society of Parenteral and Enteral Nutrition (ASPEN) and the European Society for Parenteral and Enteral Nutrition (ESPEN) have proposed the following malnutrition nomenclature:

1. *Pure chronic starvation without inflammation (medical conditions like anorexia nervosa)*
2. *Chronic diseases or conditions that impose sustained inflammation of a mild to moderate degree (eg organ failure, pancreatic cancer, rheumatoid arthritis or sarcopenic obesity).*
3. *Acute disease or injury states with marked inflammatory response (eg. major infection, burns, trauma or closed head injury)(Jensen et al.,* 2010) *(page 157)*

This nomenclature acknowledges that there are differing metabolic responses within malnutrition depending on whether it is uncomplicated (1 above) or associated with disease or trauma (2&3 above). The rising levels of inflammation with the latter groups may be associated with anorexia (reduced protein and energy intake) and increased catabolism (increased breakdown of body tissues).

Screening for malnutrition

There have been recommendations that screening for malnutrition takes place within 24 hours of hospital admission (White, Guenter, Jensen, Malone, & Schofield, 2012). Ferguson et al (Ferguson, Capra, Bauer, & Banks, 1999) found that the Malnutrition Screening Tool MST, when used in acute hospitals with adults, was both sensitive and specific (both 93%). On the basis of ASPEN's and ESPEN's description of the mixed aetiologies for PEM, some presentations for PEM could be less easily identified. Screening people who may not be weighed on a regular basis may

not identify the problem and malnutrition may be missed. Patients who have been underweight all their lives, never eaten much and therefore do not report reduced appetite or weight loss will also score low on an MST. Similarly, overweight patients with no marked loss of appetite and some degree of inflammatory process may be at risk of malnutrition with stable fat stores and diminishing muscle mass. Seldon (2009) cited other possible problems with the screening process, including lack of time and complacency.

Assessment for malnutrition and monitoring progress

Once a patient has screened as high risk for malnutrition, an assessment needs to take place promptly to provide accurate diagnosis. The Patient Generated – Subjective Global Assessment (PG-SGA) (Detsky et al., 1987) is widely accepted for use in diagnosing malnutrition. The assessment tool uses the parameters of weight change, food intake, symptoms that impact on food intake, functional capacity, presence of disease or trauma, age relative to 65 years and presence of metabolic stress. It includes a physical examination (fat stores, muscle status and presence of oedema or ascites) to assess nutritional status. Using PG-SGA, patients are given a global assessment of either A (well nourished), B (moderate or suspected malnourishment) or C (severely malnourished) and this is combined with a numerical score, which assists in defining intervention.

However, SGA tools have some limitations. Problems again occur with the questions related to weight history and appetite changes. Malnourished patients may have BMI in the accepted or overweight range and body fat could mask the loss of lean body tissue (Bauer, Capra, & Ferguson, 2002)

The PG- SGA is not used alone but in combination with a dietary assessment that takes into account a number of other parameters. These include a diet history and investigation of any recent changes in food intake. Energy and nutrient needs are compared with an estimation of patient needs. The medical history is reviewed – noting diseases and conditions that impact on intake, absorptive capacity, increased nutritional needs and inflammatory conditions. Medications and their possible impact on nutritional status are considered. Pathology results are evaluated noting inflammatory markers and signs of poor status. There are however, few blood tests to assist in the diagnosis and monitoring of malnutrition in the short term. Markers of nutritional status such as albumin and ferritin are reduced by inflammation rather than malnutrition. Key workers in malnutrition (K. N. Jeejeebhoy, Detsky, & Baker, 1990) have stated that traditional markers of malnutrition lose their specificity in the sick adult.

The diagnosis of malnutrition is made on the basis of a lengthy consultation, which involves a degree of subjectivity. Once the diagnosis has been made, the progress and effectiveness of the patient management needs to be monitored. Malnutrition recovery is often too subtle to measure in the short term. The PG-SGA category and score may not change quickly even though there may have been improvement in both energy and protein intake.

The key feature of protein energy malnutrition and the main issue that clinicians wish to avoid is the loss of lean body tissue (muscle which is the chief store of protein within the body). Consequently some researchers have explored the use of muscle strength and function to evaluate protein status in patients. Muscle strength as an indicator of protein status, which impacts on functionality, could provide useful information. Body functionality could offer a means of assessing the level of malnutrition in a more objective manner. Physiotherapists have an established history of assessing muscle function using dynamometers. Handgrip strength (HGS) measurement by hand held dynamometer has been used by physiotherapists to assess the functioning of the hand and is quick and cheap to perform. A reading is obtained that has been found to be reliable and can be reproduced by another assessor using the standard technique(Mathiowetz et al., 1985). The readings can be compared with normative data for age and sex from healthy population groups (Massy-Westropp, Gill, Taylor, Bohannon, & Hill, 2011)

Windsor & Hill, (1988) found that handgrip strength was a sensitive measure of protein loss in surgical patients. Protein content of the body was measured directly by in-vivo neutron activation analysis and the authors concluded that HGS was a valid index of skeletal muscle mass. This was a pivotal study that has led to much research on HGS in particular patient groups in relation to PEM.

Research in severely depleted patients has demonstrated that muscle function shows altered force, lower maximal relaxation rate and increased fatigability and that these muscle abnormalities were reversed by re feeding (Gibson, 2005). Changes have been noted to take place

in the muscle before other changes that affected anthropometry and blood values have taken place (K. Jeejeebhoy, 2000). It has also been stated that nutrition exerts effects on muscle function independently of muscle mass (Stratton, Green, & Elia, 2003). A review paper by Norman et al (Norman, Stobaus, Gonzalez, Schulzke, & Pirlich, 2011) evaluating HGS as an outcome predictor and marker of nutritional status stated that their own research had found malnourished patients to have 25.8% lower HGS values compared to well-nourished patients (Norman 2005). The group had also found that HGS improved in a group of malnourished patients with benign gastrointestinal disease who were re-fed over a three-month period (Norman 2008). Norman et al had also conducted re-feeding work with a group of elderly patients, which was not as successful and reported other studies conducted by other workers that were in agreement. They suggested that frailty of aging was different to malnutrition.

The elderly are a complex group with multifactorial reasons for PEM. Muscle loss is expected to occur with age and this is demonstrated in the normative data tables for HGS (Mathiowetz, 1985, Massy-Westropp, 2011). A small study which was not included in the Norman et al review paper involved 17 malnourished elderly patients (Bos et al., 2001). Bos et al (2001) found that HGS increased by 35% in a supplemented group of malnourished women and concluded that HGS correlated with fat free mass (muscle) in frail elderly women so it could be used as a tool for assessment. Conversely (Williams, Driver, Older, & Dickerson, 1989) found no difference in any of the measurements, including HGS, in a group of elderly women at nutritional risk who had been admitted to an orthopaedic ward for fractured neck of femur for total hip replacement. Williams et al (1989) identified potential compliance issues with the oral nutrition supplement (ONS) regime administered at mid meal tea breaks.

Another study (Katakity, Webb, & Dickerson, 1983) looked at 12 clinically stable elderly patients in a long-stay hospital who were studied for 12 weeks. The patients were not identified as being at risk nutritionally. The ONS (milk based and vitamin fortified), which was provided during the supplementation period, was associated with increased HGS which declined when the ONS was withdrawn in the final stage of the study. Katakity et al (1983) reported that the most remarkable improvement occurred in one male patient who at the start of the study could not grip the dynamometer hard enough to provide a measurement. After receiving supplementation for one month his HGS rose to16kg and then to 21kg and 25kg. When supplementation ceased the HGS fell to 18kg after 2 weeks.

These studies are small but they indicate that improved nutritional status can be associated with improved HGS in the elderly.

Malnutrition is associated with many disease states and some researchers have targeted specific conditions to evaluate HGS and malnutrition. A study was conducted with 140 chronic heart failure patients to examine the association between body composition measured by Dual Energy X-ray Absorptiometry (DEXA) and prognostic factors for mortality. They found that higher lean body mass was associated with higher HGS (Oreopoulos et al., 2010).

Bin et al (Bin, Alvares-da-Silva, & Francesconi, 2010) compared HGS to other methods of assessing malnutrition in a group of 75 patients in remission from Crohn's disease (CD). Using HGS, 73.3% were identified as malnourished (2 standard deviations from the mean on standardized tables for the population) compared to 18.7% malnourished identified by SGA. They noted that while the sensitivity was high (78.6%) HGS had a very low specificity (27.9%), which would have implications for false positive diagnoses. They then considered that more work was required in order to fully evaluate HGS with CD - by using DEXA, inflammatory markers and clinical outcomes for patients. An incidence of 73.3% malnutrition seems particularly high for a group in remission, but the long term effects of an acute inflammatory disease and the medications to treat it, in combination with the nutritional impact of both malabsorption and bowel pain, could affect the long term muscle function and the desire to eat.

A study evaluating HGS as an indicator of nutritional status in 274 men and 162 women receiving maintenance haemodialysis was conducted in Brazil (Silva et al., 2011). Handgrip strength was measured in the arm without the arteriovenous fistula. The HGS was correlated with Malnutrition Inflammation Score – which has 10 features (7 from the SGA plus BMI, serum albumin and total iron binding capacity). They made adjustments for age, sex, race, months on dialysis and adequacy of dialysis and found that there was an association between poor HGS and higher levels of malnutrition and inflammation. The team reported that one of the limitations of the study included that the fistula may have been in the dominant arm for some people.

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Some specialist dietetic departments use HGS for their client group who are subject to fluid overload and are difficult to assess physically for example, renal and liver disease patients. The Dietitians Association Australia (DAA) website (accessed May 2011) held a PowerPoint presentation by (Heyman, May 2011) discussing the Jamar dynamometer when assessing nutritional status of patients in the liver unit at Royal Prince Alfred Hospital. Email contact (27 May 2011) further reinforced that she found it a very effective means of monitoring a patient's nutritional status:

"Grip strength reflects oral intake over the past few days, current protein status and is an early indicator of potential changes to muscle mass if current intake is continued. It is part of a nutritional assessment that I use to monitor pts over time, guide the advice I will provide at each visit and motivate pts to continue to improve or maintain their current oral intake."

Contrary to these findings text books (Mahan & Escott-Stump, 2008); (Mueller, 2012) and Evidence Based Practice Guidelines (DAA Malnutrition Steering Committee, 2009) have tended to simply list HGS as a method for further assessing a patient's status. There is no discussion of method (practice guidelines) or mention of any limitations.
However a consensus statement of the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition (White et al., 2012) has given very strong support for HGS in the assessment for malnutrition. They listed six criteria for the diagnosis of malnutrition which includes reduced functionality as measured by HGS. Although there was no discussion of its limitations they do indicate that there is no expectation of reduced function in moderate malnutrition. When interpreting the measurements obtained they stated "*consult normative standards supplied by the manufacturer of the measuring device.*" (table p 735)

Possible limitations of HGS as a tool to evaluate nutritional status

For clinicians seeking an objective measure to include in their process for evaluating malnutrition risk and assessing its management, HGS appears very exciting. However for the tool to be most effective the measurement must only be affected by skeletal muscle strength and while standardised normative data take into account age and sex, there are other variables that need to be considered.
Two papers that have evaluated HGS as a tool for malnutrition assessment have made the following suggestions regarding other variables that may impact on HGS. Windsor and Hill in their important 1988 paper discussed other factors in addition to age, sex and muscle mass which included posture, circadian rhythm, psychological state, sedative drugs, treatment options and the primary disease process. Pain, electrolyte status, metabolite concentration and motivation were other factors that were mentioned as impacting. Norman et al (2011) in their review paper stated that in acute or chronic disease, various factors influenced HGS including: co morbidity load, medical treatment, immobilization, inflammation, infection, endotoxemia, corticosteroids, muscle relaxants, hypoxia, electrolyte imbalances and oxidative stress.
Hand pain is likely to be an issue that impacts on HGS measurement. Coldham et al (Coldham, Lewis, & Lee, 2006) suggested only taking one HGS measurement for patients who are experiencing hand pain. Email contact with Heyman (27 May 2011) indicated that HGS was still useful in patients who had problems with their hands:

"The results will be affected by some conditions such as arthritis, sedation, amputated fingers or other previous injuries to the hands. As long as it is not painful for the pts to have their grip strength measured, I find in my pts with arthritis measuring grip strength is still a useful tool as it can improve with improved oral intake although it may remain well below normal".

Measurement of HGS by hand held dynamometer is also a voluntary activity and is dependent on the motivational levels of each patient, which may limit its effectiveness. Efforts to use involuntary muscle contractions via electrical stimulation (Medicine, 1997) clearly illustrate that it is impractical.

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There are issues occurring with the use of HGS for some patients as outlined in the email contact with Prof Vicki Baracos (May 2013) where she discussed assessment of physical functioning as a means of detecting muscle waste:

"… tests that variously evaluate upper limb function, lower limb function or composite functions such as the timed sit to stand test. Which one of these has the greatest specificity to detect malnutrition or sarcopenia, I think is debated. One thing that I have heard people say is that when older people start to use their arms to push themselves up out of a chair then their arms get relatively more work and can be somewhat spared compared to other parts of the musculature. On that basis one might expect a somewhat reduced sensitivity using handgrip strength…."

In addition to the possible confounding variables there is a lack of consensus on measurement protocols for HGS for nutritional assessment (Norman et al., 2011).Physiotherapists are able to test HGS on people who are essentially fit and well but the majority of inpatients that need nutritional assessment are likely to be unwell and in bed or resting in a chair. Hillman et al (Hillman et al., 2005) investigated posture in a sample of 55 well participants and found that two postures correlated well with each other – reclined in bed and seated in a chair with arm supported. The HGS measurements were made using a strain gauge dynamometer, which fitted neatly in the participants hands.

A review of the literature was conducted (Roberts et al., 2011) to establish some consensus when measuring HGS and they reported that the Jamar dynamometer was the most widely cited, accepted as a gold standard and had extensive normative data to support its use. They stated that the second handle position was commonly used although it may cause problems for those with long finger nails. They produced the Southampton protocol, which allowed for a seated position, testing both hands (3 measurements each hand alternating sides) and used the maximal HGS. The Jamar is a heavy dynamometer and does not fit neatly in the hand so the observer supported the weight of the dynamometer taking care not to restrict its movement. They recommended standard language to encourage maximum response from the patient. The Jamar is a hydraulic sealed system which measures the strength of the grip regardless of where the pressure is applied (Ward & Adams, 2007).

The cut off points for the identification of patients at risk of malnutrition by weak HGS are not clear or consistent between studies. Haverkort et al (Haverkort, Binnekade, de Haan, & van Bokhorst - de van der Schueren, 2011) investigated the use of HGS using a Jamar dynamometer to identify malnutrition in preoperative patients and evaluated four methods of making decisions previously used by four research teams (Matos, Tavares & Amaral, 2007; Webb, Newman, Taylor &Keogh, 1989; Alvares-da-Silva & Silveira,2005; Klidjian, Foster, Kammerling, Cooper & Karran 1980). However Haverkort et al reported that none of the cut off points had enough diagnostic accuracy to allow for introduction of HGS as a standard measure to detect malnutrition in their particular patient group.

A letter written to the journal in response to the Haverkort et al (2011) paper identified key areas that were lacking in the research (Amaral & Mendes, 2012). These included the limitations of evaluating HGS using the National Dutch Perioperative Nutrition Guideline which only looked at weight (percentage of unintentional weight loss over one and six months and BMI<18.5kg/m2). Amaral et al (2012) criticised the direct use of Webb et al team's cut off value as this team had used a different type of dynamometer (mechanical (Duffield Medical)). The Haverkort study was also criticised for having a low number of malnourished participants in their study group with which to answer their research question.

Haverkort et al (2012) had obviously been very keen to explore all options when evaluating ways to interpret HGS for patients for in their original report they included communication with Mathiowetz regarding using the normative data (Mathiowetz et al 1985) supplied with the Jamar dynamometer. Mathiowetz is reported as not recommending it be used for the purpose of malnutrition assessment. This reluctance is understandable, for Mathiowetz has not been working with malnourished patients. However using pre-existing normative data for malnutrition screening in combination with other assessment tools offers a guideline which could assist a clinician wishing to evaluate functionality. Cut off points may need to be evaluated for particular patient diagnostic groups. Two teams used 85% of normal value (Webb, Newman, Taylor, & Keogh, 1989) (Norman et al., 2005).

In addition to cut off points there is a need to decide which measurement to use – there are usually two functional hands and only one value can be used to make a decision. Some studies have used just the right hand to take measurements regardless of dominance. Some studies have used the non-dominant hand (Matos, Tavares, & Amaral, 2007), (Alvares-da-Silva & Silveira, 2005), (Webb et al., 1989), (Klidjian, Foster, Kammerling, Cooper, & Karran, 1980) (Norman et al., 2005). Another group of researchers measure HGS in both hands and then take the strongest measurement (Roberts et al., 2011). Cannulas and injury may mean that the hand of choice is not always available. At this stage many researchers have made decisions based on what appears to be art rather than science with respect to hand and measurement choice.

Why is this research important?

It is clear from the literature that a relationship has been established between HGS and muscle mass (Windsor & Hill, 1988);(Norman, Kirchner, et al., 2008);(Oreopoulos et al., 2010).There are concerns that other factors could impact on HGS including medications that affect muscle (Mor, Wortman, Mitnick, & Pillinger, 2011) and other variables suggested by Windsor &Hill (1988) and Norman et al (2011).Further supporting work needs to be conducted so there can be a greater level of confidence for use of this tool for all patients. Such work includes:

- Evaluating cut off point for HGS measurement to indicate risk of PEM.
- Protocol for conducting measurements .Which hand to use – dominant or non-dominant or test both individually. How to use the measurements - maximal strength or the mean of three measurements.
- Posture while measuring the HGS of patients weakened by disease and malnutrition. Often patients are in bed and the simplicity of HGS measurement would be lost if they need to adopt a seated posture.
- Impact of a patient's lifestyle and how this may affect HGS -characteristics of any manual work and sports or hobbies that may impact on muscle development in this area of the body. The level of general day-to-day activity.
- If certain medications are possibly affecting the HGS.
- The effect of certain disease states on muscle function.
- Is it possible that HGS is more accurately a measure of function rather than actual protein status? Both however are important factors in assessing a patient's recovery and nutritional status.

The project initially aimed to:
1. Determine if HGS is a useful tool for detecting and monitoring nutritional status (and this may include that they stay well nourished) in patients age 60 years and over in a rural hospital setting.
2. Develop a method for measuring HGS and then produce site specific practice guidelines to include:
   - Standardised typical posture encountered in hospital patients.
   - Standardised verbal encouragement for patients to generate maximal force when performing HGS measurements
   - How best to measure HGS. Whether to use one hand or individually measure both hands
   - If maximal or the mean of these measurements give most useful results
   - Effective cut off points for HGS that will assist in the diagnosis of malnutrition.

Research Question:
Can the dynamometer provide a precise and reliable tool to identify patients with malnutrition in a rural hospital? (Malnutrition refers to insufficient protein and energy and is referred to as Protein Energy Malnutrition or PEM.)

Null hypothesis 1:
Hand Grip Strength (HGS) alone is not useful in diagnosing malnutrition in this patient group.

Alternative hypothesis 1:

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Hand Grip Strength (HGS) enhances diagnosis of malnutrition in this patient group.

Null hypothesis 2:
In the short term Hand Grip Strength does not change significantly to indicate a change in nutritional status.

Alternative hypothesis 2:
Hand Grip Strength (HGS) is lower in patients with malnutrition and will increase with re feeding.

Methods
Study design
This cross sectional analytical study aimed to investigate how useful HGS was for adult inpatients in the Bega District Hospital (80 bed rural hospital) on the far south coast of New South Wales in the assessment of their nutritional status with respect to PEM. The study commenced 29 October 2012 and was completed 25 March 2013.

Participants were male or female, 60 years and older and inpatients on either surgical or medical wards. They were able to follow instructions and use a hand held dynamometer with one or both hands. Excluded from the study were patients who were transferred from the mental health unit, day surgery patients, and patients at the end of their life. Potential participants for the study were identified after consultation with the Nursing Unit Managers (NUM) and nurses caring for the patients.

The principal researcher approached patients identified by nursing staff on the ward level and informed them of the study and provided them with the patient information sheet. Written consent was obtained from those who were willing to participate in the study. Regular recruitment sessions were conducted until an adequate sample size was achieved.

Sample size
Sample size was calculated allowing for age, sex and a predicted 2:1 ratio of well-nourished to malnourished participants. A sample of 124 was determined, with a higher figure of 241 required if multiple logistic regression was to be used.

Screening Stage 1
Prior to testing HGS the participant was asked questions relating to dominance of hands (which hand had more power, which hand they wrote with), activity levels and hand problems, such as, arthritis, injury and pain and which hand or hands were affected.

Measurement of hand grip strength
HGS was measured by only one of the co-researchers using the Jamar hydraulic hand held dynamometer (Lafeyette Instrument, Indianapolis, IN). After demonstrating the technique, the researcher instructed the participant using a predetermined script (appendix 1).

The posture of the patient at the time of HGS was following the protocol of either sitting in a hospital chair with arm support (appendix 2 figure 1) or reclined in bed with arm support (folded hospital towel under their forearm) (appendix 2 figure2). Posture was recorded. Handle position was recorded and position two was maintained throughout the study. The researcher supported the weight of the dynamometer as per the photograph in the appendix - similar but not identical to the Southampton protocol (Roberts et al 2011). This method assisted in detecting when participants were inadvertently raising their arm in an attempt to get more power. Both hands were individually tested for HGS unless there was injury, disease or discomfort preventing this. The measurement commenced with the dominant hand and three handgrip measurements were taken with a brief interval between them as the measurement was recorded and the measure was returned to zero. The grip was held for three seconds. Hand grip strength was recorded to the nearest kilogram and the maximum and the mean scores were recorded. A period of 2-3 minutes was allowed between measuring dominant and non-dominant hands. The time of day that the HGS was measured was recorded.

Other data recorded at the time of HGS measurement

Questions were asked regarding dietary intake prior to HGS measurement and the number of hours since they had last eaten. The number and type of supplements were recorded. The medical records were consulted for the number of days since admission, the number of medications and noting those that may impact on HGS (appendix 3) and if there were any form of neurological condition. Living arrangements were also identified.

In order to assess the usefulness of HGS in screening for malnutrition other data was recorded - direct observation of appearance and the MST (Malnutrition Screening Tool) score from the nursing admission sheet which was either conducted by nursing staff or the principal researcher.

Anthropometry

Anthropometry was collected by one of the co researchers (International Society for Advancement of Kinanthropometry ISAK level 1)

Height was measured using the stadiometer on the ward to the nearest 0.5cm. If the patient was unable to stand, height was reported or estimated from ulna length (rxkinetics.com/height)

Weight was measured on ward weighing scales to the nearest 0.1 kg either on the standing scales or on chair scales if the patient was unable to stand to be weighed. If the patient was unable to be weighed at the time of assessment, the weight was then taken from medical notes or reported. Weight and height was used to calculate BMI (weight (kg) /height (m²))

Mid Upper Arm Circumference (MUAC) was measured (to the nearest mm) using the Lufkin W606PM flexible steel measuring tape, on both sides of the body unless affected by injury or disease. Two measurements were taken at each site, if the second measure was not within 5% of the first measure, a third measure was taken.

Triceps skin fold (TSF) was measured (to the nearest 0.1 cm) using the Slim Guide skinfold calliper (range: 0.00-80.00) on both sides of the body unless affected by injury or disease. Two measurements were taken at each site, if the second measure was not within 5% of the first measure, a third measure was taken. Measurements for TSF were not taken if excess body fat or unequal distribution of body fat affected the reliability of the measurement.

The participants were asked to stand in a relaxed position, with their arms hanging by their sides, (hands in the mid-prone position for the TSF), as per ISAK protocol. However, most of the measurements were taken with the patient sitting on the edge of the bed as they were unable to stand.

Mid Arm Muscle Area (MAMA) was estimated using:

$$\text{MAMA (cm}^2\text{)} = \frac{(\text{MUAC (cm)} - (\pi \text{TSF (cm)}))^2}{4\pi}$$

This was then corrected for males (-10) and females (-6) (Heymsfield, McManus, Smith, Stevens, & Nixon, 1982).

Participants that passed into the second stage (flow chart appendix 4) did so on the basis of having a MST score ≥2 or on the basis of direct observation – appeared emaciated.

Assessment Stage 2

Participants that entered the second stage were given a full nutrition assessment, which included medical history. A PG-SGA was conducted for the diagnosis of malnutrition.

Further follow up was not possible due to discharge of patients to other facilities. Due to low numbers in the study there is no formal report for the proposed stages 3-4 which were monitoring while in hospital and monitoring after discharge.

Those participants who were not considered at risk of malnutrition or diagnosed with malnutrition at stage 1 or 2 were screened on a weekly basis for HGS (flow chart appendix 4).

Statistical analysis
Normalised data

The Jamar dynamometer handbook provides normative or reference data that use 5-year age groupings (Mathiowetz et al., 1985) however there were insufficient participant numbers in some of these age groups and in order to protect the privacy of research participants, Australian derived normative data (Massy-Westropp et al., 2011) were used as a reference for handgrip strength. This

data is presented in broader age groupings and for this study this meant two age groups comprising 60-69 year olds and the 70 years and over (appendix 5)

Sensitivity of screening
The sensitivity of HGS as a tool in screening for malnutrition was calculated for those participants who were administered PG-SGA (n=30), using three different HGS cut-offs 65%, 75% and 85% of the normative or reference data. Values at or below the cut off were deemed as weak. Sensitivity was calculated using the standard formula:

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Two thirds of the participants (n=66) indicated low level physical activity. Some of the participants were still working on properties, using both of their hands in the garden, using tools working on engines, changing gears when truck driving.

Malnutrition screening

Malnutrition risk by MST revealed that 21 participants were at increased risk of malnutrition. Direct observation by clinical staff revealed another four participants at increased risk. Clinical staff referred 8 study participants for nutritional assessment on the basis of long term multiple health problems.

Seven high risk participants were lost to assessment because of discharge or transfer. Thirty participants were assessed by PG-SGA. Twenty six participants were found to be malnourished by PG-SGA. Six of these were severely malnourished.

Malnutrition screening by direct observation and MST identified only 69.2% of the 30 patients who needed to be further assessed by PG-SGA. Malnutrition risk determined by direct observation, MST and a HGS of less than 65% of the normative value, increased the sensitivity to nearly 77%. Malnutrition risk determined by direct observation, MST and a HGS of less than 85% of the normalised values, increased the sensitivity to 88.5% (table 1).

Table 1   Sensitivity of HGS as a screening tool for malnutrition

Method	Sensitivity
Direct observation and MST	69.2%
Direct observation, MST and HGS 65% normative value	76.9%
Direct observation, MST and HGS 75% normative value	76.9%
Direct observation, MST and HGS 85% normative value	88.5%

There was an association between increased risk of malnutrition as determined by MST and direct observation and a weakened HGS using the dominant hand for both the maximum HGS (p value = 0.021) and the mean of three HGS (p value= 0.017) (table 2).

HGS and diagnosed malnutrition. There was no direct association found between moderate to severe malnutrition (as diagnosed by PG-SGA) and HGS (table 3). This may reflect the problems with a small sample of malnourished participants (n= 26) and that an even smaller sample of these (n=6) were severely malnourished.

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Table 2   Test of association between malnutrition risk (direct observations and MST) and HGS

Muscle weakness determined by hand (measurement)	Level	Not at risk (N=72)		At risk (N=24)		Overall	Odds Ratio	P-value
		N	(%)	N	(%)			
Left hand dysfunction (max)	Missing	7	(9.7)	1	(4.2)	8		
	No	46	(63.9)	9	(37.5)	55	3.8(1.4,10)	0.011^
	Yes	19	(26.4)	14	(58.3)	33		
Left hand dysfunction (mean)	Missing	7	(9.7)	1	(4.2)	8		
	No	43	(59.7)	9	(37.5)	52	3.0(1.1,8.1)	0.029^
	Yes	22	(30.6)	14	(58.3)	36		
Right hand dysfunction (max)	Missing	2	(2.8)	0	(0)	2		
	No	46	(63.9)	10	(41.7)	56	2.7(1.0,6.9)	0.054^
	Yes	24	(33.3)	14	(58.3)	38		
Right hand dysfunction (mean)	Missing	2	(2.8)	0	(0)	2		
	No	44	(61.1)	8	(33.3)	52	3.4(1.3,9.0)	0.017^
	Yes	26	(36.1)	16	(66.7)	42		
Dominant hand dysfunction (max)	Missing	5	(6.9)	0	(0)	5		
	No	47	(65.3)	10	(41.7)	57	3.3(1.3,8.6)	0.025^
	Yes	20	(27.8)	14	(58.3)	34		
Dominant hand dysfunction (mean)	Missing	5	(6.9)	0	(0)	5		
	No	45	(62.5)	9	(37.5)	54	3.4(1.3,9.0)	0.015^
	Yes	22	(30.6)	15	(62.5)	37		
Dominant hand (unless missing) dysfunction (max)	No	49	(68.1)	10	(41.7)	59	3.0(1.2,7.7)	0.021*
	Yes	23	(31.9)	14	(58.3)	37		
Dominant hand (unless missing)dysfunction (mean)	No	47	(65.3)	9	(37.5)	56	3.1(1.2,8.2)	0.017*
	Yes	25	(34.7)	15	(62.5)	40		

^ Fisher's Exact Test
* P-value < 0.05

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Table 3   Univariate tests of association between personal characteristics and muscle weakness indicated by the mean HGS of the dominant hand

Variable	Level	No muscle weakness (N=56) N	(%)	Muscle weakness (N=40) N	(%)	Overall	Odds Ratio	P-value
Sex	Female	36	(64.3)	17	(42.5)	53	2.4(1.1,5.6)	0.034*
	Male	20	(35.7)	23	(57.5)	43		
Age group	60-69 year olds	23	(41.1)	11	(27.5)	34	1.8(0.8,4.4)	0.17
	70+	33	(58.9)	29	(72.5)	62		
Living arrangements[#]	Alone/Other	17	(30.4)	15	(37.5)	32		
	Partner/Family/Aged care	36	(64.3)	23	(57.5)	59	1.4(0.6,3.3)	0.743
	Missing	3	(5.4)	2	(5)	5	1.3(0.2,9.0)	0.899
Dominant hand	Left or Ambidextrous	8	(14.3)	2	(5)	10	3.2(0.6,16)	0.186^
	Right	48	(85.7)	38	(95)	86		
Recent physical activity	Medium/High physical activity	19	(33.9)	11	(27.5)	30	1.4(0.6,3.3)	0.503
	Negligible to low physical activity	37	(66.1)	29	(72.5)	66		
Hand Problems	No	26	(46.4)	14	(35)	40	1.7(0.7,3.8)	0.294^
	Yes	29	(51.8)	26	(65)	55		
Neurological problems	No	50	(89.3)	29	(72.5)	79	3.8(1.2,12)	0.026*
	Yes	5	(8.9)	11	(27.5)	16		
Posture for HGS	Bed	39	(69.6)	25	(62.5)	64	1.4(0.6,3.2)	0.464
	Chair	17	(30.4)	15	(37.5)	32		
Medications associated with muscle loss	None of these medications	16	(28.6)	8	(20)	24	1.8(0.7,4.9)	0.331^
	1 or more of the identified medications	32	(57.1)	29	(72.5)	61		
Discharge destination[#]	Aged Care or other health facility	11	(19.6)	11	(27.5)	22		
	Home	44	(78.6)	27	(67.5)	71	1.6(0.6,4.3)	0.228
	Missing/Deceased	1	(1.8)	2	(5)	3	0.5(0.04,6.4)	0.453
PG-SGA rank[a]	A	2	(15.4)	2	(11.8)	4	1.4(0.2,11.2)	1
	B or C (malnourished)	11	(84.6)	15	(88.2)	26		

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Table 3 (cont) Univariate tests of association between personal characteristics and muscle weakness indicated by the mean HGS of the dominant hand

Explanatory variable	Level	No muscle weakness (N=56)		Muscle weakness (N=40)		Overall	Odds Ratio	P-value
PG-SGA Score[a]	<9	3	(23.1)	2	(11.8)	5	2.3(0.3,16.0)	0.628
	≥9	10	(76.9)	15	(88.2)	25		
Height (cm)[I]		167.8	(10.4)	165.7	(8.7)	(n=88)		0.253
Weight (kg)[I]		79.1	(21.3)	72.9	(21.4)	(n=88)		0.944
LOS (days)[I]		8.4	(8.8)	13	(16.4)			
Mid Upper Arm Muscle (Right arm)[I]		47.8	(15.3)	42.4	(14.3)	(n=74)		0.721
Total number of medicines[I]		9.8	(3.5)	9.4	(3.5)	(n=90)		0.862

Missing values omitted unless otherwise stated

* P-value < 0.05

^ Fishers' Exact Test

Logistic regression

[a] N=30

[I] Mean(SD); Two samples t-test for difference

Anthropometry and malnutrition There was no association between anthropometrics (BMI, MUAMA) and malnutrition status with this group (appendix 6).

Discussion

This study provides support for the use of HGS in malnutrition screening in combination with MST and direct observation. The mean of three HGS measurements from the dominant hand offered the greater association with malnutrition risk compared to the maximum of the three measurements. This finding is supportive of the concept that malnutrition is associated with altered force and increased fatigability (Gibson, 2005). Fatigability may only be recognised by the three repeat measurements. Using an 85% cut-off point of the normative value offered greater sensitivity in this group of participants.

More research will be required to answer the research question and hypotheses that were posed. This small study lacked sufficient malnourished patients (26 out of the total of 96 subjects) and had insufficient flow through the stages (9 of 96 patients reached stage 3 and one reached stage 4) Consequent data analysis focused on the screening to nutrition assessment stages. (Stages1 - 2 as per the flow chart appendix 4).

The results provide support for the hypothesis that HGS alone is not useful in diagnosing malnutrition in this patient group, as there was poor association with HGS and malnutrition as diagnosed by PG-SGA. This at first was surprising after the association found with increased risk of malnutrition (by MST and direct observation) but it may reflect the problems with a small sample of participants who had malnutrition diagnosed by PG-SGA (n=26). White et al (2012), who strongly support the use of HGS in documentation to support a diagnosis of malnutrition, state that reduced hand grip strength for moderate malnutrition is not applicable.

The aetiology of malnutrition (Jensen 2011) and the duration of malnutrition could impact on HGS - this was not always known. Norman et al (2011) suggested that muscle strength in elderly people is possibly more related to frailty than nutritional status.

Within this group of participants HGS was observed to show great variation. Hand grip strength relative to normative or reference values may not be the method of choice for all patients. Those with increased upper body strength as a result of increased upper body activity or reduced function of lower limbs may suit another functional assessment. Some participants were malnourished on the basis of PG-SGA but had normal HGS for age and gender. This may reflect their individual above average strength. This may alter with nutritional status.

Normative data may be useful but everyone may have their own HGS which may change with nutritional status. The HGS measurement could be considered rather like pathology results where the changes that occur over time sometimes offer more information than individual measurements. If HGS can be measured at an earlier stage eg pre admission clinic, the change or lack of change could be the real indicator. Allowing the patient to be their own control in these circumstances could be the most effective means of using HGS.

In addition to the small numbers, bias may have occurred when older, sicker patients declined take part.

Other factors that could have impacted on HGS had no significant effect eg medications associated with muscle weakness. Medication associations may not be observed in all patients.

Low numbers of malnourished patients made it impossible to present case studies and describe some of the value of HGS as perceived by the researchers when monitoring participants. Benefits included patients relating to their measurements and finding encouragement with increased maximal values. Benefits for the researchers included a glimpse of positive HGS change relating to change in circumstances. This was very subtle for the mean of the HGS but much more obvious for the maximal HGS. This study also demonstrated how a fall injury caused the dominant hand to bear the brunt of the injury and the non-dominant hand was the only hand that could be used for the HGS measurement. There were some cases of very thin people achieving hand grip strength measurements above the cut off points and this may reflect the type of patient often seen in a rural hospital - still working with animals and doing some degree of manual work. This may account for the wide variation observed in HGS and the lack of association with diagnosed malnutrition in this study.

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While in the process of writing up this report another study in press (Flood, Chung, Parker, Kearns, & O'Sullivan, 2013) was found which had been evaluating HGS in an Australian metropolitan hospital. They achieved a good level of participation (n=217) and found that HGS was a good predictor of nutrition status as defined by PG-SGA. They found a high proportion of malnourished participants - well-nourished patients (n=45), moderately malnourished (n=148) and severely malnourished (n=24). They used a predictive equation for HGS based on age, sex and BMI and then expressed HGS as a percentage of predicted HGS. These patients were also directly referred for dietetic intervention, possibly leading to the strong associations found in this study.

Strengths of the study.
- The clearly defined researcher roles for HGS measurement and anthropometry were maintained throughout the study.
- Standard clear instructions were given consistently for HGS measurements.
- This study is the first to look at HGS in a mixed sample of patients in a rural Australian hospital.

Limitation of the study
- Patients were at various stages of admission. Greater understanding of HGS could have been obtained with earlier contact.
- The study relied upon consultation with nursing staff for referrals to potential participants for the study – not all staff was familiar with all of the patients on the ward level. Time constraints restricted full consultation with all nursing staff who were directly involved in patient care.
- The small proportion of malnourished patients.
- Patients were moved to another facility (local or out of area) and this impeded the process in all stages of the study. There was a plan to conduct the study in the other local facility and ethics had approved this amendment but other work pressures did not allow for the timely follow up of these participants.
- Attempts were made to take HGS measurements at the same time of day but this was not always possible.
- Although HGS had been demonstrated by Hillman (2004) as comparable between the reclined (bed) and seated (chair) postures there was subtle difference with the posture for the reclined position in this study – arm resting on a folded towel (bed) and the seated posture hand extended over the edge of the arm of the chair.
- Older, sick and weak patients were less likely to participate in the study.

Conclusion

There is no single test that can be used by clinicians in a rural facility to assess malnutrition. The literature provides a clear understanding that HGS is useful in the evaluation of PEM in conjunction with other parameters.

White et al (2012) in their consensus statement on the characteristics recommended for the identification of malnutrition clearly outline characteristics of malnutrition and state that two or more these characteristics are required to make an assessment of malnutrition. There is however a proviso at the bottom of the table *"Changes are anticipated as new research becomes available" (*page 735).This was possibly not aimed at HGS but the whole field of malnutrition assessment. However HGS is the area that has the least clarity for clinicians.

This small study has provided an insight into both the potential and the limitations of HGS. In this group HGS increased the sensitivity of screening in conjunction with standard practice. Hand grip strength is a simple objective indicator of functionality and is therefore a valid item to measure when assessing nutritional status. Hand grip strength should be used in conjunction with standard tools and clinical judgement when establishing nutritional status.

Recommendations
Management

Although dietetic and nursing staff have the interest and the ability to screen for malnutrition there is not the staffing levels to ensure that this takes place. Ideally all patients admitted to a facility should receive thorough malnutrition screening. While conducting this study the MST was largely filled out by the principal researcher (80%).

As malnutrition incidence is approximately 39% for patients over the age of 60 years within some rural hospital facilities in rural NSW (Seldon, 2009) there is a need for additional allied health

assistants to complement the role of the dietetic and nursing staff. They could conduct nutrition screening which could include HGS, MST, and routine anthropometric checks on admission. Using HGS at the same time as standard screening would increase the sensitivity of the process. Handgrip strength may offer a much more robust objective test in a week's time than a repeat MST alone. The allied health assistant would provide a pivotal role in ensuring timely referral and nutrition support with subsequent improved outcomes.

Implications for practice
1. Hand grip strength enhances standard nutrition screening.
2. HGS offers another dimension to standard nutrition assessment as it is an objective measure. It would not be appropriate to use it alone as there is too much individual variation in HGS.
3. Need for site specific practice guidelines to ensure consistent results.
4. Need to measure HGS as close as possible to a patient's admission.
5. Need to consider inter-professional approach to malnutrition assessment with input from physiotherapy for additional testing of functionality that goes beyond HGS.

Further Research
1. Sensitivity and specificity of hand grip strength (HGS) in screening for malnutrition in hospital inpatients aged 60 and over. A study involving University of Wollongong student dietitians on combined clinical and research placement at BDH in 2014 – this is only at the proposal stage.

2. Consider a retrospective study evaluating HGS in patients screened as at increased risk of malnutrition and how their HGS responds to re-feeding- if we are able to introduce routine HGS measurements for all inpatients.

3. Further analysis of the use of the mean of the dominant hand measurements for diagnosis.

4. Establish what constitutes clinically significant amounts of change in the mean HGS. Will the maximum HGS achieved in the screening stage offer a significant change to aim for when re-feeding?

5. Establish the effects of comorbidity on HGS.

6. Evaluate the use of bulb dynamometer as an alternative to the Jamar dynamometer for patients with hand problems (AUSPEN conference 2012 Prof Jürgen Bauer promoting the bulb dynamometer for patients with hand problems).

7. Proposal to evaluate quality of life and vitamin D status with HGS in conjunction with the visiting renal specialist and nursing staff in the renal dialysis unit.

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Appendix 1: Guidelines for Measuring HGS

Guidelines for conducting HGS by hand held dynanometer for the purpose of nutritional assessment at BDH

Taking the measurement
- Using the Jamar hand dynamometer
- Using data collection form **record all measurements and relevant information.**
- Folded towel to support the arm – reclined posture in bed

Ask questions to determine the dominant hand, the extent of any hand problems and the effect of activity on hand strength – record the responses on the form. Record date and time of day.

Patient posture As per Hilman et al 2004 seated or reclined in bed (with adjustments).
either
i) Seated (standard comfortable hospital chair) with arm rest (arms supported) wrist just over the edge of the arm of the chair. Both feet on the floor. **See photo appendix 2 or**
ii) Reclining in bed (30° angle) <u>Forearm supported</u> (on a folded towel). Legs stretched out comfortably. **See photo appendix 2**
Record posture

For <u>all</u> patients
- Elbow in 90 ° flexion.
- Shoulder adducted and neutrally rotated.
- Wrist neutral.
- The tip of the dynamometer supported by the researcher.
(as per Roberts et al 2011. "support the weight of the dynamometer ….but care not to restrict its movement") **See photos.appendix 2**
- Handle position- position 2. Patients may require handle position change in some circumstances – long finger nails etc. Record handle position.

<u>Clear instructions to the patient</u>
Demonstrate how they will hold the machine and how it functions.
<u>Inform the patient:</u>
The handle will not move with their hand grip <u>but</u> it will measure the force that they exert.
The test is to evaluate nutritional status only.

<u>Set instructions given to each patient when measurements are taken</u>
"Are you ready? …
*Squeeze as hard as you can.
**Harder!…Harder!…Relax." (*A/ Professor Chiarelli received as email Oct 2011 Powerpoint presentation for Physiotherapist students at Newcastle University).

- Both hands individually tested for hand grip strength unless injury, disease or discomfort (eg canula) prevent this
- Measurement commences with the dominant hand
- Three hand grip measurement taken for each hand. The grip held for 3 seconds. Hand grip strength recorded to the nearest kilogram. Calculate the mean of 3

measurements. A period of 2-3 minutes allowed between measuring dominant and non-dominant hand.
- Ensure that the measure is returned to zero after recording the measurement.
- Infection control. Wipe the dynamometer with alcohol wipe after conducting measurements on a patient.

Appendix 2: HGS Postures

Figure1
Student demonstrating seated posture

Figure 2
Orthopaedic patient only able to have reclined posture

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Appendix 3: Drugs Associated with Muscle Weakness

Disease state	Group of drugs	Names
Cardiovascular disease	**Lipid lowering –statins** (HMG-CoA) – *most prevalent drug induced myopathies*	Simvastatin – Zocor, Lipex Pravastatin- Pravachol,Lipostat Atorvastatin - Lipitor, Torvast, Caduet Rosuvastatin – Crestor Lovastatin – Mevacor, Altocor, Altoprev Fluvastatin – Lescol Pitavastatin – Livalo, Pitava
	Lipid lowering - Fibrates	Benzofibrates – Bezalip Cipofibrate – Modalim Clofibrate – Gemofibozil – Lopid (inhibits statin elimination) Fenofibrate – Triclor
	Lipid lowering - other	Niacin (Nicotinic acid) Ezitimibe
	Antiarrhythmic agents	Amiodarone Procainamide Labatalol
	Other **cardio active drugs** after prolonged admin may cause problems	aminocaproic acid, warfarin calcium channel antagonists – diliazem
Rheumatologic drugs	**Corticosteroid drugs**	fluorinated glucocorticoids: triamcinolone betamethasone dexamethosone
	Other immune modulating drugs	Colchicine Chloroquines cyclosporine tacrolimus (Prograf) d-Penicillamine Azathiopirine Gold therapy Infliximab Interferon
Infectious disease drugs	**Antiviral agents**	Zidovudine Didanosine Lamivudine Zalcitabine
	Anti fungal and anti bacterial	Ketoconzole Itraconzole Rifampin Quinolone derivatives

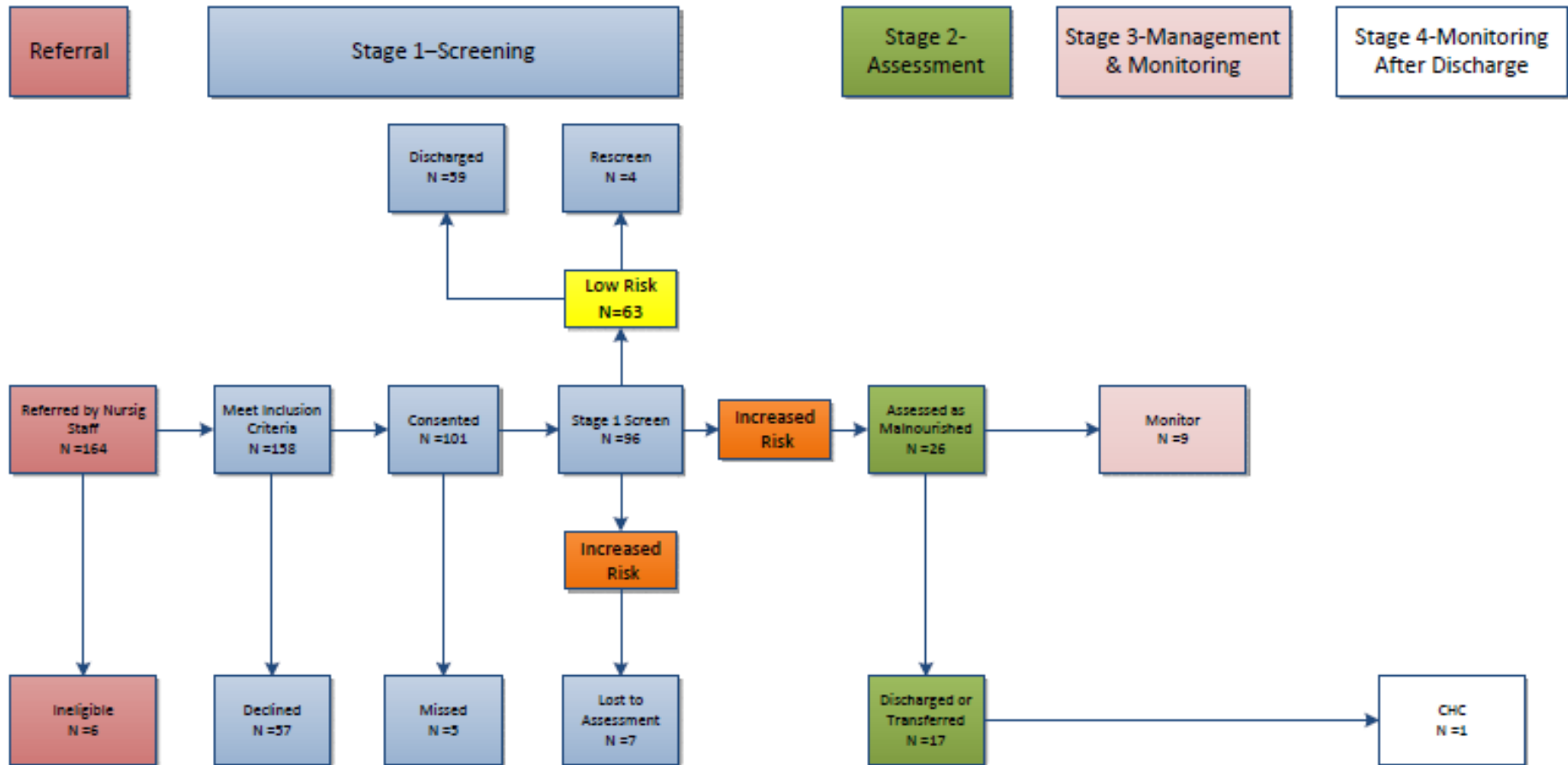|		
Oncology drugs		Vincristine Imatinib mesylate Leuprolide acetate – 5 – azacytidine, cytarbine Cyclophosphamide + mitoxantrone All-trans retinoic acid
Gastrointestinal drugs		Omeprazole Other PPIs Cimetidine or Ranitidine
Neurologic and Psychiatric drugs		Phenytoin hypersensitivity Valproic acid Levodopa
	Anti Psychotics	Clozapine, Risperdone, Melperone, Olanzapine, Loxapine Haloperidol
	Anti depressants	Tricyclic antidepressants and MAOI also -rarely implicated
		Succinylcholine- muscle relaxant Halothane – inhaled anaesthetic

Drug induced myopathies range from asymptomatic serum CK level elevations to severe rhabdomyolosis

Reference
Drugs causing muscle disease – Mor et al
Rheum Dis Clin N Am 37 (2011) 219–231

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Appendix 4: Patient Flow Through the Study

Appendix 5: Table of HGS Normative Data with 85% Cut Off Points

Age	Men				Women			
	HGS right (kg)		HGS left (kg)		HGS right (kg)		HGS left (kg)	
	Mean	85% of mean	Mean	85% of mean	Mean	85% of mean	Mean	85% of mean
60-69	40	34	38	32.3	24	20.4	23	19.6
70+	33	28	32	27.2	20	17	19	16.2

Data (mean) taken from (Massy-Westropp et al., 2011)

Appendix 6: Table of Association Between Mean HGS of the Dominant Hand and Continuous Variables

Explanatory variable	No			Yes			
	N	Mean	Std. Dev	N	Mean	Std. Dev	P-value
BMI	50	27.97	6.93	38	26.32	6.9	0.986
HGS_LHS_max1	52	29.37	9.45	36	21.39	8.47	0.497
HGS_LHS_mean1	52	28.18	9.21	36	19.94	7.96	0.364
HGS_RHS_max1	55	30.09	7.97	39	19.92	6.94	0.376
HGS_RHS_mean1	55	28.71	7.68	39	18.69	6.78	0.425
LOS	56	8.39	8.77	40	12.95	16.36	0
MUAM_LHS	46	47.15	15.67	28	43.54	14.58	0.7
MUAM_RHS	46	47.78	15.25	28	42.39	14.26	0.721
Tot_num_meds	51	9.82	3.45	39	9.44	3.53	0.862
Weight	50	79.12	21.26	38	72.94	21.44	0.944