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Malnutrition and Handgrip Strength in Hospitalized and Non-Hospitalized Children 6-14 Years Old

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A thesis submitted to the faculty of
Brigham Young University
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ABSTRACT

Malnutrition and Handgrip Strength in Hospitalized and Non-Hospitalized
Children 6-14 Years Old

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Background: Malnutrition is concerning in children because it effects proper growth and development. Handgrip Strength (HGS) has been identified as a diagnostic indicator for identifying pediatric malnutrition but normal reference ranges have not yet been established; therefore, HGS can be used to identify malnutrition but not quantify the degree of malnutrition: mild, moderate, or severe. The aim of this study was to determine if HGS differed between hospitalized and non-hospitalized children and to describe the association between HGS and several parameters including height, weight, body mass index (BMI), and mid-upper arm circumference (MUAC). *Methods:* One hundred nine hospitalized and 110 non-hospitalized pediatric patients ages 6-14 years participated in this cross sectional, nonequivalent control group design study. Nutrition status was evaluated using BMI z scores and MUAC z scores, and HGS was evaluated within 48 hours of hospital admission or at a well-child appointment. *Results:* According to BMI z scores, 24.8% of hospitalized and 18.3% of non-hospitalized participants were malnourished. Mean HGS of hospitalized participants was not significantly different from non-hospitalized participants ($p=.2053$). HGS was found to be associated with age, height, dominant hand, and MUAC *z* scores in all participants. *Conclusion:* The difference in HGS measurements was not statistically significant between hospitalized and non-hospitalized children using a one-time HGS measurement. Further research examining HGS measurements over time as well as comparing HGS measurements to the degree of malnutrition deficit in pediatrics is needed.

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ABSTRACT

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INTRODUCTION

Obtaining adequate nutrition is essential for the proper growth and development of children. The American Society of Parenteral and Enteral Nutrition (ASPEN) has defined malnutrition as "an imbalance between nutrient requirement and intake, resulting in cumulative deficits of energy, protein or micronutrients that may negatively affect growth, development, and other relevant outcomes."[1] Malnutrition encompasses both undernutrition and overnutrition. For the purposes of this paper, malnutrition is used in the context of undernutrition.

In developed countries malnutrition is typically the result of disease or illness.[2] Malnutrition can develop through malabsorption of nutrients, increased nutrient losses, increased energy expenditure, and altered utilization of nutrients.[1,3] The consequences of malnutrition include more complicated hospitalizations and adverse consequences which lead to increased length of hospital stay, increased costs, decreased ability to fight infections, poor or delayed wound healing, slower obtainment of pre-hospitalization activity level, the development of other diseases, and if not treated morbidity and mortality.[3-8] In a study of 175 children ages 31 days to 17.9 years, researchers found that malnourished children had a higher rate of infectious complications compared to well-nourished children and increased postoperative length of hospital stay.[9] Another study of 385 critically-ill children admitted to the intensive care unit (ICU) found that 45.5% of the children were malnourished upon admission and had a greater length of hospital stay and required longer mechanical ventilation.[10] Effective and early diagnosis and treatment of illness-related malnutrition is necessary to improve patient outcomes and decrease length of stay and other medical expenses.

Malnutrition is concerning in children because it affects proper growth and development. Thus, timely and accurate identification of malnutrition in children is critical. The Academy of

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Nutrition and Dietetics (AND) and ASPEN have recommended several indicators to assess and identify malnutrition including but not limited to growth parameters according to growth charts, standardized z scores for BMI-for-age, weight-for-height, length/height-for-age, mid-upper arm circumference (MUAC), as well as handgrip strength (HGS).[11]

Growth is the primary outcome measure of nutrition status in children.[1] Early identification of malnutrition is crucial so that stunting, a common and non-reversible consequence of chronic malnutrition, does not develop.[12] MUAC is another anthropometric measurement that can be used to evaluate nutrition status. A study examining the relationship between MUAC and malnutrition of 135 children found that MUAC was decreased in children with acute malnutrition providing evidence that MUAC is a useful parameter to identify children who are at risk for or are malnourished.[13] There is a close relationship between MUAC and BMI,[14,15] and MUAC may predict poor outcomes better in acutely hospitalized patients.[16] Dasgupta et al.[15] conducted a study of 194 adolescent male students, ages 10-19 years and found that MUAC is more sensitive in identifying malnutrition than BMI. MUAC is also an important and useful measurement for individuals whose weight may be influenced by lower extremity edema, ascites, and steroids. The World Health Organization (WHO) and the United Nations Children's Emergency Fund (UNICEF) through a longitudinal study found that MUAC identifies children at higher risk for malnutrition better than weight for height measurements.[17]

Handgrip strength is a measurement of functional status. Measuring HGS is easy, non-invasive, and inexpensive and may lead to earlier identification of malnutrition in children. HGS reacted faster to changes in nutritional status compared to other anthropometric and biochemical measurements in children older than 6 years.[3,9] HGS is associated with height, weight, age, and gender.[18,19] Children's muscle strength is positively correlated to age and associated with gender

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due to changes in body size.[20,21] In a study of 2,241 children and adolescents ages 4-15 years, there was a significant increase in HGS with each ascending year, males tended to be stronger than females, and an acceleration in HGS was observed starting at ages 11-12 years.[18] Other studies found similar findings with age and gender and showed the same acceleration in HGS between 11 and 12 years.[22,23]

There is a need to develop systems that track malnutrition based on the degree of deficit: mild, moderate, or severe. HGS reference ranges for pediatrics have only been established for specific populations.[21,24,25] A lack of normal reference ranges for HGS in pediatrics makes it challenging to distinguish a low handgrip strength due to disease compared to a normal, healthy handgrip strength. Limited research exists on using HGS as an indicator of malnutrition in hospitalized pediatric patients. If a difference in HGS is found between healthy children and those at higher risk for illness-related malnutrition, HGS may be used as an effective tool to identify and quantify illness-related malnutrition.

The primary purpose of this study was to determine if HGS differed between hospitalized children within 48 hours of admission and non-hospitalized children. The secondary purpose was to describe the association of HGS with height, weight, BMI, MUAC, hand dominance, activity level, pain level, disease severity, nutrition support, nutrition intervention, and nutrition risk.

METHODS

Study Setting and Population

Pediatric patients were recruited from two not-for profit healthcare facilities located in the intermountain west. The first facility was a 289-bed pediatric level I trauma center. The second facility was a private pediatrics practice. A convenience sample of 110 hospitalized

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patients and 110 non-hospitalized patients participated in a cross sectional, nonequivalent control group design study from June 2015 through December 2015.

The samples were stratified by age with n= 55 for participants 6-9 years and n=55 for participants 10-14 years at each facility. Inclusion criteria were ages 6-14 years, ability to understand verbal and/or written directions in English, perform the handgrip strength measurement test, and stand long enough to take height and weight measurements. Patients with a chromosomal disorder that affected height were excluded. As a result of the inclusion/exclusion criteria, pediatric participants from the hospitalized group were typically on the children's medical/surgical units, immunocompromised unit, and neuroscience-trauma units.

Subjects were recruited using flyers. At the hospital, the dietary technician who completed the standard nutrition screening identified children who met the inclusion criteria and provided the patient and parent/caregiver with a flyer about the study. If the patient and parent/caregiver chose to participate in the study a designated member of the research team obtained assent from all patients 7 years of age and older wanting to participate in the study as well as consent from the parent/caregiver within 48 hours of admission to the hospital. The researcher then administered the questionnaire and collected measurements. At the pediatrics practice, the nurse who completed the standard patient history for a well-child visit identified patients who met the inclusion criteria and provided the patient and parent/caregiver with the flyer. If the patient and parent/caregiver chose to participate in the study a designated member of the research team obtained assent from all patients 7 years of age and older wanting to participate in the study as well as consent from the parent/caregiver. The researcher then administered the questionnaire and collected the appropriate measurements immediately following the patient's well-child visit.

Prior to data collection, human subject approval was obtained from the Intermountain Healthcare and Brigham Young University Institutional Review Boards (IRB). Members of the research team were trained on the following: taking proper anthropometric measurements using the National Health and Nutrition Examination Survey (NHANES) protocol, how to use the Jamar® Plus Hand Dynamometer instrument, and proper questionnaire administration. Members of the team were also given standardized definitions for physical activity, disease severity, and pain scale for consistent data collection.

<div align="center">Data Collection and Variable Definition</div>

Researchers gathered participant age, gender, physical activity prior to hospitalization or well-child visit, hand dominance, and pain level through a verbal questionnaire. Additionally hospitalized participants were asked about disease severity and nutrition support through the questionnaire. A parent/caregiver was present during the questionnaire and assisted. The participants' responses were recorded electronically.

Physical activity level prior to hospitalization or well-child visit measurement was divided into four categories: ≥ 5 days per week; 4-5 days per week; 2-3 days per week; ≤ 2 days per week.

Next, the dominant hand of the child was identified. The researcher placed a pen in the palm of her hand and presented it directly in front of the child. The child was asked to take the pen from the researcher's hand and pretend to write his/her first name in the air. The dominant hand was identified as the hand used to write in the air.

Next, the Wong-Baker FACES Pain Rating Scale was used to assess pain.[26] The child was shown the faces/scale, the researcher explained the scale to the child, and then the child was asked to identify what face looked like how he/she felt.

For hospitalized children, additional questions were administered with the preliminary questionnaire. The first question identified the severity of the patient's disease. The severity of disease of hospitalized patients was divided into three categories: mild (score 1)—patient is weak but out of bed regularly; moderate (score 2)–patient is confined to the bed due to illness but can get out of bed with assistance; severe (score 3) – patient is confined to the bed due to severe disease.[27]

The next few questions addressed the overall nutrition status of the hospitalized children. The first question identified if the child was receiving nutrition support through a feeding tube or was on total parenteral nutrition (TPN). The nutrition risk score was also obtained from the patient's medical record. The nutrition risk score was based on the standard nutrition screening tool used by the hospital and included the patient's admitting diagnosis, BMI percentile, diet order, and respiratory status. Based on the nutrition risk score, a Registered Dietitian Nutritionist (RDN) evaluated the patient's nutritional status and determined whether a thorough nutritional assessment was needed.   Finally, it was recorded whether the child received a complete dietitian nutrition assessment by a RDN, indicating the child was malnourished or at risk for malnutrition.

The researcher then measured the child's weight, height, mid-upper arm circumference, and handgrip strength. The participant's weight was measured using a mechanical scale (Seca 882) and the measurement was recorded to the nearest 0.1 kg. Weight measurements were obtained with no shoes and the participant wearing light clothing. Height was measured using a portable stadiometer to the nearest 0.1 cm. Mid-upper arm circumference (MUAC) was measured with a flexible, non-stretchable tape on the right arm halfway between the acromion process of the scapula and olecranon process at the tip of the elbow following the National Health and Nutrition Examination Survey procedures to the nearest 0.1 cm.[28] BMI *z* scores and

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MUAC *z* scores were calculated and participants were categorized into normal, mild, moderate, and severe malnutrition classes according to the Consensus Statement of the Academy of Nutrition and Dietetics/American Society for Parental and Enteral Nutrition.[11]

HGS was measured by gripping the Jamar® Plus Hydraulic Hand Dynamometer with the subject sitting with the arm by the side of the body, elbow unsupported, and the forearm stretched to 90^0. HGS was measured three times in each hand, alternating hands between each measurement. A separate mean for the dominant and non-dominant hand were calculated based on the three measurements in each hand. The children received $10 compensation for participation in the study.

Statistical Analysis

The data were analyzed using a mixed models analysis of covariance (ANCOVA). The sample size of our study provided enough power to detect a difference in HGS of 1.3kg. In order to determine the best model, the model was fit after comparing the demographic information: gender, age category (6-10 years and 11-14 years), height *z* score, weight *z* score, BMI *z* score, mid-upper arm circumference *z* score, hand dominance, activity level, pain level, nutrition support (yes or no), and nutrition risk score. After the analysis, the best-fit model for the demographics had age category, height *z* score, dominant hand, and mid-upper arm circumference *z* score as the independent variables and HGS as the dependent variable. The primary variable of interest, whether or not the subject was hospitalized, was then added to the model.

Following this analysis, the hospitalized and non-hospitalized groups were separated and analyzed using the best-fit model to evaluate HGS. In the hospitalized group, nutrition risk score and dietitian nutrition assessment (yes or no) were included in the model.

Frequencies of the variables handgrip strength, BMI z score, and mid-upper arm circumference z score were calculated. Each variable was divided into quartiles according to the values observed in our study subjects. Based on these quartiles, chi-squared tests for independence were performed.

Specificity, sensitivity, positive predictive values, and negative predictive values were also generated to evaluate the performance of HGS for correctly screening malnourished patients on the basis of malnutrition classification by MUAC z score cut-offs.[11] Malnourished participants were identified and divided according to age category. Dominant hand HGS was ranked from lowest to highest, and quartiles were determined. A HGS in the first quartile was considered a low test in this study population. Two participants were removed from the chi-squared tests with HGS and sensitivity and specificity data due to missing dominant handgrip strength measurements. All analyses were done using the Statistical Analysis Systems statistical software package, version 9.4 (SAS Institute, Inc, Cary, NC). Significant results were considered when $P<.05$.

RESULTS

Demographics

The demographic characteristics of our sample are summarized in Table 1. A total of 220 pediatric patients enrolled in the study and were divided into hospitalized (n=109) and non-hospitalized (n=110) groups. One hospitalized subject was removed from data analysis due to incomplete results. The mean age was 10.1 ± 2.6 years ranging from 6 to 14 years.

From the entire study population, 184(84%) participants reported having no pain to just a little bit of pain. One hundred seventy nine (82%) participants reported participating in some form of physical activity more than four days a week. Of the hospitalized subjects, 84 (77%) had

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mild disease severity and 25(22.9%) had moderate disease severity. Only 31(28.4%) hospitalized participants received a dietitian nutrition assessment.

According to BMI z score class, 18 (16.5%) hospitalized and 19 (17.3%) non-hospitalized participants were classified with mild malnutrition and 6 (5.5%) hospitalized and 1 (1%) non-hospitalized participants were classified as moderately malnourished. Only 3 (2.8%) of the hospitalized participants and no non-hospitalized participants were considered severely malnourished (Figure 1). According to MUAC z score classification, 25 (22.9%) hospitalized and 21 (19.1%) non-hospitalized participants were classified with mild malnutrition, and 3 (2.8%) of hospitalized and no non-hospitalized participants were considered moderately malnourished (Figure 2).

Outcome

According to the mixed model, age category (p<.0001), height z score (p<.0001), dominant hand (p<.0001), and MUAC z score (p=.0462) significantly influenced HGS; however, HGS was not significantly influenced by hospitalization (p=.2053) (Table 1). The mean handgrip strength (HGS) of hospitalized subjects was 12.4 ± .37 (mean ± SD, kg) and the mean HGS for non-hospitalized subjects was 13.1 ± .37 (mean ± SD, kg) (Table 1).

Handgrip strength in the non-hospitalized group was significantly influenced by height z score (p=0.0165) and MUAC z score (p=0.0227). There was also a significant difference in HGS between the younger age group ages 6-10 years and the older age group ages 11-14 years (p<.0001). The dominant hand was also significantly stronger than the non-dominant hand in the non-hospitalized children (p<.0001) (Table 2).

In the hospitalized population the height z score significantly influenced HGS (p=.0011). HGS was not significantly influenced by MUAC z score (p=0.622). There was a significant

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difference in HGS between the younger age group ages 6-10 years old and the older age group ages 11-14 years (p<.001). Dominant hand was also significantly stronger than non-dominant hand (p=.0003). HGS of hospitalized subjects was not significantly influenced by nutrition risk score (p=.300). There was also not a significant difference in HGS between the hospitalized subjects who received a dietitian nutrition assessment and those who did not receive a dietitian nutrition assessment (p=.771) (Table 3).

Chi-squared tests of independence were calculated comparing the frequencies of BMI z score, MUAC z score and HGS for the entire pediatric population. A significant difference was found between MUAC z score and HGS ($\chi^2(9)=18.36$, p=.03) (Table 4) and MUAC z score and BMI z score ($\chi^2(9)=281.61$, p<.0001) (Table 5). The association between BMI z score and HGS was approaching significance ($\chi^2(9)=16.15$, p=.06) (Table 6).

HGS measurements were also evaluated for their ability to accurately identify malnutrition in each age group. Twenty-four participants in the 6-10 year old age group and 30 participants in the 11-14 year old age group were identified as malnourished according to MUAC z score. Sensitivity, specificity, and positive and negative predictive values were reported in Table 8.

DISCUSSION

The alternative hypothesis of this study was there would be a significant difference between HGS of hospitalized and non-hospitalized children based on reports of malnutrition in hospitalized children.[1,9,29,30] However, there was no significant difference in HGS between the two groups. This was most likely because there was no significant difference between the primary indicators of malnutrition and physical activity level between the hospitalized and non-hospitalized participants, See Table 1. According to BMI z scores and MUAC z scores, 18(16.5%) and 25(22.9%) hospitalized children were classified as mildly malnourished and

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19(17.3%) and 21(19.1%) non-hospitalized children were classified as mildly malnourished. Eighty-two (75.2%) and 81(74.3%) hospitalized children, and 90(81.8%) and 89(80.9%) non-hospitalized children were classified as well- nourished defined by a BMI *z* score > -1 and MUAC *z* score >-1. Sixty-four (58.7%) hospitalized participants reported participating in physical activity more than 5 days per week prior to their current hospitalization compared to 67(60.9%) non-hospitalized participants. Seventy-eight (71.6%) hospitalized participants did not receive a dietitian nutrition assessment.

Historically, malnutrition has been defined as percent of ideal body weight, as first described by Gomez and Waterlow.[31,32] Now the Academy of Nutrition and Dietetics/American Society of Parenteral and Enteral Nutrition 2014 Pediatric Malnutrition Consensus Statement recommends using negative z scores for weight for height, BMI-for-age, length/height, and MUAC to classify malnutrition when only one data point is available.[11] BMI-for-age *z* scores, height-for-age *z* scores, and mid-upper circumference *z* scores were used to classify malnutrition in this study.[11] A strong association between MUAC *z* scores ($p=.0462$), height z scores ($p<.0001$), and although not significant BMI z scores ($p=.54$) was found with HGS. Hand dominance ($p<.0001$) and age ($p<.0001$) also had a significant association with HGS.

To the best of our knowledge no other studies have investigated the relationship between HGS and the degree of deficit of mild, moderate, and severe malnutrition in pediatrics. Although HGS has been found to be a useful tool for identifying malnutrition,[33-35] there is insufficient data to quantify the degree of malnutrition.[11] This study attempted to quantify the degree of malnutrition for HGS; however, there were low numbers of participants in each of the malnutrition degree categories. This could be due to the inability of severely malnourished children to perform the HGS test.

This study found that BMI and MUAC are highly correlated (p<.0001); however, BMI does not take into consideration muscle mass. HGS is a measurement of muscle function. This study found there is a significant association between MUAC and HGS (p=.03) but the association between BMI and HGS only approached significance (p=.06). Changes in HGS may be seen sooner than changes in both MUAC and BMI; thus, HGS may be a more useful measure to identify malnutrition.

Sensitivity and specificity are terms used to gauge the validity of a test.[36] It would be ideal to have a test that is both sensitive and specific to detect malnutrition. In clinical practice, screening tools such as hand dynamometry tests should have high sensitivity to properly identify malnutrition. This study found HGS to have a sensitivity of 21.1-28.6% according to MUAC *z* scores. This indicates that 71.4-78.9% of the participants identified as malnourished based on MUAC *z* score were not properly identified as malnourished with HGS. HGS had higher specificity (60-100%) according to MUAC *z* scores, indicating that up to 40% of healthy children had a false positive test, or a low grip strength, that would have improperly categorized them as being malnourished according to MUAC *z* score (Table 8). Sensitivity data is typically ran against a validated standard and although MUAC *z* scores have been used to recognize and identify malnutrition, the relationship between MUAC *z* scores still elicits further research. A study done in adults found HGS at admission had good sensitivity for screening patients for nutrition risk.[35] The ability for HGS to be a sensitive marker of nutrition status may vary between adults and children; however, it is possible that HGS might detect malnutrition earlier than both BMI *z* score and MUAC *z* score in children.

HGS, especially in adults, has been studied extensively in outpatient settings and has been found to be associated with various health outcomes, including malnutrition.[37-40] The

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findings of this study suggest that HGS in an acute, pediatric setting may not be ideal for the identification of malnutrition using a one-time measurement within 48 hours of admission. A limitation of this study is that a one- time, average HGS measurement was taken on each participant within the first 48 hours of admission. HGS has been found to be associated with nutritional status in children when multiple HGS measurements are taken at admission and then again at discharge.[27] HGS as a measurement of malnutrition might be better utilized in an outpatient setting, with specific disease populations, where nutritional status and HGS can be measured over time. A few limitations of this study were obesity and body composition were not taken into consideration and might also influence HGS, siblings were also not excluded from participation in this study, and there is a potential for reporting bias from using the self-reported questionnaire.

Conclusion

This study found the difference in HGS measurements was not statistically significant between hospitalized and non-hospitalized children using a one-time HGS measurement. Further research examining HGS measurements over time as well as comparing HGS measurements to the degree of malnutrition deficit in pediatrics is needed. The association between HGS and patient diagnosis, biochemical markers indicative of malnutrition, body composition and muscle mass, and subjective global assessment[41] might also be useful to consider in future studies.

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Table 1. Demographics of Pediatric Participants (N=219)

	Hospitalized		Non-hospitalized		p-value
	n	**%**	**n**	**%**	
Total participants	109	49.8[a]	110	50.2[a]	
Gender					**.06**
Male	59	54.1	50	45.5	
Female	50	45.9	60	54.5	
Age					**<.0001**
Group 1 (6-10 Years)	**57**	**52.3**	**53**	**48.2**	
6 Years	13	11.9	14	12.7	
7 Years	11	10.1	12	10.9	
8 Years	9	8.3	14	12.7	
9 Years	12	11	5	4.6	
10 Years	12	11	8	7.3	
Group 2 (11- 14 Years)	**52**	**47.7**	**57**	**51.8**	
11 Years	18	16.5	7	6.4	
12 Years	7	6.4	28	25.5	
13 Years	12	11	14	12.7	
14 Years	15	13.8	8	7.3	
Pain level					**.84**
No hurt	45	41.3	87	79.1	
Hurts little bit	33	30.3	19	17.3	
Hurts little more	19	17.4	4	3.6	
Hurts even more	5	4.6	0	0	
Hurts Whole lot	6	5.5	0	0	
Hurts Worst	1	0.9	0	0	
Activity Level					**.73**
>5d/wk	64	58.7	67	60.9	
4-5d/wk	20	18.4	28	25.5	
2-3d/wk	16	14.7	14	12.7	
<2d/wk	9	8.3	1	0.9	
Receiving Nutrition Support					
Yes	4	3.7	n/a	n/a	
No	105	96.3	n/a	n/a	
Nutrition Risk Score (Mean ± SD)	**2.44 ± 2.69**		**n/a**		
MNT, assessment					
Yes	31	28.4	n/a	n/a	
No	78	71.6	n/a	n/a	
Severity of Disease					
Mild	84	77.1	n/a	n/a	
Moderate	25	22.9	n/a	n/a	
Severe	0	0	n/a	n/a	
BMI z Score[11]					**.54**

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Normal	82	75.2	90	81.8	
Mild Malnutrition	18	16.5	19	17.3	
Moderate Malnutrition	6	5.5	1	1	
Severe Malnutrition	3	2.8	0	0	
MUAC z Score[11]					**.0462**
Normal	81	74.3	89	80.9	
Mild Malnutrition	25	22.9	21	19.1	
Moderate Malnutrition	3	2.8	0	0	
Severe Malnutrition	0	0	0	0	
Mean HGS (Mean ± SD), Kg*	**12.4 ± .37**		**13.1 ± .37**		**.2053**
6-10 years old	9.49 ± .77		9.87 ± .41		
11-14 years old	15.57 ± .69		16.25 ± .40		

BMI (body mass index) z score normal >-1, mild=-1 to -1.9, moderate=-2 to -2.9, severe= -3 or less;

MUAC (mid-upper arm circumference) z score normal >-1, mild=-1 to -1.9, moderate=-2 to -2.9, severe= -3 or greater; HGS, handgrip strength; MNT, medical nutrition therapy/received dietitian nutrition assessment.

[a] Data expressed as percent of entire population

Table 2. Mixed Model Analysis of Handgrip Strength for Non-hospitalized Pediatric Patients at Well-Child Visit

Variable	Handgrip Strength	p-value
Hand dominance[a]		<.0001
Dominant hand	13.67 ± .31	
Non-dominant hand	12.44 ± .31	
Age Category[a]		<.0001
6-10 Years	9.87 ± .41	
11-14 Years	16.25 ± .40	
Height z score[b]	.72 ± .30	.02
MUAC z score[b]	.75 ± .32	.02

[a]Data are expressed as mean ± SD

[b]Data are expressed as slope ± SE

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Table 3. Mixed Model Analysis of Handgrip Strength for Hospitalized Pediatric Patients Within 48 Hours of Admission

Variable	Handgrip Strength	p-value
Hand dominance[a]		<.0001
Dominant hand	13.14 ± .59	
Non-dominant hand	11.92 ± .59	
Age Category[a]		.0003
6-10 Years	9.49 ± .77	
11-14 Years	15.57 ± .69	
Height z score[b]	1.46 ± .44	.0011
MUAC z score[b]	.22 ± .44	.6227
Nutrition Risk Score[b]	-.29 ± .28	.30
MNT, assessment		.7707
Yes	12.77 ± 1.26	
No	12.28 ± .66	

[a]Data are expressed as mean ± SD

[b]Data are expressed as slope ± SE

MUAC, mid-upper arm circumference; MNT, medical nutrition therapy/received dietitian nutrition assessment

Table 4. Cross Tabulations of Handgrip Strength Quartiles by Mid-Upper Arm Circumference z Score Quartiles for Total Participants (N=217)

		MUAC z Score Quartiles Percent (Frequency)				
		1	2	3	4	Total
HGS Quartiles	Quartile Range	-3.8 to -.894	-.895 to .126	.127 to 1.0	1.01 to 3.5	
1	0 to 12.5	45.0 (18)	20.0 (8)	17.5 (7)	17.5 (7)	100
2	12.51 to 15.5	26.7 (16)	30.0 (18)	21.7 (13)	21.7 (7)	100
3	15.51 to 19.5	20.0 (11)	29.1 (16)	29.1 (16)	21.8(12)	100
4	>19.5	12.9 (8)	22.6 (14)	29.0 (18)	35.5 (22)	100
Total		24.4 (53)	25.8 (56)	24.9 (54)	24.9 (54)	100

Note: Number in parentheses is frequency of MUAC measurements in each quartile

MUAC, mid-upper arm circumference; HGS, handgrip strength

CHI Square p= .03

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Table 5. Cross Tabulations of Mid-Upper Arm circumference *z* Score Quartiles by BMI *z* Score Quartiles

for Total Participants (N=219)

		BMI *z* score Quartiles Percent (Frequency)				
		1	2	3	4	Total
MUAC *z* Quartiles	*Quartile Range*	*-3.8 to -.649*	*-.65 to .112*	*.113 to .747*	*.748 to 3.5*	
1	*-3.8 to -.894*	79.6 (43)	16.7 (9)	3.7 (2)	0.0 (0)	100
2	*-.895 to .126*	17.5 (10)	64.9 (37)	17.5 (10)	0.0 (0)	100
3	*.127 to 1.0*	1.9 (1)	18.5 (10)	59.3 (32)	20.4 (11)	100
4	*1.001 to 3.5*	0.0 (0)	0.0 (0)	16.7 (9)	83.3 (45)	100
Total		24.6 (54)	25.6 (56)	24.2 (53)	25.6 (56)	100

Note: Number in parentheses is frequency of MUAC measurements in each quartile

MUAC z, mid-upper arm circumference z score; BMI, body mass index

CHI Square p <.0001

Table 6. Cross Tabulations of Handgrip Strength Quartiles by Body Mass Index *z* Score Quartiles for

Total Participants (N=217)

		BMI *z* score Quartiles Percent (Frequency)				
		1	2	3	4	Total
HGS Quartiles	*Quartile Range*	*-3.8 to -.649*	*-.65 to .112*	*.113 to .747*	*.748 to 3.5*	
1	*0 to 12.5*	35.0 (14)	25.0 (10)	27.5 (11)	12.5 (5)	100
2	*12.51 to 15.5*	31.7 (19)	20.0 (12)	26.7 (16)	21.7 (13)	100
3	*15.51 to 19.5*	18.2 (10)	32.7 (18)	23.6 (13)	25.5 (14)	100
4	*>19.5*	14.5 (9)	25.8 (16)	21.0 (13)	38.7 (24)	100
Total		24.0 (52)	25.8 (56)	24.4 (53)	25.8 (56)	100

Note: Number in parentheses is frequency of MUAC measurements in each quartile

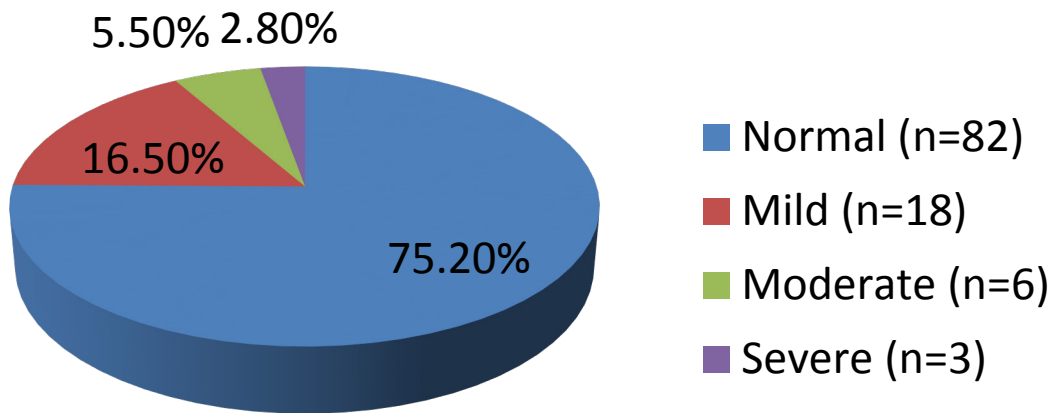BMI, body mass index; HGS, handgrip strength

CHI Square p=.06

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Table 7. Comparison of Handgrip Strength Results with Identification of Malnutrition According to Mid-

Upper Arm Circumference *z* Score

	Malnutrition, n (%)	Sensitivity (%)	Specificity (%)	PV+ (%)	PV- (%)
6-10 Years					
MUAC *z* score	24 (21.8)	21.1	60	66.7	16.7
11-14 Years					
MUAC *z* score	30 (27.5)	28.6	100	0	9.1

% Malnutrition based on total participants in age group, 6-10 years (n=110), 11-14 (n=109)

MUAC, Mid-Upper Arm Circumference; PV+, Positive Predictive Value; PV-, Negative Predictive Value

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Hospitalized Participants

5.50% 2.80%

16.50%

75.20%

- Normal (n=82)
- Mild (n=18)
- Moderate (n=6)
- Severe (n=3)

Non-Hospitalized Participants

17.30%

1%

81.80%

- Normal (n=90)
- Mild (n=19)
- Moderate (n=1)
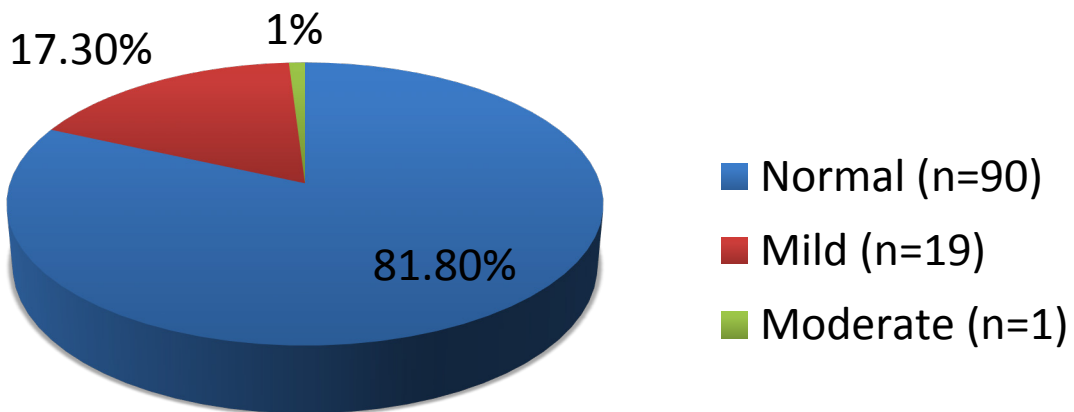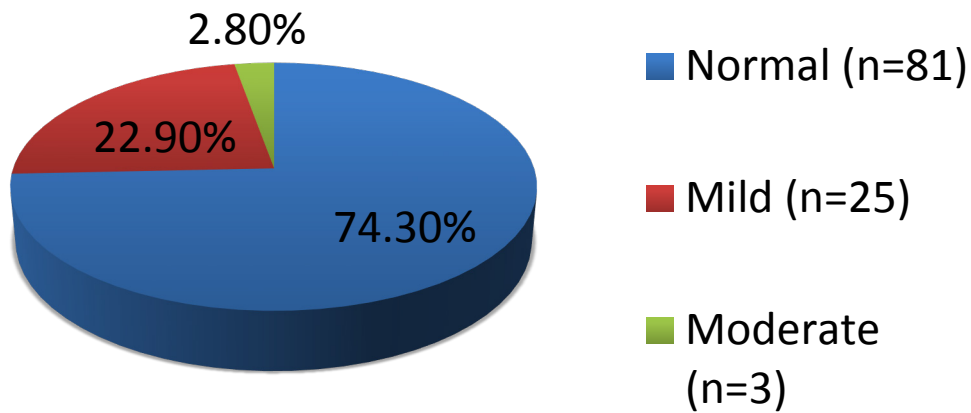
Figure 1. Malnutrition according to BMI *z*-score. BMI (body mass index) *z* score normal >-1, mild=-1 to -1.9, moderate=-2 to -2.9, severe= -3 or less

Hosptialized Participants

2.80%

22.90%

74.30%

- Normal (n=81)
- Mild (n=25)
- Moderate (n=3)

Non-Hospitalized Participants

19.10%

80.90%
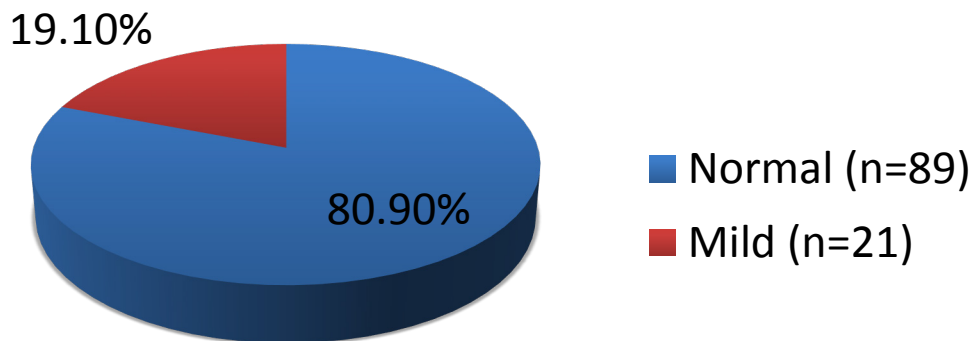
- Normal (n=89)
- Mild (n=21)

Figure 2. Malnutrition according to MUAC *z*-score. Malnutrition according to MUAC *z*-score.

MUAC (mid-upper arm circumference) *z* score normal >-1, mild=-1 to -1.9, moderate=-2 to -

2.9, severe= -3 or less.

APPENDIX A: RESEARCH PROPOSAL

Problem Statement

Obtaining adequate nutrition is essential for the proper growth and development of children.[42] A child's food intake is typically influenced by many factors including the child's family environment, social trends, media messages, peer influence, illness, and disease.[42] Children who are sick usually have a decreased appetite and limited food intake.[42] When an individual's nutrient intake does not match the individual's requirements for optimum health a state of nutritional deficiency or excess can develop. Once the nutritional reserves have been depleted and intake is not adequate to meet metabolic needs a state of undernutrition or malnutrition will ensue.[42]

The American Society of Parenteral and Enteral Nutrition (ASPEN) has defined malnutrition as "an imbalance between nutrient requirement and intake, resulting in cumulative deficits of energy, protein or micronutrients that may negatively affect growth, development, and other relevant outcomes."[1] Malnutrition can develop through inadequate oral intake of food, impaired nutrient digestion and absorption, dysfunctional metabolic processes, or by increased excretion of nutrients.[42] The negative consequences of malnutrition include impaired growth and development, a decreased ability to fight infection, delayed wound healing, poor clinical outcomes from disease or trauma, the development of other diseases, and if not treated morbidity and mortality may result. [42]

In developed countries malnutrition is typically the result of disease or illness.[2] In the United States, Germany, France and the United Kingdom it has been estimated that 6-14% of hospitalized children suffer from acute malnutrition.[2] Consequences of malnutrition include more complicated hospitalizations leading to increased length of stay and cost of hospitalization,

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poor wound healing and slower obtainment of pre-hospitalization activity level.[11] Malnutrition in children is concerning because it affects proper growth and development. Thus, timely and accurate identification of malnutrition in children is critical. Nutritional risk in the hospital setting includes factors such as disease state, energy intake, and lack of appropriate weight gain. Patients with higher nutrition risk should receive a comprehensive dietitian nutrition assessment to determine appropriate nutrition intervention. Patients who are at low nutrition risk typically do not receive dietitian nutrition intervention.

Currently, there is not a standardized approach to identify malnutrition in pediatric patients older than 60 months.[11] The Academy of Nutrition and Dietetics (AND) and ASPEN have recommended that the following indicators be used to assess and identify malnutrition: estimation and adequacy of food and nutrient intake, assessment of energy and protein needs, growth parameters according to growth charts and standardized z-scores, weight gain velocity, mid-upper arm circumference, handgrip strength, and the documentation of Tanner stages.[11]

Among the indicators identified, handgrip strength(HGS), a measurement of functional status, may be important in identifying early malnutrition. This is due the fact that muscle function has been shown to react faster to changes in nutritional status and therefore may be a better diagnostic tool for identifying malnutrition than other anthropometric and biochemical measurements in children older than 6 years.[11] Measuring HGS is easy, non-invasive and inexpensive and may lead to earlier identification of malnutrition in children and improve outcomes. However, normal reference ranges of handgrip strength in large pediatric populations have not yet been established.[11] Currently there is not sufficient data to differentiate the degree of malnutrition using HGS. HGS measurements in children need to be collected in hospitalized and

non-hospitalized children to establish reference ranges for children and quantify the degree of malnutrition.

Purpose Statements

The purpose of this research is to:

(1) Determine if there is a difference in handgrip strength between non-hospitalized children, low risk hospitalized children with no dietitian nutrition assessment, and high risk hospitalized children with dietitian nutrition assessment.

(2) Determine if there is a relationship between handgrip strength and weight, height, disease severity, physical activity level, mid-upper arm circumference, BMI z-score, and nutrition intervention.

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APPENDIX B: LITERATURE REVIEW

Malnutrition

Adequate nutrition is important for proper growth and development of children. When nutritional intake is less than optimum and does not meet a child's basic needs, a state of malnutrition can develop. The American Society of Parenteral and Enteral Nutrition (A.S.P.E.N.) has defined malnutrition as "an imbalance between nutrient requirement and intake, resulting in the cumulative deficits of energy, protein, or micronutrients that may negatively affect growth, development, and other relevant outcomes."[1]

Based on its etiology, malnutrition can be classified as either illness-related or caused by other environmental/behavior factors associated with decreased nutrient intake, and/or delivery.[1] Malnutrition can also be categorized as being either acute or chronic. Malnutrition is considered acute if it lasts for three months or less before resolving, and malnutrition is considered chronic if it persists for more than three months.[1] Acute malnutrition is most typically associated with a sudden or severe onset of a disease or condition, whereas chronic malnutrition is a disease or condition that has lasted for three months or longer.[11]

Traditionally, malnutrition has been associated with kwashiorkor and marasmus in developing countries.[43] These conditions develop due to inadequate protein-energy consumption. Kwashiorkor is the result of inadequate protein intake and marasmus is the result of both protein and energy being inadequate. Malnutrition associated with kwashiorkor and marasmus is not commonly found in the United States. In developed countries such as the United States, malnutrition is most frequently observed in hospitalized acute and/or chronically ill children. Thus, malnutrition is typically the result of a disease, burns, chronic conditions, trauma, or surgery.[1] Malnutrition is also found in children with special healthcare needs. Children with

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special healthcare needs are those who are at risk for a chronic physical, developmental, behavioral, or emotional condition who also require health related services beyond that of most children.[11] Children are at an increased risk for malnutrition compared to adults because they have a higher energy need per unit of body weight with limited energy stores, and require more energy for growth and development.[44] The prevalence of illness-related malnutrition has been reported as 6%-51% in hospitalized children, but these numbers are most likely underestimated.[1] This underestimation is most likely due to various nutrition screening practices, lack of uniform definitions, and the failure to prioritize nutrition as part of patient care practices.[1]

Malnutrition can result in numerous complications and greatly impact the overall well-being of the child. Malnutrition is shown to be associated with increased morbidity and mortality in both children and adults.[11,44,45] Stunting, a decrease in height velocity, is a common complication of chronic malnutrition.[1] Other complications of malnutrition in infancy include decreased growth, reduced or delayed mental and psychomotor development, and increased behavior problems during childhood.[44]

Malnutrition can also lead to the progression of the underlying disease or condition, poor wound healing, slow return to previous level of activity, and complications that can significantly increase the length of stay and cost of hospitalization.[11] In a study of 175 children ages 31 days to 17.9 years researchers found that malnourished children had a higher rate of infectious complications compared to well-nourished children and increased postoperative length of hospital stay.[9] Hecht et al.[5] conducted a multi-center study of 2567 participants, ages 1-18 years, and from 14 centers in 12 different countries. Malnutrition in this study was defined as underweight and based on BMI <-2 standard deviation scores (SDS). After data collection and analysis it was found that 7% of the children admitted to the hospital had a BMI <-2 SDS and

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that there was an increase in length of stay of 1.3-1.6 days if they were malnourished.[5] Effective and early diagnosis and treatment of illness-related malnutrition is necessary to improve patient outcomes and decrease length of stay and other medical expenses.

<div align="center">Screening and Assessment of Malnutrition</div>

Nutrition screening is done to identify individuals who are at nutritional risk, followed by a nutrition assessment, and finally an appropriate intervention plan is generated to address nutritional concerns. Researchers have tried to find ways to identify and classify malnutrition for years. One method that has historically been used is the Waterlow Criteria which classifies malnutrition as mild, moderate, or severe based on percentage of ideal body weight.[11,31] One disadvantage of this criteria is that weight can be influenced by many factors and therefore influence the results. Therefore, researchers are continuing to identify other indicators of malnutrition so it can be better identified and classified.   In the United States, nutrition screening within 24 hours of hospital admission is a requirement of The Joint Commission.[46] Identifying individuals upon admission to a hospital or primary care setting who are at risk of malnutrition or malnourished reduces more costly hospitalizations by preventing additional illnesses or worsening of their underlying disease or condition.[11] A cross sectional study of 322 children admitted to a hospital were screened to determine their nutritional status. It was found that almost 40% of the children admitted to the hospital were malnourished.[47] This high prevalence provides concrete evidence for the need to have fast, easy and reliable nutritional screening tools so that malnutrition can be quickly identified and treated to minimize complications.

Lack of standardized screening tools makes it challenging to identify children with malnutrition. A retrospective chart audit of patients admitted to a hospital found that patient charts had incomplete nutrition chart notes because of lack of standardized screening tools.[48]

Standardized and validated screening tools are necessary to identify children who are at nutritional risk. The Academy of Nutrition and Dietetics consensus statement indicates that, "The universal use of a single set of diagnostic parameters will expedite the recognition of pediatric undernutrition, lead to the development of more accurate estimates of its prevalence and incidence, direct interventions, and promote improved outcomes."[11]

Anthropometric Measurements. Currently nutrition screening and assessment involves the use of multiple parameters to identify malnutrition. One method is anthropometric measurements which evaluate proper growth and development. Common anthropometrics taken for children include weight, length/height, and head circumference. Typically these measurements are documented on growth charts established by the World Health Organization (WHO) or the Centers for Disease Control and Prevention (CDC) and help identify growth problems. The growth charts measure weight for age, length for age, weight for length, and head circumference for age.[49] The WHO growth charts describe how a child under ideal circumstances should grow and develop and are used for children less than two years of age. In contrast the CDC charts are used for children over two years of age and are growth references, not a standard, that describe growth of children in the United States over a 30 year period. Weight, length/height, and head circumference are each influenced by the nutritional status of an individual.

Weight Measurements. Weight measurements are another anthropometric indicator of malnutrition and are important to obtain when assessing malnutrition.[11] Children typically should experience age appropriate growth and weight gain. Lack of weight gain is the first indicator of malnutrition. Many factors can impact accurate weight measurements in acute illness. Weight can be influenced by fluid retention, edema, dressings, tubing, and other equipment necessary for

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care.[1] Weight can be influenced by a person's hydration status. Weight can be positively or negatively skewed by either excess fluid such as edema and ascites or dehydration. Mwangome et al[50] conducted a study to examine how hydration status related to acute malnutrition. In this study, children ages 3-5 years who were admitted to the hospital were evaluated for malnutrition and hydration status. Children who met the criteria of the study had their mid-upper arm circumference (MUAC), weight, and height measured. These measurements were then repeated after 48 hours after being provided appropriate nutrition and rehydration. The results of this study found that after rehydration the mean weight gain and MUAC increased significantly; however, the percent change in absolute MUAC was much less than the percent weight change. This study suggests that MUAC is less affected by dehydration than weight for length z-scores.[50] Thus, MUAC may be a better unit of measure than weight when assessing and monitoring malnutrition in critically ill children.

Height Measurements. Growth measurements are another anthropometric measurement used to identify malnutrition. Growth is the primary outcome measure of nutrition status in children.[1] Obtaining accurate height measurements is important in identifying malnutrition. If malnutrition is not addressed early when lack of weight gain is first seen, eventually length/height of the individual is compromised and an individual may suffer from stunting, which is difficult to reverse. A study of 222 children found stunting was the most common form of malnutrition.[12] It is important to identify lack of weight gain and hopefully prevent stunting. Identifying malnutrition earlier facilitates earlier intervention and fewer complications. Obtaining accurate height measurements is important in the identification of malnutrition.

Mid-upper arm circumference (MUAC). Mid-upper arm circumference (MUAC) is another anthropometric measurement used to evaluate nutrition status. Dasgupta et al.[15]

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conducted a study of 194 adolescent male students ages 10-19 years to determine if there was a difference between BMI and MUAC in determining nutrition status. The results of this study showed that both BMI and MUAC identify malnutrition, but that MUAC is more sensitive in identifying malnutrition. Thus this study concluded that MUAC is a reliable and practical method of assessment of nutritional status in adolescents.[15] MUAC has been correlated to BMI in both children and adults.[11] A study of 1561 patients also supported this finding. It was found that BMI and MUAC were correlated and that MUAC was easier to obtain and predicted patient outcomes better than BMI.[16] MUAC is also an important and useful measurement to take for individuals whose weight may be influenced by lower extremity edema, ascites, or steroids. A study examining two cohorts of children looked to determine if MUAC or MUAC z-scores was better at predicting mortality risk. It was found that MUAC and MUAC z-scores were both good prognostic indicators for mortality, but because it is easier to collect measurements for MUAC, MUAC is recommended.[51] The World Health Organization (WHO) and UNICEF through a longitudinal study found that MUAC identifies children at higher risk for malnutrition better than weight for height measurements.[17] A study examining the relationship between MUAC and malnutrition of 135 children found that MUAC was decreased in children with acute malnutrition providing evidence that MUAC is a useful parameter to identify children who are at risk for or are malnourished[13].

Body Mass Index. Body mass index (BMI) is typically used to determine if weight is appropriate for height. There are no valid BMI cutoffs for assessing malnutrition in adults or children.[2] Because height measurements are necessary for calculating BMI, early detection of acute malnutrition is not feasible. It is recommended that the World Health Organization (WHO) growth charts with standardized z-scores be used in assessing proper growth in children

0-2 years and the Center for Disease Control and Prevention (CDC) growth charts for children 2 years and over.[49] These standards are used to show how children should grow under ideal conditions and to help in the understanding and measurement of nutritional status in children.[52] The use of z-scores, which are standard deviation (SD) scores, is the most established way to describe malnutrition.[2] Malnutrition is categorized as mild with a z-score of -1 to -1.9, moderate with a z-score of -2 to -2.9, and severe with a z-score of -3 or greater.[11] Stunting or chronic malnutrition is defined as < -2 SD.[2,5] BMI z-scores along with weight, length/height, and MUAC are useful anthropometric measurements used to identify malnutrition; however, when assessing an individual for malnutrition there are other assessment parameters that need to be considered.

Functional Status. Another nutritional assessment parameter considered when completing a nutrition assessment is functional status. Functional nutrition assessment evaluates the body as a whole and how well the individual can complete the activities of daily living.

Handgrip Strength (HGS). Handgrip strength (HGS) is one measurement considered under functional assessment. HGS is a measurement of muscle function and is measured using handgrip dynamometry. The thought behind HGS is that strength in the hands reflects strength elsewhere.[42] It has been shown that muscle function responds earlier to nutritional changes than other anthropometric measurements.[53] The Jamar® Hand Dynamometer is considered the gold-standard tool used for measuring HGS due to its established reliability with good test-retest reproducibility and excellent inter-rater reliability.[54]

Many factors influence handgrip strength. Some of these factors include hand size and dominance, posture, joint position, effort, encouragement, time of day the measurements are taken, training of the researcher/assessor for taking the measurements, cooperation of the subject,

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age of the subject, fatigue, state of nutrition, pain, presence of amputation, restricted motion and sensory loss.[54,55] Another factor that can influence HGS is the frequency of testing. Ertem et al.[55] in a study of 877 male participants found that there is a significant difference between maximum versus average handgrip strength of three consecutive handgrip strength tests, and that the average of three consecutive measurements of handgrip strength is more consistent for standard hand evaluation.[55] Another study compared the HGS of pre-pubertal (age 9.49 +/-0.96 years) and pubertal (14.6+/- 0.50 years) male wrestlers. It was found that the mean of two or three HGS trials was more accurate than a single trial or the best of two or three trials.[56] Another factor that has been shown to influence HGS is the activity level of the individual. An active individual is more likely to have greater muscle mass and strength than an ill individual, and would therefore experience greater strength. A cross-sectional study of 384 children ages 8-20 years was performed to determine if HGS was related to total muscle strength in children, adolescents, and young adults. This study found that there is a strong correlation between HGS and total muscle strength.[57] Because of the various factors that can influence HGS, procedure standardization for taking HGS measurements are crucial for accurate results.

Although there are many factors that can influence HGS, there is extensive evidence that there is a relationship between HGS and nutritional status in adults.[34,42,58-60] It has also been found that decreased HGS was associated with increased length of hospitalization in cancer patients.[61] HGS has again been found to be predictive of mortality. In a study of 923 individuals, ages 50 years and older from a traditional African population, HGS was compared to age, sex, height and BMI. The study found that HGS declined with age and that decreased HGS was predictive of mortality.[45]

In contrast to adults who demonstrate decreased HGS with age, the HGS of healthy children increases with age. A cross sectional study of 2241 children and adolescent ages 4 to 15 years found that there is a significant difference in HGS of each ascending year in favor of the older groups, and boys tended to be stronger than girls.[18] It was also found that weight and height have a strong association with grip strength in children.[18] Another cross sectional study of 295 healthy children both male and female ages 6 to 13 years found that grip strength increased with age, that the dominant hand was stronger than the non-dominant hand, and that HGS was positively correlated with fat-free mass and height.[62] Another study looked at HGS of 525 children ages 6-12 years and found that HGS increased with advancing age and HGS for boys was greater than girls.[19] Ploegmakers'[18] study looked at the relationship of age and HGS in relation to puberty. This study noted that grip strength in both hands of males was equal until age 12 years, but after age twelve the dominant hand appeared to have increased strength and the non-dominant hand did not increase in strength until age 13 years. Similar findings were found in both hands of females starting at the age of 11 years. A strong correlation between height and strength was also found and the researchers noted that it is most likely a result of puberty.[18]

Acute and chronic illness factors such as disease severity, co-morbidity load, medical treatment, and immobilization can lead to muscle weakness.[53] Nutritional status is typically reduced in illness and leads to decrease muscle strength and ultimately decreased muscle function.[53] Norman and his group found 25.8% lower absolute handgrip strength values in malnourished hospitalized patients compared to well-nourished hospitalized patients.[53] Decreased HGS has been shown in multiple studies to be a good indicator of increased postoperative complications, increased length of hospitalization, increased rate or re-hospitalization, and decreased physical status in adults.[53] In a cross-sectional study of 688

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hospitalized subjects ages 18-91 it was determined that 24.1% of the study participants presented with moderate or suspected undernutrition and 23.8% of the participants were severely undernourished and over 50% of the participants were overweight or obese.[60] It was found that participants who were malnourished had a lower HGS. HGS was positively correlated with mid-arm muscle circumference, adductor pollicis muscle thickness, body height, wrist circumference, hand length, and palm width. HGS was negatively correlated with age, weight, number of drugs, functional activity decline, and patient generated subjective global assessment (PG-SGA) scores.[60] This study shows that there are multiple factors associated with HGS. For adults, it is typical to experience decreased HGS with aging. In contrast, healthy children as they grow and age should experience increased HGS.

Some research has been conducted to find reference values for healthy children, but very little research has been done to identify HGS reference values for hospitalized children that would be helpful in identifying and treating malnutrition. A study conducted by Silvia et al[27] looked and the relationship of HGS as an indicator of nutrition status in hospitalized pediatric patients. The study involved 89 patients divided into two groups, ages 6-14 years and ages 15-18 years. This study examined BMI z scores, severity level of disease, physical activity level, and HGS. They found that 30.3% of children admitted to the hospital were undernourished upon admission, and 64% of the children experienced decreased HGS during the hospital stay. Further this study found that HGS at admission was independently associated with undernutrition.[27]

The U.S. healthcare system is concerned with the identification of the most reliable, reproducible, safe/low-risk, and cost-effective indicators to support nutritional evaluation.[11] Because of its fast response to nutritional status, HGS measurements could potentially be considered a fundamental parameter to assist in identifying malnutrition. Matos et al[63] conducted

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a study to see if HGS could be used as a screening tool in identifying patients that are classified as being undernourished in a hospital setting. Three hundred and thirty three patients were recruited in this cross sectional study from two public hospitals, with 314 subjects used in the analysis of the study. HGS was performed on their non-dominant hand. Nutritional risk was evaluated using the Nutrition Risk Screening (NRS-2002) recommended by the European Society for Clinical Nutrition and Metabolism (ESPEN). The study found that patients identified through screening as nutritionally at risk had lower HGS and therefore concluded that HGS could be useful in identifying patients at nutritional risk. [63]

From these studies presented it is evident that more research needs to be done on the evaluation of handgrip strength in pediatric patients, specifically in the hospital setting, to better be able to identify and ultimately treat malnutrition.

APPENDIX C: COMPLETE METHODS

Study Setting and Population

Pediatric patients were recruited from two not-for profit healthcare facilities located in the intermountain west. The first facility was a 289-bed pediatric level I trauma center. The second facility was a private pediatrics practice. A convenience sample of 110 hospitalized patients and 110 non-hospitalized patients participated in a cross sectional, nonequivalent control group design study from June 2015 through December 2015.

The samples were stratified by age with n= 55 for participants 6-9 years and n=55 for participants 10-14 years at each facility. Inclusion criteria were ages 6-14 years, ability to understand verbal and/or written directions in English, perform the handgrip strength measurement test, and stand long enough to take height and weight measurements. Patients with a chromosomal disorder that affected height were excluded. As a result of the inclusion/exclusion criteria, pediatric participants from the hospitalized group were typically on the children's medical/surgical units, immunocompromised unit, and neuroscience-trauma units.

Subjects were recruited using flyers. At the hospital, the dietary technician who completed the standard nutrition screening identified children who met the inclusion criteria and provided the patient and parent/caregiver with a flyer about the study. If the patient and parent/caregiver chose to participate in the study a designated member of the research team obtained assent from all patients 7 years of age and older wanting to participate in the study as well as consent from the parent/caregiver within 48 hours of admission to the hospital. The researcher then administered the questionnaire and collected measurements. At the pediatrics practice, the nurse who completed the standard patient history for a well-child visit identified patients who met the inclusion criteria and provided the patient and parent/caregiver with the

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flyer. If the patient and parent/caregiver chose to participate in the study a designated member of the research team obtained assent from all patients 7 years of age and older wanting to participate in the study as well as consent from the parent/caregiver. The researcher then administered the questionnaire and collected the appropriate measurements immediately following the patient's well-child visit.

Prior to data collection, human subject approval was obtained from the Intermountain Healthcare and Brigham Young University Institutional Review Boards (IRB). Members of the research team were trained on the following: taking proper anthropometric measurements using the National Health and Nutrition Examination Survey (NHANES) protocol, how to use the Jamar® Plus Hand Dynamometer instrument, and proper questionnaire administration. Members of the team were also given standardized definitions for physical activity, disease severity, and pain scale for consistent data collection.

<div align="center">Data Collection and Variable Definition</div>

Researchers gathered participant age, gender, physical activity prior to hospitalization or well-child visit, hand dominance, and pain level through a verbal questionnaire. Additionally hospitalized participants were asked about disease severity and nutrition support through the questionnaire. A parent/caregiver was present during the questionnaire and assisted. The participants' responses were recorded electronically.

Physical activity level prior to hospitalization or well-child visit measurement was divided into four categories: ≥ 5 days per week; 4-5 days per week; 2-3 days per week; ≤ 2 days per week. The child was asked, "how many days a week do you go outside to play, participate in sports/dance, run/walk, ride a bike, or play at a park? " Then the researchers presented each of the four categories of activity level and recorded the child's response.

Next, the dominant hand of the child was identified. The researcher placed a pen in the palm of her hand and presented it directly in front of the child. The child was asked to take the pen from the researcher's hand and pretend to write his/her first name in the air. The dominant hand was identified as the hand used to write in the air.

Next, the Wong-Baker FACES Pain Rating Scale was used to assess pain.[26] The child was shown the faces/scale, the researcher explained the scale to the child, and then the child was asked to identify what face looked like how he/she felt.

For hospitalized children, additional questions were administered with the preliminary questionnaire. The first question identified the severity of the patient's disease. The severity of disease of hospitalized patients was divided into three categories: mild (score 1)—patient is weak but out of bed regularly; moderate (score 2)–patient is confined to the bed due to illness but can get out of bed with assistance; severe (score 3) – patient is confined to the bed due to severe disease.[27] To assess the severity of the disease the child was asked, "While in the hospital are you able to get out of bed regularly by yourself, do you get out of bed regularly but need assistance to get out of bed, or are you required to stay in bed always?"

The next few questions addressed the overall nutrition status of the hospitalized children. The first question identified if the child was receiving nutrition support through a feeding tube or was on total parenteral nutrition (TPN). The nutrition risk score was also obtained from the patient's medical record. The nutrition risk score was based on the standard nutrition screening tool used by the hospital and included the patient's admitting diagnosis, BMI percentile, diet order, and respiratory status. Based on the nutrition risk score, a Registered Dietitian Nutritionist (RDN) evaluated the patient's nutritional status and determined whether a thorough nutritional assessment was needed. Finally, it was recorded whether the child received a complete dietitian

nutrition assessment by a RDN, indicating the child was malnourished or at risk for malnutrition. The child was asked, "Are you currently receiving nutrition support through a feeding tube or IV (TPN)- not including water?". If the child answered yes to the question, a follow-up question was asked, "When was your nutrition support started? During your current hospitalization or prior to your current hospitalization?" Data obtained from the patient's medical record included the nutrition screening risk score for the child, and whether or not the child had received a comprehensive nutrition assessment by the registered dietitian nutritionist.

The researcher then measured the child's weight, height, mid-upper arm circumference, and handgrip strength. The participant's weight was measured using a mechanical scale (Seca 882) and the measurement was recorded to the nearest 0.1 kg. Weight measurements were obtained with no shoes and the participant wearing light clothing. Height was measured using a portable stadiometer to the nearest 0.1 cm. Mid-upper arm circumference (MUAC) was measured with a flexible, non-stretchable tape on the right arm halfway between the acromion process of the scapula and olecranon process at the tip of the elbow following the National Health and Nutrition Examination Survey procedures to the nearest 0.1 cm.[28] BMI *z* scores and MUAC *z* scores were calculated and participants were categorized into normal, mild, moderate, and severe malnutrition classes according to the Consensus Statement of the Academy of Nutrition and Dietetics/American Society for Parental and Enteral Nutrition.[11]

HGS was measured by gripping the Jamar® Plus Hydraulic Hand Dynamometer with the subject sitting with the arm by the side of the body, elbow unsupported, and the forearm stretched to 90^{0}. HGS was measured three times in each hand, alternating hands between each measurement. The researcher explained the procedure and how to use the dynamometer. Then the researcher directly handed the child the dynamometer in the hand that was to be measured

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and would encourage the child to grip the dynamometer with as much strength as possible by saying, "Squeeze, squeeze, squeeze, squeeze, squeeze!" A separate mean for the dominant and non-dominant hand were calculated based on the three measurements in each hand. The children received $10 compensation for participation in the study.

Statistical Analysis

The data were analyzed using a mixed models analysis of covariance (ANCOVA). The sample size of our study provided enough power to detect a difference in HGS of 1.3kg. In order to determine the best model, the model was fit after comparing the demographic information: gender, age category (6-10 years and 11-14 years), height z score, weight z score, BMI z score, mid-upper arm circumference z score, hand dominance, activity level, pain level, nutrition support (yes or no), and nutrition risk score. After the analysis, the best-fit model for the demographics had age category, height z score, dominant hand, and mid-upper arm circumference z score as the independent variables and HGS as the dependent variable. The primary variable of interest, whether or not the subject was hospitalized, was then added to the model.

Following this analysis, the hospitalized and non-hospitalized groups were separated and analyzed using the best-fit model to evaluate HGS. In the hospitalized group, nutrition risk score and dietitian nutrition assessment (yes or no) were included in the model.

Frequencies of the variables handgrip strength, BMI z score, and mid-upper arm circumference z score were calculated. Each variable was divided into quartiles according to the values observed in our study subjects. Based on these quartiles, chi-squared tests for independence were performed.

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Specificity, sensitivity, positive predictive values, and negative predictive values were also generated to evaluate the performance of HGS for correctly screening malnourished patients on the basis of malnutrition classification by MUAC *z* score cut-offs.[11] Malnourished participants were identified and divided according to age category. Dominant hand HGS was ranked from lowest to highest, and quartiles were determined. A HGS in the first quartile was considered a low test. Two participants were removed from the chi-squared tests with HGS and sensitivity and specificity data due to missing dominant handgrip strength measurements. All analyses were done using the Statistical Analysis Systems statistical software package, version 9.4 (SAS Institute, Inc, Cary, NC). Significant results were considered when *P*<.05.

APPENDIX D: COMPLETE RESULTS

Demographics

The demographic characteristics of our sample are summarized in Table 1. A total of 220 pediatric patients enrolled in the study and were divided into hospitalized (n=109) and non-hospitalized (n=110) groups. One hospitalized subject was removed from data analysis due to incomplete results. The mean age was 10.1 ± 2.6 years ranging from 6 to 14 years.

From the entire study population, 184(84%) participants reported having no pain to just a little bit of pain. One hundred seventy nine (82%) participants reported participating in some form of physical activity more than four days a week. Of the hospitalized subjects, 84 (77%) had mild disease severity and 25(22.9%) had moderate disease severity. Only 31(28.4%) hospitalized participants received a dietitian nutrition assessment, and only 4 (3.7%) hospitalized subjects reported receiving some form of nutrition support.

According to BMI z score class, 18 (16.5%) hospitalized and 19 (17.3%) non-hospitalized participants were classified with mild malnutrition and 6 (5.5%) hospitalized and 1 (1%) non-hospitalized participants were classified as moderately malnourished. Only 3 (2.8%) of the hospitalized participants and no non-hospitalized participants were considered severely malnourished (Figure 1). According to MUAC z score classification, 25 (22.9%) hospitalized and 21 (19.1%) non-hospitalized participants were classified with mild malnutrition, and 3 (2.8%) of hospitalized and no non-hospitalized participants were considered moderately malnourished (Figure 2).

Outcomes

According to the mixed model, age category (p<.0001), height z score (p<.0001), dominant hand (p<.0001), and MUAC z score (p=.0462) significantly influenced HGS; however, HGS was

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not significantly influenced by hospitalization (p=.2053) (Table 1). The mean handgrip strength (HGS) of hospitalized subjects was 12.4 ± .37 (mean ± SD, kg) and the mean HGS for non-hospitalized subjects was 13.1 ± .37 (mean ± SD, kg) (Table 1).

Handgrip strength in the non-hospitalized group was significantly influenced by height z score (p=0.0165) and MUAC z score (p=0.0227). There was also a significant difference in HGS between the younger age group ages 6-10 years and the older age group ages 11-14 years (p<.0001). The dominant hand was also significantly stronger than the non-dominant hand in the non-hospitalized children (p<.0001) (Table 2).

In the hospitalized population the height z score significantly influenced HGS (p=.0011). HGS was not significantly influenced by MUAC z score (p=0.622). There was a significant difference in HGS between the younger age group ages 6-10 years old and the older age group ages 11-14 years (p<.001). Dominant hand was also significantly stronger than non-dominant hand (p=.0003). HGS of hospitalized subjects was not significantly influenced by nutrition risk score (p=.300). There was also not a significant difference in HGS between the hospitalized subjects who received a dietitian nutrition assessment and those who did not receive a dietitian nutrition assessment (p=.771) (Table 3).

Chi-squared tests of independence were calculated comparing the frequencies of BMI z score, MUAC z score and HGS for the entire pediatric population. A significant difference was found between MUAC z score and HGS ($\chi^2(9)=18.36$, p=.03) (Table 4) and MUAC z score and BMI z score ($\chi^2(9)=281.61$, p<.0001) (Table 5). The association between BMI z score and HGS was approaching significance ($\chi^2(9)=16.15$, p=.06) (Table 6).

HGS measurements were also evaluated for their ability to accurately identify malnutrition in each age group. Twenty-four participants in the 6-10 year old age group and 30 participants in

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the 11-14 year old age group were identified as malnourished according to MUAC *z* score. Sensitivity, specificity, and positive and negative predictive values were reported in Table 8.

APPENDIX E: COMPLETE DISCUSSION

The alternative hypothesis of this study was there would be a significant difference between HGS of hospitalized and non-hospitalized children based on reports of malnutrition in hospitalized children.[1,9,29,30] However, there was no significant difference in HGS between the two groups. This was most likely because there was no significant difference between the primary indicators of malnutrition and physical activity level between the hospitalized and non-hospitalized participants, See Table 1. According to BMI z scores and MUAC z scores, 18(16.5%) and 25(22.9%) hospitalized children were classified as mildly malnourished and 19(17.3%) and 21(19.1%) non-hospitalized children were classified as mildly malnourished. Eighty-two (75.2%) and 81(74.3%) hospitalized children, and 90(81.8%) and 89(80.9%) non-hospitalized children were classified as well- nourished defined by a BMI z score > -1 and MUAC z score >-1. Sixty-four (58.7%) hospitalized participants reported participating in physical activity more than 5 days per week prior to their current hospitalization compared to 67(60.9%) non-hospitalized participants. Seventy-eight (71.6%) hospitalized participants did not receive a dietitian nutrition assessment.

Historically, malnutrition has been defined as percent of ideal body weight, as first described by Gomez and Waterlow.[31,32] Now the Academy of Nutrition and Dietetics/American Society of Parenteral and Enteral Nutrition 2014 Pediatric Malnutrition Consensus Statement recommends using negative z scores for weight for height, BMI-for-age, length/height, and MUAC to classify malnutrition when only one data point is available.[11] BMI-for-age z scores, height-for-age z scores, and mid-upper circumference z scores were used to classify malnutrition in this study.[11] A strong association between MUAC z scores (p=.0462), height z scores

(p<.0001), and although not significant BMI z scores (p=.54) was found with HGS. Hand dominance (p<.0001) and age (p<.0001) also had a significant association with HGS.

To the best of our knowledge no other studies have investigated the relationship between HGS and the degree of deficit of mild, moderate, and severe malnutrition in pediatrics. Although HGS has been found to be a useful tool for identifying malnutrition,[33-35] there is insufficient data to quantify the degree of malnutrition.[11] This study attempted to quantify the degree of malnutrition for HGS; however, there were low numbers of participants in each of the malnutrition degree categories. This could be due to the inability of severely malnourished children to perform the HGS test.

This study found that BMI and MUAC are highly correlated (p<.0001); however, BMI does not take into consideration muscle mass. HGS is a measurement of muscle function. This study found there is a significant association between MUAC and HGS (p=.03) but the association between BMI and HGS only approached significance (p=.06). Changes in HGS may be seen sooner than changes in both MUAC and BMI; thus, HGS may be a more useful measure to identify malnutrition.

 Sensitivity and specificity are terms used to gauge the validity of a test.[36] It would be ideal to have a test that is both sensitive and specific to detect malnutrition. In clinical practice, screening tools such as hand dynamometry tests should have high sensitivity to properly identify malnutrition. This study found HGS to have a sensitivity of 21.1-28.6% according to MUAC *z* scores. This indicates that 71.4-78.9% of the participants identified as malnourished based on MUAC *z* score were not properly identified as malnourished with HGS. HGS had higher specificity (60-100%) according to MUAC *z* scores, indicating that up to 40% of healthy children had a false positive test, or a low grip strength, that would have improperly categorized

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them as being malnourished according to MUAC *z* score (Table 8). Sensitivity data is typically ran against a validated standard and although MUAC *z* scores have been used to recognize and identify malnutrition, the relationship between MUAC *z* scores still elicits further research. A study done in adults found HGS at admission had good sensitivity for screening patients for nutrition risk.[35] The ability for HGS to be a sensitive marker of nutrition status may vary between adults and children; however, it is possible that HGS might detect malnutrition earlier than both BMI *z* score and MUAC *z* score in children.

HGS, especially in adults, has been studied extensively in outpatient settings and has been found to be associated with various health outcomes, including malnutrition.[37-40] The findings of this study suggest that HGS in an acute, pediatric setting may not be ideal for the identification of malnutrition using a one-time measurement within 48 hours of admission. A limitation of this study is that a one- time, average HGS measurement was taken on each participant within the first 48 hours of admission. HGS has been found to be associated with nutritional status in children when multiple HGS measurements are taken at admission and then again at discharge.[27] HGS as a measurement of malnutrition might be better utilized in an outpatient setting, with specific disease populations, where nutritional status and HGS can be measured over time. A few limitations of this study were obesity and body composition were not taken into consideration and might also influence HGS, siblings were also not excluded from participation in this study, and there is a potential for reporting bias from using the self-reported questionnaire.

Conclusion

This study found the difference in HGS measurements was not statistically significant between hospitalized and non-hospitalized children using a one-time HGS measurement. Further

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research examining HGS measurements over time as well as comparing HGS measurements to the degree of malnutrition deficit in pediatrics is needed. The association between HGS and patient diagnosis, biochemical markers indicative of malnutrition, body composition and muscle mass, and subjective global assessment[41] might also be useful to consider in future studies.

APPENDIX F: IRB APPROVAL

Intermountain
Healthcare Research
Institutional Review Board

May 19, 2015

IRB # 1040474 **Study Alias:** HGS Pediatrics
PI: Sarah Bellini
Title: *Evaluating Handgrip Strength in Pediatric Patients*

Amendment Application - Expedited Review
IHC IRB (Corporate)
Approved: 05/13/2015
Expiration Date: 02/11/2016
Submission Reference #: 004931

This above mentioned Amendment Application has been reviewed and approved by a member of the
IHC IRB (Corporate).

The following submission items have been approved:

Title	Version Number	Version Date
0515 recruitment flyer	Version 2.0	05/07/2015
0515 hgs irb application revisions	Version 2.0	05/07/2015
Comparing Handgrip Strength in Hospitalized and Non-hospitalized Children	Version 2.0	05/07/2015

If you have any questions regarding this decision please contact the IRB analyst assigned to your study,
Anita Pascoe or call the IRB Office at (801) 408-1991 opt. 1.

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Intermountain
Healthcare Research
Institutional Review Board

December 23, 2015

IRB # 1040474 **Study Alias:** HGS Pediatrics
PI: Sarah Bellini
Title: *Evaluating Handgrip Strength in Pediatric Patients*

Renewal Application - Expedited Review
IHC IRB (Corporate)
Approved: 12/23/2015
Expiration Date: 12/22/2016
Submission Reference #: 006840

This above mentioned Renewal Application has been reviewed and approved by a member of
the IHC IRB (Corporate) via expedited review in accordance with 45 CFR 46.110(f)(4).

The FDA requires that research projects be reviewed yearly, or more often at the discretion of
the IRB Committee. You will receive an email notification when it is time for renewal of this
study. It is your responsibility to respond to this notification or approval for this study will be
discontinued. In the meantime, please submit any administrative, procedural or clinical changes
to the IRB for approval prior to making them effective.

It is your responsibility to notify DHHS and/or the FDA, and the Chairperson of the IRB
Committee of any occurrence or emergency that seriously increases the risk to or affects the
welfare of subjects.

If you have any questions regarding this decision please contact the IRB analyst assigned to your
study, Yvonne Elaine Skinner-Ntiri or call the IRB Office at (801) 408-1991 opt. 1.

APPENDIX G: RECRUITMENT FLYER

RESEARCH PARTICIPANTS NEEDED

PURPOSE: To collect measurements of handgrip strength for hospitalized and non-hospitalized pediatric patients in relation to each patient's overall well-being.
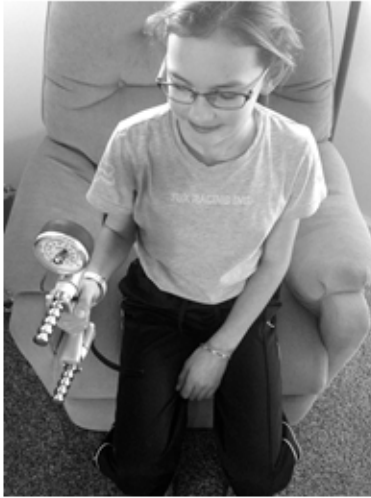
ABOUT: This study will take place from May 2015 until May 2016 OR until enough children have participated in the study. Research data will be collected during your current hospitalization or at the time of your well-child appointment. Data collection will only take 15 minutes.

ELIGIBILITY: Participants in this study must be between the ages of 6 and 14, be able to follow verbal and written directions in English, and perform the handgrip strength measurement. Participants must be admitted to Primary Children's Medical Center or be seen for a well-child visit at Intermountain Hillcrest Pediatrics.

COMPENSATION: Participants will be given a $10 for participation. Money will be given to participant at the time of the study.

BENEFITS of Research: Data collected from this research study will add to a better understanding of nutrition in pediatrics.

If you and your child are interested in participating in this study please contact one of the following:

Sarah G. Bellini, PhD, RD, CD
Assistant Professor
Department of Nutrition Dietetics and
Food Science
ESC 141
Brigham Young University
Provo, UT 840602-4602
801-422-0015
sarah_bellini@byu.edu

Primary Children's Hospital
Jennifer W. Derrick MS, RDN, CD
Administrative Dietitian, Research &
Education
Food & Nutrition Services
801-662-5310
jennifer.derrick@imail.org

Intermountain Hillcrest Pediatrics
Mark C. Templeman, MD
5063 Cottonwood Street #160
Murray, UT 84107
801-507-1850

Research Time-Frame: May 2015- May 2016

APPENDIX H: PARENTERAL CONSENT FORM

Parental permission form

What   Comparing Handgrip Strength in Hospitalized and Non-hospitalized Children

Where   Primary Children's Hospital   Hillcrest Pediatrics
              Jennifer Derrick MS, RD,   Dr. Mark Templeman, MD
              100 Mario Capecchi Dr.   5063 Cottonwood St. #160
              Salt Lake City, UT 84132   Murray, UT 84107

Who   Primary Investigator: Sarah Gunnell Bellini PhD, RDN, CD 801-422-0015

            Co- investigators: Jennifer W. Derrick MS, RDN, CD (801) 662-5310
                                    Mark Templeman MD (801) 507-1850
                                    Amanda Nederostek MS, RDN, CD (801)662-5303
                                    Robin Aufdenkampe MS, RDN, CD (801) 662-5313
                                    Julie Spelman MBA, RDN, CD (801) 662 - 1404
                                    Kayla Jensen RDN, CD (720) 384-6125
                                    Amanda Burr (801) 735-1898

When   During your child's hospital stay or following your child's well-visit
             appointment for approximately 15 minutes.

Why   This study will look for a relationship between handgrip strength and
            nutrition status.

How   If you agree to have your child participate, we will do the study during your
            child's current hospital stay or clinic visit. The researcher will ask you about
            your child's physical activity and assess your child's pain level before taking
            measurements. Then the researchers will measure your child's weight,
            height, and upper arm circumference. Your child will be asked to remove
            his/her shoes and heavy clothing such as a coat for the weight and height
            measurements. Next, your child will be asked to squeeze a special tool with
            his/her hand. The researchers will record the numbers of each of the
            measurements.

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Why is this study being done?

We are asking you to give permission for your child to take part in this research study to see if handgrip strength relates to nutritional status in pediatric patients. Handgrip strength is a simple measurement and may be used to assess nutritional status if a relationship is found in this study. There is little information about using handgrip strength to measure nutritional status in children.

Why are you asking my child to take part in the study?

We are asking for your child to take part in this study because the study focuses on the handgrip strength of children ages 6- 14 to measure nutrition health. Your child is a patient at Primary Children's Hospital or a patient at Hillcrest Pediatrics that meets the study's age criteria. Approximately 100 people will take part in this study at the Primary Children's Hospital. Approximately 100 people will take part in this study at the Intermountain Hillcrest Pediatrics.

Please read this form and ask any questions you may have before giving permission for your child to be in this research study.

Who can be in the study?

We want to enroll children who…
- are between 6-14 years of age
- are able to understand verbal and written directions in English
- have the ability to perform handgrip strength measurements
- are admitted to Primary Children's Hospital or seen for a well-child visit at Intermountain Hillcrest Pediatrics
-does not have a chromosomal disorder that affects his/her height

Who cannot be in the study?

Your child cannot participate in this study if s/he…
- is not between the ages of 6-14 years of age
- is unable to squeeze the handgrip dynamometer
- is unable to follow basic instructions in English
- is not currently admitted to Primary Children's Hospital or seen for a well-child visit at Intermountain Hillcrest Pediatrics.
- has a chromosomal disorder that affects his/her height

If you agree for your child to be in this study, it will take about 15 minutes and be done in the hospital or clinic today. You will answer a question about your child's physical activity. The researcher will assess your child's pain level before taking measurements. Then the researchers will measure your child's weight, height, and upper arm. Last your child will squeeze a tool with his/her hands. The tool your child will be squeezing is similar to the one in this picture.

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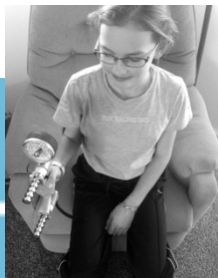
Do I have to give permission for my child to be in the study?

No, you do not have to give permission. Your decision for your child to take part in this study is completely voluntary.

What if I decide not to give permission?

You can choose not to have your child take part in this study and nothing about your child's care will change.

Can I change my mind later?

Yes. If you decide to give permission for your child to join the study, you can change your mind and decide to stop at any time.

How long will my child be in the study?

Your child will be in the study one time for approximately 15 minutes at Primary Children's Hospital or Hillcrest Pediatrics.

What will happen if I decide to let my child take part?

If you agree for your child to be in this study you will answer a few questions about his/her physical activity. The researcher will assess your child's pain level and then measure his/her weight, height, upper arm, and handgrip strength. It will take about 15 minutes.

What are the risks to my child if s/he is the study?

There are minimal risks for participation in this study. However, some children may experience anxiety and discomfort from having his/her measurements taken. Your child may potentially have pain associated with squeezing the handgrip strength tool, too. If your child does experience either of these issues counseling and medical attention will be provided.

Are there any benefits to my child if s/he takes part in the study?

There are no anticipated benefits to your child for participation in this study. The information and research that will be gathered will add to the overall understanding of nutrition status in children.

What happens if my child is injured because s/he was in the study?

If your child becomes injured while taking part in this study, Intermountain Healthcare can provide medical treatment. We will bill you or your insurance company in the usual way. Because this is a research study, some insurance plans may not pay for your treatment. If you believe your child has been injured as a result of being in this study, please call the Principal Investigator right away. You may also call the Office of Research at 1-800-321-2107.

Who do I ask if I have questions about the study or my child's rights?

If you have questions about the study please do not hesitate to call either Sarah Bellini at (801) 422-0015 or Jennifer Derrick at (801) 662-5310.

If you have questions regarding your child's rights as a research subject or if problems arise which you do not feel you can discuss with the Investigator, please contact **Intermountain's Office of Research at 1-800-321-2107.**

What are the costs of taking part in the study?
There will be not cost for participation in this study.

Will my child be paid if to take part in the study?
Each participant will be given a $10 for participation in this study.

If my child takes part in this study, what health information about him/her will you use?

This is the health information from your child's medical records that will be used in the study:
- Nutritional screening score
- Nutrition intervention

This health information will come from the information given to the researchers and from your child's medical records at hospitals and clinics where they've been treated.

The researchers will need to share your child's information with others. This information will not identify your child.

Important: You need to know that laws protect your child's health information when it is held by hospitals and healthcare providers. But if your child's health information goes to someone else, your child's health information may not be protected by those laws.

- Your child's health information may be viewed for the following purposes, and laws protect the confidentiality of your health information when used by these groups for these purposes: Intermountain's IRB (Institutional Review Board) to oversee the safety and ethics of the study
- Intermountain employees to do their job (such as give treatment, for billing matters or to make sure the research is done correctly).
- The Food and Drug Administration and others to comply with law.

If you decide to allow your child to take part in this study and sign this form, you permit researchers to use your child's health information for this study. If you **want** your child to take part in this study, please **sign** this form. If you **don't** want your child to participate, please **don't** sign this form.

You can always ask to see your child's medical information at any time; however, you will not be able to see your child's health information that is used in this study until the study is finished.

Your agreement —which is called an authorization—to share your child's health information as part of this study will end when the study ends.

Consent

I confirm that I have read and understand this consent and authorization document and have had the opportunity to ask questions. I understand that my child's participation is voluntary and that I am free to withdraw my child at any time, without giving any reason, without my medical care or legal rights being affected. I will be given a signed copy of the consent and authorization form to keep.

I agree to allow my child to participate in this research study and permit you to use and disclose health information about my child for this study, as you have explained in this document.

_____
Child's Name

(Please Note: Both parents must give their permission unless one parent is deceased, unknown, incompetent, not reasonably available, or when only one parent has legal responsibility for the care and custody of the child. If both parents are not able to sign, please list the name of the parent and the reason why they are not able to sign in the signature line.

Parent/ Guardian Name	Parent/ Guardian Signature	Title	Date

_____
Name of Person Obtaining Authorization and Consent

_____   _____
Signature of Person Obtaining Authorization and Consent   Date

APPENDIX I: PARTICIPANT ASSENT FORM

Assent Form

What	Comparing Handgrip Strength in Hospitalized and Non-hospitalized Children

Where

Primary Children's Hospital   Hillcrest Pediatrics
Jennifer Derrick MS, RD,   Dr. Mark Templeman, MD
100 Mario Capecchi Dr.   5063 Cottonwood St. #160
Salt Lake City, UT 84132   Murray, UT 84107

Who   Primary Investigator: Sarah Gunnell Bellini PhD, RDN, CD 801-422-0015

              Co- investigators: Jennifer W. Derrick MS, RDN, CD (801) 662-5310
                                   Mark Templeman MD (801) 507-1850
                                   Amanda Nederostek MS, RDN, CD (801)662-5303
                                   Robin Aufdenkampe MS, RDN, CD (801) 662-5313
                                   Julie Spelman MBA, RDN, CD (801) 662 - 1404
                                   Kayla Jensen RDN, CD (720) 384-6125
                                   Amanda Burr (801) 735-1898

When   During your hospital stay or following your well-visit appointment for
                approximately 15 minutes

Why   This study will look at how handgrip strength measures nutrition health.

How   This is a summary of what we will be doing, described on the next few pages.

If you agree to join this study, we will do the study during your hospital stay or clinic visit. The researcher will ask you and/or your parent(s) a few questions about your physical activity. Then the researchers will measure your weight, height, and your upper arm. You will remove your shoes and heavy clothing such as a coat for the weight and height measurements. Then you will be asked to squeeze a special tool with your hand to measure how strong you are. The researchers will record the numbers.

What is a research study?

A research study is a way to find out new information about something. You do not need to be in a research study if you do not want to.

Why are you asking me to be in this research study?

We are asking you to take part in this research study because we want to learn more about using handgrip strength to measure nutrition health.

Do my parents/guardian know about this study?

Yes. We have explained the study to your parents/guardian, and they said that we could ask you if you want to be in this research study. Please talk about this with your parents before you decide if you want to be in the study.

We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to be in this study.

Do I have to be in the study?

No, you do not have to be in this study. Being in this study is your choice and no one will be upset if you don't want to be in the study.

What will happen if I decide I want to be in the study?

If you agree to be in this study you will answer a few questions about your activity level. The researchers will then weigh you and see how tall you are. Next they will take a measurement around your upper arm. Last you will squeeze a tool with your hands to see how strong you are. It will take about 15 minutes.

Can I get hurt if I join the study?

It is not likely that you will be hurt if you join this study. You have to have your height and weight measured, and then squeeze a tool to measure how strong you are. The tool you squeeze is similar to the one pictured below.

Could this research study help me?
This study cannot help you. We hope to learn something from doing this research study, and someday, we hope what we learn can help people like you. There are no anticipated benefits.

Can I stop being in the study if I change my mind later?
Being in this study is up to you and no one will be upset if you change your mind later and want to stop.

Who will see the information you collect about me?
All of your records about this research study will be kept locked up so no one else can see them. The files will be kept in a locked filing cabinet and a locked office. Information kept in the computer will be password protected.

What if I have questions?
You can ask Jennifer Derrick any questions that you have about the study. If you have a question later that you didn't think of now, you can call Sarah Bellini at 801-422-0015.

You can take more time to think about being in the study. Please also talk with your parents or guardian about it. If you want to be in this research study, please write your name on the 'participant' lines below.

- **Remember, you can change your mind and stop being part of this study at any time**

- You and your parents will be given a copy of this paper to keep

_____
Name of participant (Please Print)

_____   _____
Participant signature   Date

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Q0 Study ID Number (500s)

Q1 Date of birth (mm/yyyy)

Q2 Gender"Are you a boy or a girl?"
❍ Male (1)
❍ Female (2)

Q3 What was your physical activity level prior to your well-child visit?"How many days a week do you go outside to play, participate in sports/dance, run/walk, ride a bike, or play at the park?"
❍ > 5 days per week (1)
❍ 4-5 days per week (2)
❍ 2-3 days per week (3)
❍ < 2 days per week (4)

Q4 "Explain to the child that each face is for a person who feels "happy" because there is no hurt or feels "sad" because there is a lot of hurt. Show the FACES to your child and ask him which face looks like how he feels."

Pain Scale Faces Newborn Pediatric Adult Tool   Page 1 of 1

🖶 Print this
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✉ E-mail this

Pain Scale Faces Newborn Pediatric Adult Tool

Wong-Baker FACES Pain Rating Scale

| 0 | 2 | 4 | 6 | 8 | 10 |
| No hurt | Hurts little bit | Hurts little more | Hurts even more | Hurts whole lot | Hurts worst |

From Hockenberry-Eaton M, Wilson D, Winkelstein ML: **Wong's Essentials of Pediatric Nursing**, ed. 7, St. Louis, 2005, Mosby, p. 1259. Used with permission. Copyright, Mosby.

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Q4b What is your current pain level?
- ○ 0= No hurt (1)
- ○ 2= Hurts little bit (2)
- ○ 4= Hurts little more (3)
- ○ 6= Hurts even more (4)
- ○ 8= Hurts whole lot (5)
- ○ 10= Hurts worst (6)

Q5 Dominant hand "Please take this pen/pencil in your hand and pretend to write your name."
- ○ Left hand (1)
- ○ Right hand (2)

Q6 Weight (Kg)

Q6b Comments about weight (if any)

Q7 Height (cm)

Q7b Comments about height (if any)

Q8 Mid-arm circumference of right arm (cm)

Q8b Comments about mid-arm circumference (if any)

Q9 Average handgrip strength of left hand (Kg)

Q9b Comments about left handgrip strength (if any)

Q10 Average handgrip strength of right hand (Kg)

Q10b Comments about right handgrip strength (if any)

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APPENDIX K: PRIMARY CHILDREN'S HOSPITAL SURVEY

Q0 Study ID Number (300s)

Q1 Date of birth (mm/yyyy)

Q2 Gender"Are you a boy or a girl?"
- ⭕ Male (1)
- ⭕ Female (2)

Q3 What was your physical activity level prior to your hospital stay?"How many days a week do you go outside to play, participate in sports/dance, run/walk, ride a bike, or play at the park? "
- ⭕ > 5 days per week (1)
- ⭕ 4-5 days per week (2)
- ⭕ 2-3 days per week (3)
- ⭕ < 2 days per week (4)

Q4 "Explain to child that each face is for a person who feels "happy" because there is no hurt or feels "sad" because there is a lot of hurt. Show the FACES to your child and ask him which face looks like how he feels."

Pain Scale Faces Newborn Pediatric Adult Tool   Page 1 of 1

Print this
Give feedback
E-mail this

Pain Scale Faces Newborn Pediatric Adult Tool

Wong-Baker FACES Pain Rating Scale

0	2	4	6	8	10
No hurt	Hurts little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst

From Hockenberry-Eaton M, Wilson D, Winkelstein ML: **Wong's Essentials of Pediatric Nursing**, ed. 7, St. Louis, 2005, Mosby, p. 1259. Used with permission. Copyright, Mosby.

Q4b What is your current pain level?
- ⭕ 0= No hurt (1)
- ⭕ 2= Hurts little bit (2)
- ⭕ 4= Hurts little more (3)
- ⭕ 6= Hurts even more (4)
- ⭕ 8= Hurts whole lot (5)
- ⭕ 10= Hurts worst (6)

Q5 Dominant hand"Please take this pen/pencil in your hand and pretend to write your name."
- ⭕ Left hand (1)
- ⭕ Right hand (2)

Q6 Nutritional Risk Score

Q7 Severity of your disease
- ⭕ 1= mild: Patient is week but out of bed regularly (1)
- ⭕ 2= moderate: Patient is confined to the bed due to illness but can get out of bed with assistance (2)
- ⭕ 3=Severe: Patient is confined to the bed due to severe disease (3)

Q8 Did you receive nutrition intervention/ medical nutrition therapy?
- ⭕ Yes (1)
- ⭕ No (2)

Q9 Are you currently receiving nutrition support through a feeding tube or IV (TPN)?
- ⭕ Yes (1)
- ⭕ No (2)

Q10 If you selected "Yes" that you are receiving nutrition support through a feeding tube or IV, when was your nutrition support started?
- ⭕ During your current hospitalization (1)
- ⭕ Prior to your current hospitalization (2)
- ⭕ N/A. I am not receiving nutrition support. (3)

Q11 Weight (Kg)

Q11b Comments about weight (if any)

Q12 Height (cm)

Q12b Comments about height (if any)

Q13 Mid-arm circumference of right arm (cm)

Q13b Comments about mid-arm circumference (if any)

Q14 Average handgrip strength of left hand (Kg)

Q14b Comments about left handgrip strength (if any)

Q15 Average handgrip strength of right hand (Kg)

Q15b Comments about right handgrip strength (if any)

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