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Measurement of Function Post Hip Fracture: Testing a Comprehensive Measurement Model of Physical Function

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Abstract

Background—Measurement of physical function post hip fracture has been conceptualized using multiple different measures.

Purpose—This study tested a comprehensive measurement model of physical function.

Design—This was a descriptive secondary data analysis including 168 men and 171 women post hip fracture.

Methods—Using structural equation modeling, a measurement model of physical function which included grip strength, activities of daily living, instrumental activities of daily living and performance was tested for fit at 2 and 12 months post hip fracture and among male and female

participants and validity of the measurement model of physical function was evaluated based on how well the model explained physical activity, exercise and social activities post hip fracture.

Findings—The measurement model of physical function fit the data. The amount of variance the model or individual factors of the model explained varied depending on the activity.

Conclusion—Decisions about the ideal way in which to measure physical function should be based on outcomes considered and participant

Clinical Implications—The measurement model of physical function is a reliable and valid method to comprehensively measure physical function across the hip fracture recovery trajectory.

Practical but useful assessment of function should be considered and monitored over the recovery trajectory post hip fracture.

Keywords

hip fracture; function; measurement

Assessment of physical function post hip fracture is commonly evaluated and is critically important both from the perspective of the individual patient (Gorman et al., 2013) as well as the impact on the health care system (Grigoryan, Javedan, & Rudolph, 2014). Repeatedly it has been noted that at 12 months post fracture, less than half of individuals who experience a hip fracture return to pre-fracture physical function (Magaziner et al., 2003; Osnes et al., 2004). The return to baseline physical function is influenced by many factors including such things as cognitive status, surgical interventions, age, other comorbid conditions and course following surgery (Ariza-Vega, Jiménez-Moleón, & Tange Kristensen, 2014; Beaupre, Jones, Johnston, Wilson, & Majumdar, 2012; Ortiz-Alonso, et. al., 2012; Taraldsen et al., 2014). Although commonly considered in the post hip fracture trajectory, physical function is recognized to be a complex concept difficult to characterize (Finch, Higgins, Wood-Dauphinee, & Mayo, 2009).

Physical function can be challenging to measure as survey measures based on verbal report and recall from patients may not be accurate and observation of function requires significant amounts of time and is often done with props such as a standardized shoe or chair (e.g, in a simulated situation versus a real-world dressing experience). Moreover, the patient may refuse to even try to perform the activity due to fear rather than ability. Survey measures tend to be the most popular method of measurement of function due to cost and ease of administration. Unfortunately there is inconsistent support for the reliability and validity of surveys and survey results frequently overestimate activity (Fitzhugh, 2015; Pryce, Johnson, Goyton, et. al., 2012). Challenges to self-report, particularly among older adults, include recall issues and bias due to social desirability (Sallis & Saelens, 2000; Tooze, Thompson, Troiano, Schatzkin & Kipnis, 2004; Sjostrom, 2002). Moreover, subjective reports and objective measures of physical function have not been strongly associated with each other (XXXX, 2008). Thus it is recommended that both approaches are used to comprehensively evaluate physical function. This combined approach includes the individual's perception of what he or she can do (i.e., the subjective reports) versus what they actually do based on objective evaluations (XXXX, 2008).

Though challenging to measure, it is important to clearly and consistently conceptualize physical function post hip fracture as it is the measure that is used to allocate resources such as staff needed to provide care, determine the level of care needed (e.g., assisted living), compare effectiveness of different types of interventions (e.g., exercise programs; nursing care interventions), predict outcomes and guide patients and caregivers in the recovery trajectory (Allen, et al., 2012; Healee, McCallin, & Jones, 2010). The Patient Reported Outcomes Measurement Information System (PROMIS) defined physical function as “ability to carry out various activities that require physical capability, ranging from self-care [basic activities of daily living (ADL)] to more-vigorous activities that require increasing degrees of mobility, strength, or endurance” (Patient Reported Outcomes Measurement Information System (PROMIS) (PROMISE Measures, 2014). Conversely, others have defined physical function as including physical fitness (cardiorespiratory fitness, strength and flexibility), sensory function, clinical condition, environmental factors and behavioural factors (Painter, Stewart, & Carey, 1999; Stewart & Painter, 1997). Building off these definitions, we propose a measurement model of physical function that includes subjective and objective reports of activities of daily living (bathing, dressing, toileting and hygiene), mobility (transfer and ambulation), physical fitness (specifically strength), and more complex instrumental activities of daily living (travel, shop, manage, meals, and house clean). Establishing a more comprehensive measure of physical function will improve how nurses evaluate function in patients post hip fracture or following other acute events and help them, and other health care providers, facilitate the recovery trajectory.

Prior Research Measuring Physical Function Post Hip Fracture

Studies describing physical function in the post hip fracture period have conceptualized and measured function using different individual assessment instruments as shown in Table 1. Generally these studies used one or multiple instruments from the categories of activities of daily living, strength, and physical performance. The majority of the studies reviewed focused only on ADLs, in some cases combining this with instrumental activities of daily living (IADLs) (Ariza-Vega, Jiménez-Moleón, & Kristensen, 2014; Beaupre, et al., 2012; Giusti, Barone, & Pioli, 2007; Goldstein & Strasser, 1997; Gorman, et. al., 2013; Heruti, Lusky, Barell, et. al, 1999; Lenze, Skidmore, Dew, et. al, 2007; McGilton, Mahomed, Davis, et. al., 2009; Naglie, Tansey, Kirkland, & et al, 2002; Penrod, Boockvar, Litke, et. al, 2004; Rolland, Pillard, Lauwers-Cances, et.,al., 2004; Vidan, Serra, Moreno, et. al., 2005). Specifically these instruments included the Barthel Index (Mahoney, 1965), the Functional Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997), the Functional Status Index (Jette, 1980), the Katz Activities of Daily Living measure (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) and the Lawton Instrumental Activities of Daily Living measure (Lawton & Brody, 1969).

A few of these studies (Taraldsen, et al., 2014; Uy, Kurrle, & Cameron, 2008) conceptualized physical function to be based on performance measures such as timed standing and walking or the Short Physical Performance Battery (SPPB) (Guralnik, et. al., 1994), the Timed Up and Go measure (Podsiadlo & Richardson, 1991) or the Tinetti Gait and Balance measure (Tinetti, 1986). The remaining studies measured multiple areas of function, although each of these was individually measured. Four studies (Di Monaco, et. al.,

2014; Laflamme, Rouleau, Leduc, Roy, & Beaumont, 2012; Magaziner, et. al., 2000; Ortiz-Alonso, et. al., 2012) conceptualized physical function using measures of ADLs and observed performance. Lastly, there was one study (Auais, Eilayyan, & Mayo, 2012) that considered multiple individual measures for ADLs, strength and performance.

The studies reviewed all evaluated physical function for different reasons: to establish predictors of function, to test the effectiveness of interventions, to consider the trajectory of recovery among hip fracture patients over time, or to consider the impact of physical function on clinical needs such as requiring a walking aid. There was no evidence to indicate which of these approaches, subjective or objective, or which measure was the best single measure of physical function. Likewise, some of the measures used overlapped and considered the same items (e.g., ability to get up from a chair). Therefore, to optimally measure physical function post hip fracture, we proposed a measurement model of physical function that incorporated all of the areas previously considered within physical function including grip strength, activities of daily living and instrumental activities of daily living and performance. The purpose of this study was to test the proposed measurement model of physical function and determine if it was reliable when used along the trajectory of hip fracture recovery and with males and females. In addition, testing was done to determine if this measurement model explained more of the variance in time spent in physical activity, exercise and social activities at 2 and 12 months post hip fracture when compared to the individual measures of physical function. Specifically we hypothesized that the measurement model of physical function (Figure 1) would fit the data at 2 months and 12 months post hip fracture and that, similar to use of other measures of physical function (das Nair, Moreton, & Lincoln, 2011; Turner-Stokes, & Siegert, 2013), there would be no difference in fit when used with males or females. In addition, we hypothesized that the 2 month measurement model of physical function would be significantly associated with time spent in physical activity, exercise and social activities at 2 months and explain more of the variance in the outcomes (physical activity; exercise; social activities) when compared to each of the individual components of the measurement model [Short Physical Performance Battery (SPPB); IADLs; Lower Extremity Gains Score (LEGs); Grip Strength; and Physical Activities of Daily Living (PADL)]. Lastly, we hypothesized that the 2 month measurement model of physical function would predict 12 month physical activity, exercise and social activities and explain more of the variance than any of the individual measures. In each model we controlled for age, comorbidities, cognition, resilience and gender.

Methods

This study was a descriptive secondary data analysis using data from a prospective cohort study (referred to as BHS-7 or the Male Hip Study) carried out in eight hospitals that were part of the Baltimore Hip Studies (BHS) network. The major focus of the parent study was to compare outcomes between males and females following a hip fracture. The study was approved by the University of Maryland Institutional Review Board and review boards at each of the study hospitals. Patients were screened and enrolled within 15 days of admission. Female enrollment was frequency-matched to males within each hospital so that females were only screened for enrollment when a male had been enrolled. Demographic data were obtained at baseline and all other measures were obtained at 2, 6 and 12 months

post hip fracture. This study used data obtained at the 2 month period to consider patient status following surgery and traditional rehabilitation and the 12 month follow up period to consider model fit at the time of full recovery and to determine if 2 month physical function was predictive of full recovery (Magaziner et al., 2000). A proxy was asked to provide data for those participants with a score <36 on the Modified Mini-Mental State Examination (3MS) (Bassuk & Murphy, 2003).

Sample

Eligible patients were community-dwelling, aged 65 years or older and admitted for surgical repair of a hip fracture to one of eight study hospitals. Individuals were excluded if they were not community dwelling, lived more than 70 miles from the hospital, not English speaking, had a pathologic fracture, were bed-bound or wheel chair dependent during the 6 months prior to the fracture, weighed more than 300 pounds, or had some type of hardware in the contralateral hip (either due to hip fracture or hip replacement) leaving no unaffected hip for bone density scanning purposes. A total of 1705 hip fracture patients were screened and 917 (54%) were eligible (405 males, 512 females). Of those eligible, 180 men and 182 women consented to participate in the study. Twenty-three participants were withdrawn from the study. Specifically, five of these individuals failed to provide data at the baseline and 2-month follow-up visit and another 18 participants were removed from the analysis sample as a result of an IRB-requested post procedure audit. The audit identified six participants who were found to be ineligible because they did not meet study inclusion criteria and 12 participants were determined to be ineligible secondary to failures in the informed consent process. The remaining 339 participants were included in the final analytic sample (168 men, 171 women). At 2 months, follow-up data were obtained on 262 participants (77% of full baseline sample) and at 12 months follow-up data were obtained on 187 (55%) of the full baseline sample. There was no difference between those who were recruited into the study at baseline and those who had follow up data obtained with regard to demographic factors, cognition or comorbidities.

Measures

In addition to age and gender, descriptive data included comorbidities based on a modified Charlson scoring system using information obtained from the medical record (Charlson, Pompei, Ales, & MacKenzie, 1987); cognition based on the 3MS (Bassuk & Murphy, 2003); and resilience using a modified version of the 25-Item Resilience Scale (Wagnild, 2003; Wagnild & Young, 1993; Wagnild, 2009), a general measure of resilience for adults across the lifespan. These measures all have prior evidence of reliability and validity and were included because they have been associated with physical activity among older adults (Gorman, et. al., 2013; Healee, et. al., 2010; XXXX, 2007).

Physical Activity and Exercise

Measurement of time spent in all physical activity and time spent in exercise were based on the Yale Physical Activity Survey (YPAS) (Dipietro, Caspersen, Ostfeld & Nadel, 1993). The YPAS is an interviewer-administered questionnaire which includes five categories of

physical activity: housework, yard work, caretaking, recreational activities and exercise (moderate intensity activity, or exercise, such as brisk walking, biking, dance, etc.) performed during a typical week. Prior use provided evidence of two week repeatability ($r=0.63$, $p<.001$), and the YPAS has been validated against several physiological variables that are indicative of habitual activity (DiPietro, et. al., 1993; Pescatello, DiPietro, Fargo, Ostfeld & Nadel, 1994). Physical activity included a sum of the time spent in all activities: housework, yard work, caretaking and recreational activities and exercise. Exercise was the sum of time spent in the exercise subset only.

Social Activity

Measurement of social activity was based on the number of times the individual engaged in any of 10 activities over the past two weeks. Activities included such things as going to movies, museums, attending meetings, religious services, going for a drive, playing cards, or doing volunteer work. These items were based on prior work done by House et al., (House, Robbins, & Metzner, 1982) evaluating a combination of social activities that included sedentary behavior, passive and solitary activity and those that required some physical activity.

Physical Function

Physical function was, as noted above, conceptualized to include grip strength, ADLs, and IADLs and two performance measures. The measures from the parent study that best addressed each of these conceptual areas were included in the measurement model of physical activity. Grip strength was measured using a JAMAR Hydraulic Hand Dynamometer (Ashford, Nagelburg & Adkins, 1996; Peolsson, Hedlund & Berg, 2001; Roberts, et. al., 2011). PADLs were based on a modified version of the Functional Status Index (Jette, 1980), revised to specifically address functional issues relevant to patients post hip fracture. A total of 14 activities were included such as getting into a car, in and out of bed, bathing, dressing and grooming. Each was scored based on subjective reports of completing the activity within the past two weeks with the help of a human or equipment, or inability to perform for health reasons. Higher scores were indicative of needing more help. IADLs were measured using a modified version of the Older Americans Resources and Services Instrument (OARS) (Lawton & Brody, 1969). This measure involved asking participants to describe their ability to perform (independently, with help or not at all) seven daily tasks over the past two weeks. As with activities of daily living, this was based on subjective reports from participants and higher scores were indicative of needing more help. All of these measures have been previously used with older adults and have established evidence of reliability and validity.

Lower extremity performance was measured using the Lower Extremity Gain Scale (LEGS) (Zimmerman, et. al., 2002). LEGS is an observed and timed performance-based measure that focuses on clinically relevant aspects of functioning for hip fracture patients. Completion of the LEGS included observing the participant reach for an item on the ground from a sitting position, putting a sock and shoe on the fractured lower extremity, stepping down four stairs, and getting on and off the toilet. Prior use provided evidence of reliability

based on a significant correlation with performance over a two day period (intra-class correlations ranging from 0.63 to 0.96) and validity based on evidence of functional improvement over time (Zimmerman, et. al., 2002).

Lastly, the SPPB (Guralnik, et. al., 1994) was used to evaluate performance of physical activities including balance based on multiple stances, time to walk 3 meters, and chair rise. There is prior evidence of reliability and validity of this measure when used with older adults (Freire, Guerra, Alvarado, Guralnik & Zunzunegui, 2012; Guralnik, et. al., 1994).

Data Analysis

Descriptive analyses are shown in Table 2. With the exception of IADL and time in physical activity which were negatively skewed, the variables included in the models were normally distributed. Corrections were made using log transformations for the two negatively skewed variables. Multi-collinearity was evaluated based on the variance inflation factor (VIF). The VIFs of all of the model variables were less than 3 indicating no significant multi-collinearity (Grewal, Cote & Baumgartner, 2004). A measurement model of physical function (Figure 1) was tested using data from the 2 and 12 month time points. The measurement model of physical function was also tested and compared for fit between males and females at 2 months post hip fracture. A full structural model (Figure 2) was tested to establish the association between the 2 month measurement model for physical function with time spent in exercise, physical activity and social activities at 2 months. An additional full structural equation model was tested to establish if the 2 month measurement model for physical function was predictive of time spent in exercise, physical activity and social activities at 12 months post hip fracture. In addition, to consider if individual measures within the measurement model of physical function explained as much of the variance in the respective outcome as the full measurement model of physical function, we tested the full structural model with each individual functional measure (e.g., grip strength, SPPB). Analyses were done using structural equation modeling and the AMOS statistical program (Arbuckle, 1997).

For all models tested, the sample covariance matrix was used as input and a maximum likelihood solution sought. The chi-square statistic divided by degrees of freedom and the Stiegers Root Mean Square Error of Approximation (RMSEA) were used to estimate model fit. The larger the probability associated with the chi-square divided by degrees of freedom the better the fit of the model to the data. A ratio of 3 was considered to be a good fit (Bollen, 1989). The RMSEA is a population based index and consequently is insensitive to sample size. A RMSEA of < 0.10 is considered good, and <0.05 is very good. Path significance (i.e., significance of the Lambda values) was based on the Critical Ratio (CR), which is the parameter estimate divided by an estimate of the standard error. A CR > 2 in absolute value was considered significant (Arbuckle, 1997). Significance for path estimates was set at $p = 0.05$. Significant differences in model fit were based on significant changes between the χ^2 and degrees of freedom of each model.

Results

Descriptive results for the sample are provided in Table 2. The mean age of the participants was 80.90 (SD=7.88) and they were generally intact cognitively, had approximately two comorbidities and were resilient. As might be expected, activity and performance measures were all low indicating largely sedentary activity at 2 months post hip fracture. By 12 months the time spent in overall physical activity increased but time spent in exercise decreased.

The measurement model of physical function is shown in Figure 1 and parameter results shown in Table 3. The path parameters were significant at both testing time points. There was excellent fit of the model to the data at 2 and 12 months. For both models the χ^2 divided by degrees of freedom was less than 3 and the RMSEA was less than 0.10. At 2 and 12 months the χ^2 divided by degrees of freedom was non-significant, further supporting the model fit (i.e., that there was not a statistically significant difference between the hypothesized and tested models). Likewise, when comparing the model fit of the measurement model of physical function at 2 months post fracture between males and females there was not a statistically significant difference in fit across genders.

Results of model testing of the full hypothesized structural equation model evaluating the relationship between the 2 month measurement model of physical function and physical activity, exercise and social activities at 2 months are provided in Table 4. Parameter estimates for the measurement model of physical function as well as testing of the full structural equation model with each individual measure of physical function used in the measurement model are shown in Table 4 along with estimates of model fit. Across all the full structural equation models tested the fit of the model to the data was poor with χ^2/df ranging from 4.0 to 12.0 and RMSEA ranging from 9.0 to 17.0.

In the 2 month full structural equation model testing of factors associated with time in overall physical activity, the measurement model of physical function and instrumental activities of daily living had the highest path estimates (both path parameters 0.37, $p=.001$). The amount of variance explained however was lower than what was found with the other individual factors (55%–58% versus 64–77%). Likewise, the measurement model of physical function had the highest path parameter (path parameter 0.30, $p=.003$) predicting physical activity at 12 months although explained less of the overall variance than some of the individual factors (27% for the measurement model of physical function versus 39% with grip strength only).

In 2 month full structural equation model testing of time spent in exercise, grip strength was the only factor to be significantly associated with exercise at 2 months and had the highest path parameter. Specifically, there was a negative association such that those with better grip strength engaged in less exercise (path parameter -0.15 , $p=.02$). This model explained the greatest amount of variance in overall time spent in exercise at 2 months post hip fracture. At 12 months, the measurement model of physical function, had the highest path parameter (path parameter 0.27, $p=.01$) and explained the greatest amount of variance in overall time in exercise (11%). Neither lower extremity function (LEGS), instrumental activities of daily

living (IADL) or grip strength alone were significantly associated with time spent in exercise at 12 months.

The measurement model of physical function also had the highest path parameter associated with number of social activities the individual engaged in at 2 months post hip fracture (path parameter 0.48, $p=.001$) and explained the greatest amount of variance. Likewise at 12 months the measurement model of physical function had the largest path parameter (path parameter 0.60, $p=.001$) and explained the largest amount of the variance in social activities at 12 months (39%) with the exception of the single factor performance measure (SPPB) which explained 40% versus 39% of the variance when tested in the model alone.

Discussion

The findings from this study support the conceptualization of physical function as incorporating the five individual measures addressing performance, physical and instrumental functional tasks and strength. All proposed individual measures fit the measurement model of physical function as hypothesized when tested at 2 months and 12 months. Further the fit was similar across both genders with similar path estimates and model fit. This supports the reliability of use of the measurement model of physical function across the recovery trajectory as well as with males and females. Among all five individual factors in the measurement model of physical function, grip strength had the lowest parameter path. Moreover, when tested individually grip strength was not significantly associated with time in physical activity at 2 or 12 months or time in exercise at 12 months post hip fracture. All the other individual variables, lower extremity function, instrumental activities of daily living, activities of daily living and physical performance (i.e., LEGS, IADL, PADL and SPPB) had path estimates of greater than 0.50 in the measurement model of physical function and were generally associated with the outcome being tested.

Conversely, grip strength was the only variable associated with exercise at 2 months post hip fracture. This was a negative association such that those with better grip strength engaged in less exercise. It is possible that at two months post hip fracture the exercise being reported was associated with time in physical therapy. Those who were stronger may have been sufficiently independent such that they were no longer receiving skilled physical therapy and thus actually did less exercise than those who were weaker. Although there is some prior research that has considered the use of strength as a measure of function (Auais, et. al., 2012; Cantarero-Villanueva, et. al., 2012), grip strength is more commonly conceptualized as a variable that is *associated with* function and functional changes over time (Pincus, 2005; Taekema, Gussekloo, Maier, Westendorp & de Craen, 2010) rather than an actual component of function (i.e., a variable that can be used to measure function). Moreover, when considered as a measure of function it is generally knee strength that is used rather than grip strength (Auais, et. al., 2012; Barbat-Artigas, et. al., 2013). While measurement of knee strength maybe helpful it is more challenging to obtain in real world settings as a Cybex dynamometer or a chair-fixed dynamometer must be used. Conversely, the measurement of grip strength can easily be done using a handheld dynamometer at the bedside.

Our measurement model of physical function does not differentiate the individual's physical capability from their actual performance. That is, the individual may be able to bathe and dress but may be unwilling to do so because it is difficult or because they have a caregiver who performs these activities without giving them the time to do so. Particularly in the post hip fracture recovery period the interpersonal relationships and type and amount of caregiving available and provided may have an influence on functional performance. That is, caregivers who perform the task for the patient may cause or contribute to the persistent functional decline that occurs among these individuals (XXXX, 2011). The measurement model of physical function does, however, provide nurses with an important baseline assessment of the current physical function of the individual from his or her perspective as well as based on observed performance. In addition, we recommend that nurses continually encourage the individual to work towards his or her full capability. Considering basic ability such as whether or not the individual has full upper extremity range of motion, for example, should serve as evidence for the nurse that the individual can feed him or herself. Cueing or role modeling may be needed if the individual is cognitively impaired.

Three of the measures within our measurement model of physical function were objective measures (LEGS, SPPB and grip strength) and two were based on self- or proxy-report (PADL and IADL). Interestingly, across all the full structural equation models tested there was no evidence to support the value of using an observed versus self/proxy reported measure. This implies that, as appropriate (i.e., if there are limited resources, or if the individual item reflects the outcome of interest such as occurs with subjective reporting of ADLs or IADLs and physical activity), a single subjective survey may be sufficient. It should be recognized, however, that the outcome measures, time spent in different types of activities, were also based on self-report versus use of actigraphy which would result in an objective measure physical activity and exercise. Thus, future work should consider the inclusion of objective outcome measures and re-test the utility of the measurement model of physical function with objective evaluations of exercise and physical activity.

The measurement model of physical function fit the data and all five variables had significant path estimates and in some cases the model of physical function explained more of the variance in an outcome than the individual measures. Parsimony and participant burden in measurement, however, needs to be considered. This is particularly important when working with older adults post an acute event as long interviews and rigorous physical testing can result in fatigue, measurement error and participant drop out (Bonk, 2010; Ridda, MacIntyre, Lindley & Tan, 2010). Depending on the type of study and focus, careful consideration should be given to the most feasible way in which to evaluate physical function. While a more comprehensive conceptualization of physical function using the measurement model of physical function may be ideal, practical consideration for the individual and the setting in which testing will be done should be considered. For rehabilitation nurses who work in ambulatory or outpatient practices, the comprehensive measurement model of physical function provides an efficient way in which to measure physical function during a Welcome to Medicare or Annual Health Visit for older adults as it covers many of the required areas of assessment and management (American College of Physicians, 2015).

To evaluate the utility and validity of the proposed measurement model of physical function we hypothesized that physical function would be associated with physical activity, exercise and social activities post hip fracture. In the full structural model we controlled for the impact of age, comorbidities, cognitive status, gender and resilience. The full structural equation model had a poor fit to the data regardless of outcome (i.e., the hypothesized model was not supported). It is possible that additional factors such as the physical environment and whether or not the individual had opportunities to engage in physical and social activities, and cultural expectations may help to more fully explain activity related outcomes (Cain, Millstein, Sallis & et. al., 2014; Eronen, et. al., 2014; Rönngren, Björk, Haage & Kristiansen, 2014). Clinically, the goal is to encourage individuals post hip fracture to engage in as much physical and social activity as possible as this has a positive impact on quality of life and ability to remain in the least restrictive living setting (Benton, Alexander & Holland, 2014; Steptoe, de Oliveira, Demakakos & Zaninotto, 2014). Ongoing research is needed to continue to explore the many factors that influence physical activity, exercise and participation in social activities among older adults post hip fracture.

At two months post hip fracture, the participants in this study reported engaging in approximately 540 minutes per week of physical activity or 77 minutes a day and approximately 180 minutes a week of exercise or 25 minutes a day of exercise. While the time spent in overall physical activity is quite low, the amount of exercise is high and almost reaches the guideline put forth for exercise activity for all older adults (American College of Sports Medicine and the American Heart Association, 2013). There was an increase in overall activity at 12 months to approximately 780 minutes a week or 111 minutes per day (almost two hours) and a decrease in time spent in exercise to 105 minutes per week or 15 minutes per day. We anticipate that this decline may be due to the fact that at 2 months some participants were still receiving skilled physical therapy while at 12 months no further physical therapy was being provided. These findings are disappointing in that the goal should be to increase time spent engaged in exercise as a way to improve quality of life as well as balance, function and endurance and prevent future falls (de Vries, et. al., 2012; Rao, Chou, Bursley, Smulofsky & Jezequel, 2014). Continued research is needed on ways in which to increase time spent in exercise and physical activity among those who have sustained a hip fracture.

Study Limitations

This study was limited by sample size, homogeneity and the fact that all were from Maryland. Further, limitations included the use of subjective measures for information related to function and physical activity and the use of proxy reporting for individuals who had moderate to severe cognitive impairment. This may have resulted in biased findings and over-inflation of descriptive findings. Despite these limitations, this study provides an example of a comprehensive way for nurses and other health care providers to consider physical function throughout the hip fracture recovery trajectory.

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Figure 1.
Physical Function

Figure 2.
Full Model

*Activity = Exercise Time; Time in Physical Activity; Social Activities

Table 1
Summary of Relevant Literature Measuring Physical Function Post Hip Fracture

Study	Activities of Daily Living	Muscle Strength and Grip	Performance	Findings
Di Monaco, et al., 2014 (Di Monaco, et al., 2014)	Barthel Index (Mahoney, 1965)		Timed Up and Go(Podsiadlo & Richardson, 1991)	Grip strength and not dual energy x-ray absorptiometry (DEXA) predicted 1 month functional recovery.
Ariza-Vega, et al., 2014 (Ariza-Vega, Jiménez-Moleón, & Kristensen, 2014; Ariza-Vega, Jiménez-Moleón, & Tange Kristensen, 2014)	Functional Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997)			Weight bearing status, pre-fracture function cognition, health status, age and fracture type influenced functional recovery at 12 months post fracture(Ariza-Vega, Jiménez-Moleón, & Kristensen, 2014); Functional recovery was noted to occur mostly over the first three months post fracture(Ariza-Vega, Jiménez-Moleón, & Kristensen, 2014).
Taraldsen, et al., 2014 (Taraldsen, et al., 2014)			Standing and Walking time based on Actigraphy; Short Physical Performance Battery (Guralnik, et al., 1994)	With geriatric focused care older adults showed more standing time and had better lower limb function based on SPPB than those who received routine care (Taraldsen, et al., 2014).
Gorman, et.al., 2013 (Gorman, et al., 2013)	Lower Extremity Measure (Jaglal, Lakhani, & Schatzker, 2000)			Function was conceptualized to include mobility and complete daily and leisure activities. These were important factors on motivating individuals to exercise post hip fracture.
Magaziner, et.al., 2000 (J. Magaziner, et al., 2000)	Physical activities of daily living (PADL) based on the Functional Status Index(Jette, 1980), including both upper and lower activities of daily living.; Instrument Activities of Daily based on the Older Americans Resources and Services Instrument (Fillenbaum & Smyer, 1981).		Modified Tinetti Gait and Balance measure (Fox, Felsenthal, Hebel, Zimmerman, & Magaziner, 1996); Walking speed; and chair rise speed.	Most areas of functioning showed progressive lessening of dependence over the first post-fracture year. The time to recovery of function varied across different areas of function.
Auais, Eilayyan & Mayo, 2012 (Auais, et al., 2012)	Activities of Daily Living with the Katz (Katz, et al., 1963) or Barthel Index (Mahoney, 1965); Instrumental Activities of Daily Living (Lawton & Brody, 1969)	Knee strength.	Six Minute Walk Test (Balke, 1963). Timed Up and Go (Podsiadlo & Richardson, 1991); Fast Gait Speed. Normal Gait Speed; Balance with scales such as the Berg Balance Scale (Berg, Wood-Dauphinee, Williams, & Maki, 1992); Physical Function subscale from the 36-Item Short Form Health Survey (Ware & Sherbourne, 1992); Gait and balance measures using the Performance Oriented Mobility Assessment (POMA) battery (Tinetti, 1986).	Extended exercise programs showed modest effect sizes for knee extension strength; balance; physical performance; Timed Up & Go; and fast gait speed.

Study	Activities of Daily Living	Muscle Strength and Grip	Performance	Findings
Laflamme, Rouleau, Leduc, & Beaumont, 2012. (Laflamme, et al., 2012)	Lower Extremity Measure (Iaglal, et al., 2000); The Harris Hip Score(Harris, 1969).		Timed Up and Go(Podsiadlo & Richardson, 1991)	The Timed Up and Go was predictive of needing a walking aid at two years post fracture.
Beaupre, et al., 2012 (Beaupre, et al., 2012)	Functional Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997)			There was significant functional decline noted post hip fracture among nursing home residents with regard to functional activities (i.e. activities of daily living) and walking.
Ortiz-Alonso, et al., 2012 (Ortiz-Alonso, et al., 2012)	Physical Activities of Daily Living (Katz, et al., 1963)		Ability to walk was defined using the Functional Ambulation Classification (Holden, Gill, Magliozzi, Nathan, & Piehl-Baker, 1984)	Functional recovery was noted to vary among individuals in different older age groups. Those who were older were at greatest risk of decline and took the longest to recover.
Giusti, et al., 2007 (Giusti, et al., 2007)	Barthel Index and Lawton Activities of Daily Living(Lawton & Brody, 1969; Mahoney, 1965)			There were similar rates and levels of recovery among cognitively impaired patients in home versus institutional based rehabilitation.
Lenze, et al., 2007 (Lenze, et al., 2007)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997)			There were no differences in functional outcomes between cognitively impaired patients who received in-patient rehabilitation versus skilled nursing services
Goldstein & Strasser, 1997)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997)			Cognitively impaired patients demonstrated gains in functional outcomes, although less so with regard to mobility.
Heruti, et al., 1999 (Heruti, et al., 1999)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997)			Those with higher cognitive status on admission had higher motor FIM scores at discharge.
McGilton, et al., 2009 (McGilton, et al., 2009)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997); Barthel Index (Mahoney, 1965)			Those with better cognitive function on admission had better functional outcomes following inpatient rehabilitation.
Rolland, et al., 2004 (Rolland, et al., 2004)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997); Montebello Rehabilitation Factor Score			There was no difference in functional outcomes following rehabilitation between those with and without cognitive impairment.
Penrod, et al., 2004. (Penrod, et al., 2004)	Function Inventory Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1997); Elderly Mobility Scale (Smith, 1994); Functional Ambulation Classification (Holden, et al., 1984); Barthel Index (Mahoney, 1965)			Cognitive status did not predict ambulation ability based on the FIM up to 6 months post hip fracture.
Horgan & Cunningham, 2003 (Horgan & Cunningham, 2003)	Elderly Mobility Scale (Smith, 1994)			Better cognition on admission and discharge was associated with improvement in mobility following rehabilitation.
Vidan, et al., 2005 (Vidan, et al., 2005)	Functional Ambulation Classification (Holden, et al., 1984)			There was better reported FAC scores among those who were exposed to a delirium intervention post hip fracture than among those who did not.

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Study	Activities of Daily Living	Muscle Strength and Grip	Performance	Findings
Naglie, et. al., 2002 (Naglie, et al., 2002)	Barthel Index for ambulation(Mahoney, 1965); Instrumental Activities of Daily Living(Lawton & Brody, 1969)			Patients who were exposed to interdisciplinary care had less decline in ambulation than those who received usual care.
Young, Xiong & Pruzek, 2011 (Young Y, Xiong K, & Pruzek RM, 2011)	The Functional Inventory Measure (Linacre, Heinemann, Wright, Granger, & Hamilton, 1994)			Different functional recovery patterns were noted between those with cognitive impairment versus those without impairment. More individuals with impairment needed human assistance for ambulation, transfers, self-care and bowel management.
Uy, Kurrle & Cameron, 2008 (Uy, et al., 2008)			Timed gait (2.44 meter walk)	There was a trend towards better ambulation in cognitively impaired persons in nursing homes after they participated in rehabilitation.

Table 2

Descriptive Statistics for Model Variables at Two and Twelve Months Post Hip Fracture.

Variable	Minimum	Maximum	Mean	Standard Deviation
Age	65.00	100.00	80.90	7.88
Comorbidities	.00	8.00	2.02	1.77
Resilience	2.47	7.00	5.80	0.88
Cognition (3MS)	2.00	100.00	83.35	17.74
Lower Extremity Gains Score at 2 Months	0.00	35.35	15.62	10.29
Short Physical Performance Battery at 2 Months	0.00	11.00	3.27	2.67
Grip Strength at 2 Months	2.00	48.00	23.89	9.07
Lower Extremity Physical Activities of Daily Living at 2 months.	0.00	12.00	7.47	3.28
Instrumental Activities of Daily Living at 2 Months	0.00	4.00	3.33	1.14
Yale Total Physical Activity at 2 Months (hrs/wk)	0.00	62.90	9.16	10.19
Yale Total Exercise Time at 2 Months (hrs/wk)	0.00	20.10	3.34	3.67
Total Number of Social Activities (over a prior two week period) at 2 Months	0.00	51.00	6.98	8.20
Yale Total Physical Activity at 12 Months (hrs/wk)	0.00	78.20	13.27	13.51
Yale Total Exercise Time at 12 Months (hrs/wk)	0.00	21.00	1.76	10.23
Total Number of Social Activities at 12 Months (hr/wk)	0.00	65.00	9.70	10.23

Table 3

Model Testing of the Measurement Model of Physical Function Tested at 2 and 12 Months Post Hip Fracture and Tested with Male and Female Participants

Time Point	Standardized Path Parameter (significance)					χ^2/df * (significance)	RMSEA **
	Grip Strength	Lower Extremity Score	Instrument Activities of Daily Living	Physical Activities of Daily Living	Short Physical Performance Battery		
2 Months	.30 (.001)	.91 (.001)	-.68 (.001)	-.84 (.001)	.88 (.001)	1.98 (.08)	.05
12 Months	.33 (.001)	.94 (.001)	-.69 (.001)	-.89 (.001)	.83 (.001)	1.17 (.32)	.02
Males (at 2 months)	.30(.001)	.91(.001)	-.68(.001)	-.84(.001)	.88(.001)	1.99(.08)	.05
Females (at 2 months)	.39(.001)	.91(.001)	-.70(.001)	-.84(.001)	.87(.001)	2.00 (.07)	.08

* χ^2/df a ratio of is considered a good fit

** Root Mean Square Error of Approximation A RMSEA of < 0.10 is considered good, and <0.05 is very good.

Table 4

Full Structural Equation Model Indices and Fit for the Measurement Model of Physical Function and the Individual Indices Within the Measurement Model of Physical Function

Model/Variable	Model Fit χ^2/df (p) *	Model Fit RMSEA **	Parameter estimates (significance)	Percent of Variance in Outcome Explained
Model: Time in Physical Activity at 2 Months				
Full Measurement Model	6.5 (.001)	.13	.37 (.001)	55%
Short Physical Performance Battery	6.2(.001)	.13	.26 (.01)	64%
Lower Extremity Gain Score	6.2(.001)	.12	.16(.01)	70%
Instrumental Activities of Daily Living	4.4(.001)	.10	-.37 (.001)	58%
Lower Extremity Physical Activities of Daily Living	4.0(.001)	.10	-.19 (.001)	67%
Grip Strength	11.0(.001)	.17	-.04(.26)	77%
Model: Time in Physical Activity at 12 Months				
Full Model	6.0(.001)	.12	.30(.003)	27%
Short Physical Performance Battery	6.0(.001)	.12	.15(.03)	32%
Lower Extremity Gain Score	6.4(.001)	.13	.09(.25)	35%
Instrumental Activities of Daily Living	3.8(.001)	.10	-.23(.001)	29%
Lower Extremity Physical Activities of Daily Living	4.4(.001)	.10	-.27(.001)	31%
Grip Strength	11.0(.001)	.17	-.13(.06)	39%
Model: Time in Exercise at 2 Months				
Full Measurement Model	6.0(.001)	.12	-.06(.33)	23%
Short Physical Performance Battery	6.1(.001)	.12	-.03(.64)	18%
Lower Extremity Gain Score	6.4(.001)	.13	-.11(.10)	26%
Instrumental Activities of Daily Living	4.4(.001)	.10	.01(.84)	14%
Lower Extremity Physical Activities of Daily Living	4.1(.001)	.10	.08(.19)	23%
Grip Strength	11.0(.001)	.17	-.15(.02)	25%
Model: Time in Exercise at 12 Months				
Full Measurement Model	5.9(.001)	.12	.27(.01)	11%
Short Physical Performance Battery	6.3(.001)	.13	.18(.04)	6%
Lower Extremity Gain Score	6.5(.001)	.13	.11(.22)	5%

Model/Variable	Model Fit χ^2/df (p) *	Model Fit RMSEA **	Parameter estimates (significance)	Percent of Variance in Outcome Explained
Instrumental Activities of Daily Living	4.4(.00)	.10	-.12(.12)	5%
Lower Extremity Physical Activities of Daily Living	4.1(.001)	.10	-.18(.02)	7%
Grip Strength	11.0(.001)	.17	.12(.14)	5%
Model: Total Number of Social Activities at 2 Months				
Full Measurement Model	5.9(.001)	.12	.48(.001)	24%
Short Physical Performance Battery	5.5(.001)	.12	.41(.001)	19%
Lower Extremity Gain Score	5.5(.00)	.12	.40(.001)	18%
Instrumental Activities of Daily Living	5.5(.001)	.10	-.34(.001)	17%
Lower Extremity Physical Activities of Daily Living	4.0(.001)	.09	-.39(.001)	17%
Grip Strength	10.0(.001)	.17	.25(.001)	15%
Model: Total number of Social Activities at 12 Months				
Full Measurement Model	5.9(.001)	.12	.60(.001)	39%
Short Physical Performance Battery	6.3(.001)	.13	.44(.001)	40%
Lower Extremity Gain Score	6.5(.001)	.13	.42(.00)	35%
Instrumental Activities of Daily Living	4.4(.001)	.10	-.33(.001)	33%
Lower Extremity Physical Activities of Daily Living	4.1(.001)	.10	-.42(.001)	36%
Grip Strength	11.0(.001)	.17	.16(.01)	37%

* χ^2/df a ratio of 1 is considered a good fit

** Root Mean Square Error of Approximation A RMSEA of < 0.10 is considered good, and <0.05 is very good.