Development of the Caregiver Assisted Transfer Technique Instrument

by

Hailee Kulich

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This dissertation was presented

by

Hailee Kulich

It was defended on

March 9, 2023

and approved by

Diane Collins, PhD, OT, Associate Professor, Department of Occupational Therapy, University of Texas Medical Branch, School of Health Professions

Rory Cooper, PhD, Professor, Department of Rehabilitation Science and Technology

Brad Dicianno, MD, MS, Professor, Department of Physical Medicine and Rehabilitation

Lynn Worobey, PhD, DPT, ATP, Assistant Professor, Department of Physical Medicine and Rehabilitation

Dissertation Director: Alicia Koontz, PhD, ATP, RET, Professor, Department of Rehabilitation Science and Technology

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Informal caregivers play an essential role in allowing individuals with disabilities to remain active in their homes and communities. However, caregivers who perform assisted transfers have a high risk of developing musculoskeletal pain and injuries. The current standard of care provides little training and education on proper transfer techniques, leaving informal caregivers underprepared to take on the roles and responsibilities associated with transfer-related activities of daily living. To address limitations in training and educational interventions, a tool called the Caregiver Assisted Transfer Technique Instrument (CATT) was developed to provide an objective method to evaluate proper technique of informal caregivers providing transfer assistance. Two research studies aimed to evaluate the psychometric properties of the CATT, including content validity, reliability, and construct validity of the CATT as a tool for clinical evaluation, and reliability and validity of the CATT as a tool for informal caregiver self-assessment. When assessing content validity after initial development, CATT items were rated favorably for their importance, clarity, and appropriateness of responses, and most items had excellent content validity ($k^* \geq 0.75$). Feedback from participants led to the creation of two versions of the CATT: one for manual lifting techniques (CATT-M) and one for transfers performed via lift-based technologies (CATT-L). Both versions of the CATT demonstrated acceptable to strong levels of interrater reliability (ICCs: 0.720- 0.872) with varying levels of intrarater reliability (ICCs: 0.266 to 0.926). Individual item reliability varied from weak to strong, indicating the need for revisions on specific items. Concurrent and construct validity assessments revealed that total CATT scores

were strongly correlated with Global Rating Scale scores from an expert clinician ($r = 0.714$; $p < 0.001$) and total scores correlated with caregiver age, level of education, hours of weekly care, general health, self-reported burden, and strength. Intrarater reliability of the CATT was acceptable when used for self-assessment tool and there was meaningful agreement between CATT expert raters and informal caregivers on their transfer technique, which may support the CATT's validity. The results from these studies suggest that the CATT may be a reliable and valid tool for assessing assisted transfer technique of caregivers.

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Preface

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1.0 Introduction

An informal caregiver provides unpaid physical, practical, or emotional support to another individual and assists with activities of daily living (ADLs), instrumental activities of daily living (iADLs), or medical tasks (AARP and the National Alliance for Caregiving, 2020; Frederick, 2018). Because informal caregivers are often spouses, close relatives, or friends of the care recipient, their role in the caregiving process can differ quite greatly from that of formal caregivers, who provide paid care as part of their job. In 2020, an estimated 53 million Americans provided unpaid care to an adult or child with a disability, increasing by over 8 million adults from an estimated 43.5 million caregivers in 2015 (AARP and the National Alliance for Caregiving, 2015, 2020). Demand for informal caregivers has increased steadily over the last decade, with the total economic value of services provide growing from $350 to $375 billion in 2007 to $470 billion by 2013 (Houser & Gibson, 2008). Costs are expected to further increase as the population ages, quality of medical care improves, and efforts to facilitate home and community-based care increase (AARP and the National Alliance for Caregiving, 2020; Houser & Gibson, 2008). Furthermore, fears surrounding the COVID-19 pandemic, low financial compensation, lack of mental health support systems, and poor working conditions have caused a steady decline in the workforce of paid caregivers, further increasing the need for informal caregivers (Dong, 2022; Hildebrandt, Stone, & Bryant, 2022). Care provided by informal caregivers has shown to decrease hospital stays, delay or prevent institutionalization, and reduce costs associated with inpatient and long-term care services for the care recipient, further increasing the demand for informal caregiving services (Mittelman, Haley, Clay, & Roth, 2006; Picone, Mark Wilson, & Chou, 2003; Van Houtven & Norton, 2008). While the care provided is essential for allowing individuals to remain

in their homes and communities, informal caregivers face many negative health consequences because of the long-term care they provide.

1.1 Informal Caregiver Health Consequences

As a result of providing care, informal caregivers may experience negative psychological, physiological, psychosocial, and financial consequences affecting health (Fauziana et al., 2018; Frederick, 2018). Of the individuals who receive assistance from an informal caregiver, approximately 63% have a long-term physical disability and 20% have a short-term physical disability, with the number of care recipients who identify as having a physical disability increasing significantly over the last five years (AARP and the National Alliance for Caregiving, 2020). Informal caregivers who provide care to individuals with physical disabilities are more likely to experience higher levels of physical, emotional, and financial strain (AARP and the National Alliance for Caregiving, 2015; Darragh et al., 2013). Fifty-seven percent of caregivers who report caring for an individual with a long term physical disability also report that their care recipient has an additional comorbidity, such as emotional or mental health issues (28%) or memory problems (36%) (AARP and the National Alliance for Caregiving, 2020). Comorbidity of conditions that caregivers have reported has increased significantly since 2015, suggesting that informal caregivers are taking on unpaid roles for adults with increasingly complex medical and support needs (AARP and the National Alliance for Caregiving, 2020).

1.1.1 Physical consequences associated with caregiving

Informal caregivers of individuals with physical disabilities are at a high risk of developing musculoskeletal pain and injury. Caregivers of individuals with physical disabilities of any kind are much more likely to assist with ADLs, iADLs, and medical or nursing tasks, including medication management, mobility-related ADLs, wound care, managing incontinence and operating specialized medical equipment (AARP and the National Alliance for Caregiving, 2015; Reinhard, Levine, & Samis, 2012). As a result, they are more likely to report a high degree of physical strain, high levels of emotional strain, and lower quality of life than those caring for an individual without a physical disability, (AARP and the National Alliance for Caregiving, 2015; Darragh et al., 2013).

In a study by Darragh et al, 94% of caregivers providing care to individuals with physical disabilities affecting mobility reported musculoskeletal discomfort in at least one body part, with 79% of caregivers reporting that their caregiving activities were responsible for causing or worsening their pain (Darragh et al., 2013). The highest incidence of pain reported was in the low back (76%), but a substantial portion of participants reported pain in the shoulders (43.5%), knees (43.5%), wrists and hands (43.5%), and neck (41.3%). While specific tasks, such as manual lifting and repositioning, can be associated with musculoskeletal pain and injury, characteristics of the caregiver and care recipient, the environment, and physical requirements of caregiving activities have all been shown to play an important role in informal caregiving musculoskeletal health (Darragh et al., 2013). Between 19% and 38% of informal caregivers report high levels of physical strain, often reporting fatigue, backache, and headache as a result of performing caregiving activities (AARP and the National Alliance for Caregiving, 2015; Darragh et al., 2013; Hartke, King, Heinemann, & Semik, 2006; Hayes, Chapman, Young, & Rittman, 2009a; Sanford, A.D.,

& Townsend-Rocchiccioli). Informal caregivers who feel they had no choice in taking on their caregiving role, are in high-intensity care situations, provide more than 21 hours of care per week, and who report feeling alone are more likely to report high levels of physical strain (AARP and the National Alliance for Caregiving, 2020). The incidence rate of injuries among informal caregivers ranges between 24% and 31% with the number and type of ADLs performed as significant predictors of injury (Darragh et al., 2013; Hayes et al., 2009a). Poor informal caregiver health has been linked to higher morbidity and mortality and is a predictor for cessation of caregiving activities (McCann, Hebert, Bienias, Morris, & Evans, 2004; Schulz & Beach, 1999).

1.1.2 Other consequences associated with caregiving

Informal caregiving has also been shown to have emotional and financial consequences. Thirty-six percent of informal caregivers consider their caregiving duties to be highly emotionally stressful, with an additional 28% reporting moderate emotional stress (AARP and the National Alliance for Caregiving, 2020). Factors including higher hours of care provided, caring for a close relative (i.e. parent or spouse), caring for an individual with a chronic condition, feelings of loneliness, and feeling a lack of choice in taking on their caregiving role have been shown to cause higher levels of stress in caregivers (AARP and the National Alliance for Caregiving, 2020; Reinhard et al., 2012). Incidences of depression and anxiety are common in informal caregiving populations (Adelman, Tmanova, Delgado, Dion, & Lachs, 2014; Gallagher, Rose, Rivera, Lovett, & Thompson, 1989; Schulz et al., 2012). The financial strain of caregiving may also impact informal caregivers. The average caregiver incurs between $4,570 and $8,728 in annual direct out of pocket costs, with higher financial strain associated with higher care hours, co-residing with or living more than one hour away from a care recipient, and years of care provided (AARP and the

National Alliance for Caregiving, 2015; Houser & Gibson, 2008). Common financial consequences of caregiving include halting savings, taking on debt, using up personal short-term savings, leaving bills unpaid or paying them late, and borrowing money from family and friends (AARP and the National Alliance for Caregiving, 2020). As of 2020, 45% of informal caregivers report experiencing at least one financial impact due to caregiving, with 34% experiencing two or more (AARP and the National Alliance for Caregiving, 2020).

1.1.3 Caregiver health, quality of life, and quality of care

The physical, emotional, and financial toll of caregiving affects caregiver health, quality of life, and quality of care. Between 20% and 32% of informal caregivers classify their overall health as poor, which is over double that of the general adult population (AARP and the National Alliance for Caregiving, 2015, 2020; Reinhard et al., 2012). Additionally, the self-rated health of informal caregivers declined between 2015 and 2020, and a comparable decline has not been seen in the general population of the United States during the same time frame (AARP and the National Alliance for Caregiving, 2020). Factors such as higher caregiving hours, younger caregivers, caring for someone with a mental health issue, co-residing with a care recipient, caregivers who report feeling alone, and performing medical and nursing tasks have been linked to negative health outcomes (AARP and the National Alliance for Caregiving, 2015, 2020; Reinhard et al., 2012). Twenty three percent of informal caregivers report that their health has gotten worse as a result of providing care (AARP and the National Alliance for Caregiving, 2020).

Employment issues are often associated with informal caregiving, as providing high hours of care is associated with a high risk of experiencing economic insecurity due to changes in work patterns, negatively impacting quality of life (Houser & Gibson, 2008). Sixty one percent of

informal caregivers report having to make workplace accommodations as a result of their caregiving responsibilities, including cutting back on work hours, taking leaves of absence, and receiving warnings about attendance and performance, with hours of care provided increasing the risk of employment complications (AARP and the National Alliance for Caregiving, 2015, 2020). This often leads to loss of wages, health insurance, other jobs benefits, or retirement savings (Reinhard et al., 2012). Despite a larger number of employers offering paid leave, 61% of informal caregivers report having no paid family leave at their workplace (AARP and the National Alliance for Caregiving, 2020). Additionally, one in ten working caregivers report having to give up work entirely or retire early to provide care (AARP and the National Alliance for Caregiving, 2020).

Informal caregivers who assist individuals with a chronic disability perform more ADLs and iADLs, assist with mobility-related ADLs, and perform a greater number of nursing and medical tasks have a higher risk of experiencing depression, lower overall health, and lower quality of life (Reinhard et al., 2012). Worsened health and quality of life greatly impact the ability of a care provider to perform tasks safely and effectively. Informal caregiver with poor physical and mental health have been shown to provide lower quality of car to their care recipients (Beach et al., 2005; Litzelman, Kent, Mollica, & Rowland, 2016). Caregivers experiencing poor physical health and depression have been shown to not only provide lower quality care, but also increases potentially harmful behaviors towards their care recipients including negative communication threats to institutionalize, and withholding food (Beach et al., 2005; G. R. Smith, Williamson, Miller, & Schulz, 2011).

1.2 Assisted Transfer Technique

When an individual cannot safely or effectively move from one surface to another, an informal caregiver may need to assist with the transfer. Transfers are the most commonly performed ADL by informal caregivers, with 41% performing transfers in and out of chairs and beds and 22% performing toilet transfers (AARP and the National Alliance for Caregiving, 2020). Assisted transfers can occur in a wide variety of locations, including but not limited to wheelchair to bed, wheelchair to chair, and wheelchair to toilet. Different forms of assistance can be provided by caregivers, depending on the care recipient's needs and the technology available to the caregiver. Manual lifting and technology assisted transfers are the primary means that informal caregivers use to perform assisted transfers.

1.2.1 Manual Transfer Techniques

Often, the quickest way to transfer a care recipient is to manually lift him or her from one surface to another. The Centers for Disease Control has guidelines on manual patient handling through the National Institute for Occupational Safety and Health (NIOSH) that are used to train professional caregivers or transfer technique and appropriate lifting recommendations (Center for Disease Control and Prevention, 2013). Although manual lifts can be fast and convenient, manual lifting and repositioning techniques have a high risk for injury to caregivers. NIOSH guidelines state that the weight to be lifted by a single person should not exceed 35 pounds (Center for Disease Control and Prevention, 2013). As transfers often place high loads on the back and upper extremities of caregivers, transfer tasks are considered high risk for caregivers, even when using proper technique. The care recipient's size, transfer distance, space constraints, and awkward

positioning make manual lifting an injury risk to both caregivers and care recipients (Owen & Garg, 1990). As the prevalence of obesity rises in the United States, the need for safe patient handling of bariatric persons also increases, as mobilization of bariatric persons poses increased risk to both the person and the caregiver due to the forces required to lift and reposition these individuals (S. Smith, Rosen, & Lee, 2015).

1.2.2 Technology Assisted Transfer Techniques

The most common forms of technology used to help transfer individuals include floor and overhead ceiling lifts. These transfer assist devices have been shown to reduce injury risk among healthcare workers (Charney & Hudson, 2003; Jäger et al., 2013). While technology can reduce risk associated with performing assisted transfers, operation of some lift devices can be just as stressful as manual lifting (Owen & Garg, 1990). Mechanical lifts require patient handling to position the sling under the person, which can be difficult for the caregiver and uncomfortable for the care recipient (Sun et al., 2018). Additionally, lifts do not completely eliminate manual repositioning and lifts associated with transfers, as they often require excessive trunk flexion and rotation to operate (Santaguida, Pierrynowski, Goldsmith, & Fernie, 2005). Power operated lifts can eliminate some of the effort and positioning demands associated with manually operated lifts and are perceived by nursing staff to be less physically demanding for both transfer and repositioning tasks (Alamgir et al., 2009). However, these transfer technologies are often expensive, difficult to use and maneuver in confined or tight spaces, and require awkward manipulation of the care recipient (Owen & Garg, 1990). As a result, transfer technology does not necessarily help reduce the physical burden experienced by informal caregivers (Darragh et al., 2013). While robotic transfer assist devices that seek to reduce or eliminate lifting performed by

caregivers are currently in development, these devices are not yet widely commercially available (Greenhalgh et al., 2019; Kulich, Wei, Crytzer, Cooper, & Koontz, 2021; Sivakanthan et al., 2021). Therefore, despite aids being present, manual lifting is often the go to method, as it is faster and more convenient despite the biomechanical implications repeated lifting has on the back and upper extremities (Darragh et al., 2013).

1.3 Physical Demands of Transferring and Impact on Health

There is a high risk of both acute and cumulative injury to both the caregiver and care recipient during assisted wheelchair transfers. In 2003, more than 100,000 wheelchair-related accidents required treatment in a US emergency department (Xiang, Chany, & Smith, 2006). Of the adult wheelchair users who received treatment, between 12.2% and 16.8% were admitted to the hospital due to a transfer-related mishap (Xiang et al., 2006). In another study examining wheelchair-related accidents, 15.5% of reported accidents involved an injury to a caregiver (Dudley, Cotter, & Mulley, 1992). Because the risk of injury is high during assisted wheelchair transfers, it is essential that safe and effective transfer technique is used to minimize the health impact on both the caregiver and care recipient.

1.3.1 Specific Health Concerns for the Caregiver

Caregivers who assist with transfers are at a high risk of developing musculoskeletal pain and injuries (Darragh et al., 2013). While there is little information available on the association between task-related physical demand placed on informal caregivers and musculoskeletal injury

specifically, this relationship is well supported in formal caregivers. Tasks including transfers, lifts, and repositioning have been linked to musculoskeletal injury in nurses and rehabilitation professionals, which are commonly performed by informal caregivers of individuals with physical disabilities (Campo, Weiser, Koenig, & Nordin, 2008; Darragh, Campo, & King, 2012; Darragh et al., 2013; Menzel, 2004; A. L. Nelson, Motacki, & Menzel, 2009). In a recent study, when asked to identify physically demanding tasks associated with care, informal caregivers identified transfers as more demanding than any other task (Darragh et al., 2013). Additionally, informal caregivers are more likely to be performing transfers in non-medical settings compared to their professional counterparts. The provision of care in non-medical settings has shown to provide additional challenges to caregivers due to characteristics of the physical environment, including the amount of space available, the layout where care is provided, and excessive clutter (Darragh et al., 2013; Hess, Kincl, & Mandeville, 2007).

1.3.2 Specific Health Concerns for the Care Recipient

Frequent mobilization of persons with physical disabilities is critical to maintaining health and quality of life. Complications associated with chronic immobility include the development of pressure ulcers, muscle atrophy, metabolic decline, joint contractures, microvascular dysfunction, atelectasis, thromboembolic disease, and psychological decline (Sivaprakasam, Wang, Cooper, & Koontz, 2017). Assisting with transfers promotes mobility beneficial to bodily functions and skin integrity. However, it is crucial that transfers be performed in a safe and effective manner to ensure the health of the individual receiving assistance. Research shows that patients are at an increased risk for musculoskeletal pain and injury during caregiver assisted transfers, including shoulder injury, bruising and pain from improper manual lifting technique, hip fractures from falls, and skin

tears from shear force that occurs with sliding during transfers (*Ergonomic Guidelines for Nursing Homes*, 2003). Therefore, it is critical that individuals with physical disabilities are transferred correctly and that caregivers understand the risks and benefits of mobility and transfers, equipment available to assist with transfers, and how to conduct biomechanically correct transfers.

1.4 Transfer Technique Training

Although many informal caregivers assist with transfers, many have never received any formal training in proper transfer technique. Current standard of care involves limited in-person training for informal caregivers with physical or occupational therapists, as the majority of the rehabilitation process is client-focused (Roth, Fredman, & Haley, 2015). While clients are usually provided with educational materials to support transition to home-based activities, informal caregivers do not always receive the same support across healthcare systems. The techniques taught to caregivers by clinicians during rehab can vary greatly. Additionally, not all individuals who end up using transfer assistance from an informal caregiver are in inpatient or outpatient rehabilitation, and as such, their caregivers may miss out on transfer training of any kind with a clinician. A uniform way of measuring performance of caregivers who perform assisted transfers, both in and out of clinical settings, does not currently exist.

As caregivers continue to provide complex care in home settings, there is a need to provide them with better training and education for the tasks they perform, including assisted transfers. Approximately 55% of informal caregivers rely on healthcare professionals as a source of information about providing care (AARP and the National Alliance for Caregiving, 2020). However, very few informal caregivers report receiving information from a healthcare

professional on how to provide care for their care recipient (29%) and how to support their own wellbeing (13%) (AARP and the National Alliance for Caregiving, 2020). In a survey of informal caregivers performed in 2020, 62% of caregivers reported wanting more information on caregiving topics (AARP and the National Alliance for Caregiving, 2020). The most commonly requested topics for additional information were how to keep their care recipient safe at home and how to manage their own physical and emotional stress (AARP and the National Alliance for Caregiving, 2020). Because transfers are one of the most physically demanding ADLs and have a higher risk of injury than other tasks, additional education and training around transfer technique may help address informational gaps commonly experienced by informal caregivers. Access to appropriate support, training, and educational programs has been shown to decrease burden experienced by informal caregivers (Frederick, 2018; Mittelman, Haley, Clay, & Roth, 2006).

1.4.1 Existing Outcomes for Evaluating Transfer Performance

Few instruments for evaluating transfer technique have been developed and are either focused on healthcare professionals or care recipients who do not require assistance with transfers. An instrument called the Direct Nurse Observation Instrument for assessment of work technique during patient transfers (DINO) was developed to assess nurses' technique during patient transfers. The DINO consists of 16 items, divided into three categories: transfer preparation, performance, and results (Johnsson, Kjellberg, Kjellberg, & Lagerström, 2004). While DINO provides an objective way to measure transfer performance, it is geared towards nurses, who only represent a small portion of individuals who provide transfer assistance to individuals with physical disabilities.

Another instrument, known as the Transfer Assessment Instrument (TAI), acts as a clinical tool to assess the transfer quality of wheelchair users in an objective manner (McClure, Boninger, Ozawa, & Koontz, 2011). The TAI has a primary focus of evaluating the positioning and techniques used by an individual who is performing an independent transfer, not those normally performed by caregivers (McClure et al., 2011; Tsai, Rice, Hoelmer, Boninger, & Koontz, 2013; L. A. Worobey, C. K. Zigler, et al., 2018). The most recent version of the TAI has been validated for use as a self-assessment tool (L. A. Worobey, Rigot, Hogaboom, Venus, & Boninger, 2018; L. A. Worobey, C. K. Zigler, et al., 2018). Additionally, extensive clinical and consumer-based educational and training materials on the TAI have been developed to support the tool, providing guidance on not only how to administer the TAI, but how to correct the deficits that are detected by the tool (Rice et al., 2013; L. A. Worobey, C. K. Zigler, et al., 2018). While the TAI is meant to serve as an assessment for independent transfers, it may serve as a useful guide for developing a similar assessment for evaluating caregivers performing assisted wheelchair transfers due to its success both as an objective observational tool and a guide for administering appropriate educational and training around transfer technique.

1.5 Significance

As the demand for informal caregivers increases, there is an increased need for educational resources and an objective tool for assisted transfer technique assessment that accommodates those providing continuous car to family members in home settings. Because most of the rehabilitation process is client-focused, clinicians have minimal time to prepare informal caregivers to be able to perform transfers safely and effectively in a home setting. Additionally, health care policy limits

the amount of time that clinicians can spend with their clients and caregivers. This leaves informal caregivers underprepared to take on the roles and responsibilities associated with transfer-related ADLs, putting both the caregiver and care recipient at a greater risk for pain and injury. By providing clinicians and caregivers with a tool meant to assess transfer quality from the caregiver perspective, transfer deficits can be identified quickly, and appropriate training and educational materials can be provided to the caregiver. An instrument that identifies specific areas for improvement may help to reinforce transfer techniques that are safe and effective for both the caregiver and care recipient. The main outcome from this project will be an objective assessment tool for the evaluation of caregiver-assisted transfer technique. Through development of this tool, clinicians will have an easy and effective way to evaluate the techniques of informal caregivers, allowing them to identify specific deficits in technique and inform training.

1.6 Specific Aims

A tool called the Caregiver Assisted Transfer Technique Instrument (CATT) was developed to provide an objective method to evaluate proper technique of informal caregivers for provide transfer assistance to individuals with physical disabilities, including individuals with spinal cord injury or disease (SCI/D). An initial draft of the CATT was developed through a comprehensive literature review, alignment with current best practice guidelines for transfer biomechanics, and expert feedback. The CATT was modelled after the TAI, since the TAI has been shown to be a reliable and valid way to evaluate the quality of independent transfer techniques (Tsai et al., 2013; L. A. Worobey, C. K. Zigler, et al., 2018).

Like the TAI, the CATT was developed to both standardize practices around transfer assessment and to increase awareness about the hazards of manual lifting to guide informal caregiver training and education around using appropriate body mechanics and technology for assisted transfers. In order to be a reliable and valid tool for clinical or self-assessment, the CATT underwent a comprehensive review with stakeholders to assess its reliability and validity. The goal of this project was to evaluate the psychometric properties of the CATT, namely content validity intra- and interrater reliability, construct validity, and concurrent validity. Additionally, we aimed to assess the reliability and agreement of CATT scores between live evaluations and video evaluations to determine if the CATT was suitable for live and remote evaluations. Another goal of this work was to assess the reliability, validity and feasibility of CATT to be used as a self-assessment tool for informal caregivers. Tool refinement was iterative process, with revisions to the tool performed after every specific aim.

1.6.1 Specific Aims and Hypotheses

Specific Aim 1: Establish the content validity of the CATT and supplemental materials using stakeholder feedback from clinicians, informal caregivers, and individuals with spinal cord injury or disease.

Hypothesis 1a: Each item on the scale will be determined to be at least somewhat important, somewhat clear, and somewhat appropriate (≥4 on 5-point Likert scale) by clinicians, informal caregivers, and individuals with SCI/D. Items that do not meet these criteria will be revised based on qualitative stakeholder feedback.

Specific Aim 2: Determine the intra-rater and inter-rater reliability of the CATT for live evaluation of assisted transfer technique of informal caregivers.

Hypothesis 2a: Each item and the overall score of the CATT will have at least good intra-rater and interrater reliability (ICC ≥0.8; K≥0.4). Items that do not meet these criteria will be revised based on expert panel and rater feedback.

Specific Aim 3: Determine the construct validity of the CATT by relating CATT scores to a global rating of assisted transfer technique by an expert rehabilitation professional

Hypothesis 3a: There will be at least a strong correlation ($r_s \geq 0.6$) between reported scores from the CATT and a global visual analog scale rating on the quality of the assisted transfer. If total CATT scores do not correlate with global VAS scores, the tool will be revised based on expert panel and rater feedback.

Hypothesis 3b: Demographic characteristics of the caregiver including lower education, lower income, and older age and demographic characteristics of the care recipient including older age, worse overall health status, and lower independence will predict lower overall scores on the CATT.

Specific Aim 4: Determine the reliability and agreement of CATT scores between videotaped and live evaluation

*Hypothesis 4a: Overall CATT scores and individual item scores determined from video recordings will be similar to scores determined from in person evaluations (total scores within the range of 95% limits of agreements as the mean difference; item scores of K ≥*0.6). *If live and taped CATT scores do not meet these criteria, the method of evaluation (i.e. number of camera angles available for taped sessions, electronic versus paper CATT, etc.) will be evaluated and changed based on expert panel and rater feedback.*

Specific Aim 5: Determine reliability, validity, and feasibility of using the CATT as a self-assessment tool for caregiver transfer technique

Hypothesis 5a: *Each item and the overall score of the CATT scored by informal caregivers during self -assessment will have at least good intra-rater reliability (ICC ≥0.8). Items that do not meet these criteria will be revised based on expert panel and rater feedback.*

Hypothesis 5b: *Informal caregiver scored CATT scores and individual item scores will be similar to scores determine by rehabilitation professional raters (total scores within the range of 95% limits of agreements as the mean difference; item scores of K ≥*0.6). *If informal caregiver and professional scores do not meet these criteria, the method of evaluation and the supplementary materials given to informal caregivers will be evaluated and changed based on informal caregiver, expert panel, and rater feedback.*

Hypothesis 5c: *Remote self-evaluation will be found to be feasible, with at least 80% of participants able to complete the self-assessment (practicality), able to complete the assessment without any technical issues (implementation),* and rating their satisfaction with the self-assessment while using the CATT as an 8 out of 10 of a numeric rating scale *(acceptability).*

1.6.2 Project Goals

The overarching goal of this project is to deliver a refined a psychometrically sound version of the CATT that can be used in both clinical and non-clinical settings. Upon completion of this project, we expect the CATT to 1) identify specific issues or deficits with assisted transfer technique, 2) identify specific areas to target educational or training interventions, and 3) provide an objective indicator for the level of risk associated with assisted transfers. The CATT is intended to be used as a tool to evaluate informal caregiver transfer technique, serving as a checklist of positioning techniques that allow for safer, more effective transfers for individuals with physical

disabilities who need assistance with these tasks. It will also be used as a guide to administer effective training and educational materials targeted towards informal caregivers.

2.0 Development and Content Validity of the Caregiver Assisted Transfer Technique Instrument

This chapter has been accepted for publication pending minor revisions in Assistive Technology.

2.1 Abstract

Informal caregivers often provide transfer assistance to individuals with disabilities; however, repeated transfers are associated with a high risk of musculoskeletal pain and injury, and training and education around transfers is minimal. The purpose of this study was to develop and assess the content validity of a new tool, the Caregiver Assisted Transfer Technique Instrument (CATT), which could be used to provide an objective indicator of transfer performance. Item importance, clarity, and appropriateness of responses were rated on a five-point Likert scale by clinicians (n=15), informal caregivers (n=10), and individuals with spinal cord injury (n=5). The content validity index and modified Kappa of each item was calculated. Participants also provided qualitative feedback on item content. In general, items were rated favorably for their importance (4.47 to 5.00), clarity (4.33 to 4.90), and appropriateness of responses (4.38 to 4.90), and most items had excellent content validity ($k^* \geq 0.75$). Feedback from participants led to the creation of two versions of the CATT: one for manual lifting techniques (CATT-M) and one for transfers performed via lift-based technologies (CATT-L). Future work will focus on establishing the reliability and validity of the CATT as well as developing training and education interventions surrounding assisted transfers.

Keywords: Outcome measures, Informal caregiving, Wheelchair, activities of daily living, patient handling

2.2 Introduction

Informal caregivers provide unpaid physical, practical, or emotional support to another individual and assist with activities of daily living (ADLs), instrumental activities of daily living (iADLs), or medical and nursing tasks ("Caregiving in the U.S.," 2015; Frederick, 2018). In 2020, approximately 53 million Americans provided unpaid care, with that number expected to rise as the population ages (*Caregiving in the U.S.*, 2020; Houser & Gibson, 2008). While the services informal caregivers provide allow individuals to remain active in their communities, many caregivers face negative health consequences. Caregivers who provide assistance with ADLs, iADLs, and medical or nursing tasks, especially tasks involving mobility, report high levels of physical strain. ("Caregiving in the U.S.," 2015; Darragh et al., 2013). In a recent study, 94% of caregivers providing assistance with mobility-related ADLs reported musculoskeletal discomfort, with 79% reporting that caregiving activities caused or worsened their pain (Darragh et al., 2013). The incidence of injuries among informal caregivers ranges from 24% to 31%, with number and type of ADLs performed as significant predictors of injury (Darragh et al., 2013; Hayes, Chapman, Young, & Rittman, 2009b).

One of the most commonly performed ADLs is assisted transfers, where a caregiver moves an individual from one surface to another (*Caregiving in the U.S.*, 2020). Manual lifting and assistive technology are the primary means used to transfer care recipients. Manual lifting is often the quickest way to transfer an individual; however, manual lifting presents a high risk of injury

to caregivers. Best practice guidelines state that the weight lifted by a single person should not exceed 35 lbs, a weight limit that is generally exceeded during transfers, placing high loads on the back and upper extremities (Center for Disease Control and Prevention, 2013). Proper technique has been shown to minimize loading and injury risk when transferring (Daynard et al., 2001). Assistive technologies, including lift-based technologies, can mitigate some of the risks associated with manual lifting and have been shown to reduce injury risk among healthcare workers (Charney & Hudson, 2003; Jäger et al., 2013). However, operation of certain lift devices can still be harmful due to positioning requirements of a sling and excessive trunk flexion and rotation required to operate lifts (Santaguida et al., 2005; Sun et al., 2018). Additionally, transfer technologies have limited applications for in-home use because they are expensive, difficult to maneuver in tight spaces, may not be portable, and can require awkward manipulation of the care recipient (Owen & Garg, 1990). As a result, transfer technology does not always reduce physical burden of caregivers and is not always available (Darragh et al., 2013).

Although informal caregivers frequently assist with transfers, many have never received formal training in proper techniques. Current standard of care involves limited in-person training with therapists, and caregivers do not always receive adequate support (Roth et al., 2015). Additionally, techniques taught to caregivers by clinicians can vary greatly, and a uniform way of measuring transfer performance of caregivers does not exist. As caregivers continue to provide support in non-clinical settings, there is a need to provide them with better training and education for the tasks they perform. Access to appropriate support, training, and educational programs has been shown to decrease caregiver burden (Frederick, 2018; Mittelman, Haley, Clay, & DL, 2006).

Few instruments for evaluating transfer technique have been developed. An instrument called the Direct Nurse Observation Instrument (DINO) was developed to assess nurses' technique

during patient transfers, consisting of 16 items evaluating transfer preparation, performance, and results (Johnsson et al., 2004). While the DINO provides an objective way to measure performance, it is geared towards nurses, who represent only a small portion of individuals who provide transfer assistance. Another instrument, called the Transfer Assessment Instrument (TAI), acts as a clinical tool to assess transfer quality in an objective manner (McClure et al., 2011). While the TAI has shown to be a reliable and valid tool for evaluating positioning and techniques for performing an independent transfer, it does not evaluate assisted transfers (Rice et al., 2013; Tsai et al., 2013; L. Worobey et al., 2021; L. Worobey et al., 2020; L. Worobey et al., 2018).

The purpose of this study was to develop and evaluate the content validity of the Caregiver Assisted Transfer Technique Instrument (CATT), which was created to provide an objective method to evaluate proper transfer technique of informal caregivers. We hypothesized that the scale items would have excellent content validity (modified Kappa (k^*) ≥ 0.75).

2.3 Methods

2.3.1 The Caregiver Transfer Technique Instrument Development

Development of the CATT was conducted in three phases (Figure 1).

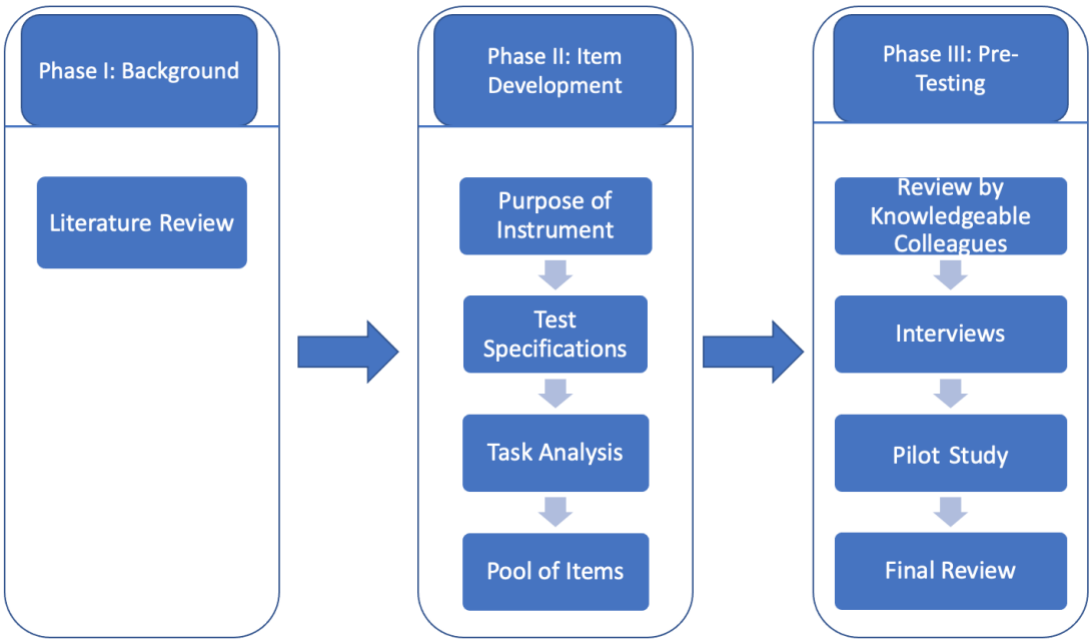


Figure 1. Framework for CATT Development (Eifert, Dudley, Eddy, Perko, & Adams, 2021).

2.3.2 Phase I and II: Background and Item Development

Prior to instrument development, a comprehensive literature review was conducted, consisting of scientific articles on assisted transfer biomechanics and current best practice guidelines.

2.3.2.1 Purpose of the Instrument

The CATT was modeled after the TAI and developed for the purpose of standardizing practices around transfer assessment and outcome measurement and to increase awareness about the hazards of manual lifting and guide informal caregiver discussions, training, and education around using appropriate body mechanics and technology for assisted transfers. The TAI was chosen as a guide when developing the CATT due to its success as a tool for independent transfer evaluation by rehabilitation professionals, a tool for self-assessment, and as a guide for clinical

and consumer-based education and training (McClure et al., 2011; L. Worobey et al., 2021; L. Worobey et al., 2020; L. Worobey et al., 2018).

2.3.2.2 Test Specifications

A preliminary item set and general format of the CATT was developed based on the DINO while the format of questions, responses, and scoring of the CATT was modeled after the TAI. The scoring structure used a numerical rating scale, where each item has a maximum score of 1 and a minimum score of 0. Items in which technique may be partially correct allow for a score of 0.5 and some provide a "not applicable' option, which excludes the item from the final score. The scores for each item are added together and scaled to give a score between 0 and 10, where 0 indicates the worst and 10 indicates the best transfer possible (Equation 1).

Equation 1. Total score calculation for the CATT

$$CATT\ Score = \frac{Total\ \ Score}{Total\ number\ of\ applicable\ items}\ x\ 10$$

2.3.2.3 Task Analysis

A task analysis of assisted transfers was performed by members of the research team to identify important components related to assisted transfer technique. The members performing the tasks analysis consisted of two rehabilitation engineers and a physical therapist with years of experience with assisted transfers ranging from 8 to 25 years. A wide variety of techniques and set ups were examined, including transfers involving manual lifting and transfers involving assistive technologies, including transfer boards, transfer discs, pivot boards, floor lifts, ceiling lifts, and robotic assistive transfer devices. Additionally, transfers to a variety of surfaces were examined,

including wheelchair to chair, bed, commode, and medical tables and examination surfaces. Three distinct domains were identified as important during transfer evaluation: set up, lift quality, and results.

2.3.2.4 Pool of Items

Based on the results of the literature review and task analysis, 20 items were created. Items were categorized as belonging to one of three distinct domains (set up, lift quality, and results). A large initial pool of items was generated to capture all relevant domains with the assumption that some would be eliminated during expert and stakeholder reviews.

2.3.3 Pre-Testing

2.3.3.1 Review by Knowledgeable Colleagues

After development of a preliminary item set, an expert panel was convened and consisted of three physical therapists, one occupational therapist, and a physician who had expertise in informal caregiver health and wellness and performing and teaching assisted transfer technique. Discussion during the panel focused on three main topics: 1) usability of the CATT, 2) target users and uses for the tool, and 3) analysis of each item, responses, and scoring structure. The battery of items was reviewed, and feedback and consensus were obtained for items to keep, remove, reword, or restructure to create the CATT (Appendix A). The CATT was refined to consist of 19 items across three domains. Supplemental materials, including videos, graphics, and additional text-based information were created to support thirteen items based on panel feedback to provide additional information that may not be included directly in the CATT. Text-based supplementary content used lay terminology at a 6th grade reading level. All materials followed Section 508 of

the Rehabilitation Act of 1973 guidelines for accessibility (Birru et al., 2004; Sand-Jecklin, 2007; United States Access Board, 2017).

2.3.4 Content Validity Assessment

2.3.4.1 Interviews

The study received approval from the University of Pittsburgh's Institutional Review Board and all participants gave electronic informed consent before study procedures occurred. Content validity was established with three groups: rehabilitation professionals, informal caregivers, and individuals with spinal cord injury or disease (SCI/D). Participants were recruited through rehabilitation clinics and via research registries.

All participants were at least 18 years of age. Rehabilitation professionals met additional criteria: experience for at least three years with 1) research or clinical care involving adults with SCI/D and 2) performing assisted transfers. Informal caregivers were also required to have: 1) provided transfer assistance to an adult with a disability for at least two transfers per week, 2) served as a caregiver for at least three months, and 3) never received formal training on assisted transfer technique as part of a professional degree or program. Individuals with SCI/D also: 1) had a diagnosis of SCI/D for at least two years, 2) required assistance with transfers, and 3) received care from an informal caregiver.

2.3.4.2 Experimental Protocol

The CATT and supplemental materials were sent electronically to stakeholders. All participants completed a socio-demographic survey. Rehabilitation professionals were asked to

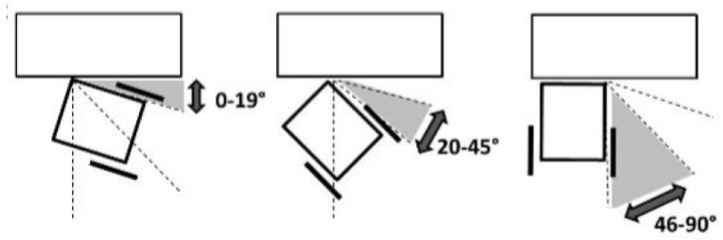
provide information about their occupation, informal caregivers about the care they provided, and individuals with SCI/D about their transfer habits.

Participants completed an online survey assessing the CATT, providing feedback on the 1) importance of each item when transferring, 2) clarity of the wording of each item, and 3) appropriateness of the responses to each item's questions (Figure 2). Each question utilized a 5-point scaled response system, where '1' corresponded to least agreement and '5' to most agreement. If an item did not score a 5, the participant was asked to fill out an open-ended response to explain why they did not fully agree with the importance, wording, or suitability of the responses. If the item contained supplemental materials, participants were asked to determine the usefulness of the supplemental material and if an item did not include supplemental material, participants were asked if they would recommend supplemental material for the item and the type of content they would find useful. A final question offered space to provide additional feedback. All survey data were collected and managed using REDCap electronic data capture tools (Harris et al., 2019).

2. The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface*.

• Between 0-19 degrees (1 for power wheelchair, 0 for manual wheelchair)
• Between 20-45 degrees (1 for manual wheelchair, 0 for power wheelchair)
• Between 45-90 degrees (0)
• The environmental surroundings prevent the wheelchair from being positioned at an optimal angle (N/A)

Supplemental material 2



How important is this factor when performing an assisted transfer?	◯ Not important ◯ Somewhat unimportant ◯ Neither important nor unimportant ◯ Somewhat important ◯ Very important
How clear is the wording of this item?	◯ Not clear ◯ Somewhat unclear ◯ Neither clear nor unclear ◯ Somewhat clear ◯ Very clear
How appropriate are the responses to the question?	◯ Not appropriate ◯ Somewhat inappropriate ◯ Neither appropriate nor inappropriate ◯ Somewhat appropriate ◯ Very appropriate
Please give us the reason(s) why you do not fully agree with the item's importance, wording or responses	_____
Does the supplemental material provide useful information?	◯ Yes ◯ No
Please provide any additional feedback that you have about this item	_____

Figure 2. Example question as shown in REDCap with response options.

2.3.4.3 Data Analysis

All statistical analyses were performed with SPSS Version 26 (IBM). The level of significance was set to alpha= 0.05. Descriptive statistics (means, standard deviations) were used to summarize Likert Scale questions for each item's importance, clarity, and response

appropriateness by item and by participant group. A Mann Whitney U test was performed to examine differences in responses between rehabilitation professionals and non-professionals (informal caregivers and care recipients). The content validity index (CVI) of each item was calculated by dividing the number of experts who scored each item as "very important/clear/appropriate" by the total number of assessments for each item (Polit, Beck, & Owen, 2007). CVI scores range from 0.0 to 1.0, where a score of 0.0 indicates that no stakeholders rated the item as "very important/clear/appropriate" and a score of 1.0 indicates that all stakeholders rated the item as "very important/clear/appropriate". A k* value was calculated using the formula described in Equation 2 (Polit et al., 2007). A k* of 0.4 – 0.59 was considered to be fair, 0.6 – 0.74 was considered to be good, and 0.75 or higher was considered to be excellent (Cicchetti & Sparrow, 1981). Qualitative comments were coded by two study team members independently, compared, and analyzed to identify themes (Patton, 1999).

Equation 2. Modified kappa (k*) formula (Polit et al., 2007), where N indicates the number of stakeholders and A indicates the number agreeing on good importance, clarity, or appropriateness.

$$k^* = \frac{CVI - P_c}{1 - P_c}, where\ P_c = \left[\frac{N!/A!}{(N-A)!}\right] 0.5^N$$

2.3.5 Tool Revision Criteria

Items with a k* of less than 0.75 for their importance, clarity, or response appropriateness were flagged for revision. Qualitative feedback was used to inform item and supplemental material refinement, generation, or elimination.

2.3.6 Pilot Study

After revision, the CATT was used to evaluate assisted transfers by two experts in transfer technique who were unfamiliar with CATT. The expert raters were selected via convenience sampling consisted of a prosthetist/orthotist clinician and researcher and a biomechanist and physiatrist with 30 and 4.5 years of professional experience, respectively. A third expert rater, a rehabilitation engineer with eight years of experience in evaluating wheelchair transfers who was part of the CATT's development team, also evaluated the transfers. Raters were asked to evaluate four simulated transfers: two using manual lifting and two using a floor-based lift. One of each transfer was performed using perfect technique, while the other transfer was performed with technique deficits. Total percent agreement for all items between raters was calculated (Equation 3). Novice raters also provided feedback on the structure and set up of the CATT, ease of use, and items they found confusing or lacking in information.

Equation 3. Total percent agreement calculation, where A equals the number of raters in agreement, n indicates the number of raters, and N indicates the total number of items assessed for agreement.

$$Total\ percent\ agreement = \frac{\sum \frac{A}{n}}{N}\ x\ 100\%$$

2.3.7 Final Review

The revised CATT was reassessed by the original expert panel. They were asked to address any wording or content problems.

2.4 Results

2.4.1 Participants

Thirty participants completed the content validity survey (Table 1). Rehabilitation professionals (n=15) consisted of six physical therapists, five occupational therapists, three rehabilitation-focused researchers, and one nurse. They had 11.1 ± 9.3 years of experience with performing transfers. Rehabilitation professionals worked with adults (93.3%), seniors (93.3%), and children (13.3%) with a variety of disabilities, including SCI/D, stroke, cardiovascular disease, cardiopulmonary disease, congenital conditions, neuromuscular diseases, orthopedic impairments, and osteo- and rheumatoid arthritis. They reported working with manual wheelchairs (100%), power wheelchairs (93.3%), scooters, (60.0%), manual wheelchairs with power assist (46.7%), and recreational mobility devices (26.7%).

Informal caregivers (n=10) consisted of those who provided care to their spouses (30%), children (20%), another family member (30%), and close friends (20%). Most caregivers reported providing more than 32 hours a week of care to their care recipient (60%) and performing an average of 3.5 ± 2.8 transfers per day. Eight caregivers (80%) reported that they use no assistive device when transferring, one (10%) reported using a transfer board, and one (10%) reported using a mechanical floor lift.

Of the individuals with SCI/D (n=5), four had a SCI (80%) and one had multiple sclerosis (20%). Four (80%) used a power wheelchair, and one used a manual wheelchair (20%), with participants reporting an average of 10.0 ± 4.1 years of experience with their wheeled mobility device. Participants reported transferring 5.2 ± 3.0 times per day, with three participants

transferring with no assistive technology, one using a transfer board, and one using a floor-based lift.

Table 1. Summary demographics for CATT survey participants. Means (± standard deviations) and counts (percentages) are displayed where appropriate

	Rehabilitation Professionals (n=15)	**Informal Caregivers** (n=10)	**Individuals with SCI/D** (n=5)	**All participants** (n=30)
Age (years)	37.1 (12.4)	53.0 (17.4)	45.0 (12.4)	43.7 (15.6)
Gender				
Male (%)	3 (20%)	4 (40%)	5 (100%)	12 (40%)
Female (%)	12 (80%)	6 (60%)	0 (0%)	18 (60%)
Race				
Caucasian (%)	12 (80%)	7 (70%)	5 (100%)	24 (80%)
African American (%)	1 (7%)	2 (20%)	0 (0%)	3 (10%)
Asian (%)	2 (13%)	1 (10%)	0 (0%)	3 (10%)
Weight (kg)	68.3 (11.3)	87.7 (23.9	76.7 (16.0)	76.1 (18.7)
Height (cm)	169.5 (8.4)	169.0 (9.8)	179.8 (2.8)	171.1 (9.0)

2.4.2 Quantitative Analysis

Participants had favorable ratings for items, with mean ratings ranging from 4.47 to 5.00 for importance, 4.33 to 4.90 for clarity, and 4.38 to 4.90 for response appropriateness (Table 2). Professionals had significantly higher ratings for the importance of item 1 (5.0 ± 0.0; 4.53 ± 0.83; p=0.16) and item 17 (5.0 ± 0.0; 4.33 ± 0.9; p=0.007) and the clarity of item 1 (4.67 ± 0.82; 4.27 ±

0.70; p=0.43) than non-professionals. There were no other significant differences between group ratings ($p>0.05$).

Table 2. Average (± standard deviations) ratings for all CATT items for importance, clarity, and response appropriateness for all participants (n=30).

Item	Importance	Clarity	Response Appropriateness
1. Transfer surface and environment are clear of obstacles	4.77 (0.63)	4.47 (0.78)	4.59 (0.78)
2. Wheelchair is oriented at an appropriate angle	4.80 (0.48)	4.33 (1.15)	4.52 (0.74)
3. Care recipient is close to the transfer surface	4.87 (0.35)	4.63 (0.93)	4.59 (0.73)
4. Care recipient's hips are brought forward to the front of the seat	4.83 (0.38)	4.70 (0.65)	4.71 (0.81)
5. Care recipient's feet are secure	4.86 (0.58)	4.70 (0.70)	4.38 (0.90)
6. Transfer surfaces are locked and secured	5.00 (0.00)	4.87 (0.35)	4.69 (0.71)
7. Transfer is a level or downhill transfer	4.83 (0.38)	4.73 (0.91)	4.67 (0.88)
8. Caregiver uses a transfer device	4.63 (0.56)	4.53 (1.07)	4.69 (0.60)
9. Caregiver asks for help if someone is available to assist	4.47 (0.73)	4.63 (0.85)	4.52 (0.69)
10. Caregiver bend their knees and keeps back straight while lifting	4.97 (0.18)	4.70 (0.79)	4.79 (0.49)
11. Caregiver grips the care recipient securely around the hips, buttocks or transfer belt	4.77 (0.77)	4.53 (0.86)	4.50 (0.88)
12. Caregiver does not pull on the care recipient's arms	4.90 (0.31)	4.80 (0.76)	4.86 (0.45)
13. Care recipient is leaned forward toward the caregiver's shoulder or hip opposite to transfer surface	4.93 (0.25)	4.77 (0.63)	4.62 (0.86)
14. Caregiver uses a forward and backward rocking motion to gain momentum	4.70 (0.53)	4.90 (0.31)	4.76 (0.44)
15. Caregiver performs pivoting movement of feet	4.93 (0.25)	4.83 (0.38)	4.90 (0.31)
16. Transfer is well controlled	5.00 (0.00)	4.63 (0.72)	4.72 (0.80)
17. Caregiver and care recipient communicate	4.67 (0.71)	4.70 (0.65)	4.79 (0.50)
18. Care recipient is safe and secure after transfer	4.97 (0.18)	4.52 (0.95)	4.62 (0.73)
19. The transfer did not cause any additional pain or discomfort to caregiver or care recipient	4.87 (0.43)	4.73 (0.58)	4.69 (0.54)

Most items had excellent content validity ($k^* \geq 0.75$), with k^* values ranging from 0.56 to 1.0 for importance, 0.56 to 0.90 for clarity, and 0.49 to 0.90 for response appropriateness (Table 3). All items met the success criteria for importance, except for Item 8 (Caregiver uses a transfer device), Item 9 (Caregiver asks for help if available), and Item 14 (Caregiver uses forward and backward rocking motion to gain momentum). Eight of 19 items had good or fair content validity for clarity and were flagged for rewording. Twelve of 19 items were considered good or fair for response appropriateness and were examined for change. Changes to the items that did not meet the desired success criteria were informed by qualitative feedback.

Table 3. Modified kappa (k*) values for item importance, clarity, and response appropriateness.

	Importance		Clarity		Response Appropriateness	
Item	**k***	**Evaluation**	**k***	**Evaluation**	**k***	**Evaluation**
1	0.83	Excellent	0.56	Fair	0.72	Good
2	0.83	Excellent	0.61	Good	0.59	Fair
3	0.87	Excellent	0.80	Excellent	0.68	Good
4	0.83	Excellent	0.77	Excellent	0.82	Excellent
5	0.93	Excellent	0.80	Excellent	0.49	Fair
6	1.0	Excellent	0.87	Excellent	0.79	Excellent
7	0.83	Excellent	0.90	Excellent	0.81	Excellent
8	0.66	Good	0.77	Excellent	0.75	Excellent
9	0.56	Fair	0.80	Excellent	0.59	Fair
10	0.97	Excellent	0.80	Excellent	0.82	Excellent
11	0.87	Excellent	0.66	Good	0.62	Good
12	0.90	Excellent	0.90	Excellent	0.89	Excellent
13	0.93	Excellent	0.83	Excellent	0.76	Excellent
14	0.73	Good	0.90	Excellent	0.76	Excellent
15	0.93	Excellent	0.83	Excellent	0.90	Excellent
16	1.0	Excellent	0.73	Good	0.83	Excellent
17	0.80	Excellent	0.77	Excellent	0.82	Excellent
18	0.97	Excellent	0.72	Good	0.72	Good
19	0.90	Excellent	0.80	Excellent	0.72	Good

2.4.3 Qualitative Analysis

Analysis of the 353 comments received by participants revealed seven common themes (Table 4). Most comments suggested rewording of items to improve clarity (n=94). Stakeholders also provided feedback on whether they fundamentally disagreed (n=55) or fundamentally agreed (n=43) with an item. One source of disagreement occurred on items that were not applicable to lift-based transfers, and many suggestions arose to make a version of the CATT compatible with lift-based technology techniques. Many comments indicated dislike of the scoring structure of item responses (n=55). The feedback suggested reworking the scoring structure for some items to remove the ability to score a 0.5, suggesting an 'all or nothing' approach. Finally, feedback was provided on supplementary materials with suggestions to add supplementary materials (n=51), change or edit existing supplementary materials (n=42), or that the provided supplementary materials misrepresented the item text (n=9).

Table 4. Summary of comments provided by stakeholders by theme and by item

Comment Summary																				
Theme	**n**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Reword	94	11	10	2	4	8	2	9	4	5	4	4	5	2	3	4	2	5	6	4
Fundamental disagreement	59	3	5	2	5	4		3	8	10	1		2	4	5	2		3	1	1
Scoring of Item Responses	55	2	3	6	1	7	8	2	3	1	2	2	1	2	1		5	3	3	3
Add supplemental materials	51	3	2	3	1		6	1	4	3		4	10				4	2	4	4
Fundamental agreement	43	3	6	1	8	2	2	1	2	3	2	4	2		4	1			2	
Change/edit supplemental materials	42	5	5	2	8	1	1	4	3		2	1		4		4	1	1		
Supplemental materials not representative of text	9					1						7			1					
Total Comments	353	27	31	16	27	23	19	20	24	22	11	22	20	12	14	11	12	14	16	12

2.4.4 Tool Refinement

The above results and qualitative feedback were used to reword, generate, and remove items that did not meet the success criteria. The refinement process also led to developing two versions of the CATT: the CATT-M, which evaluates transfers involving manual lifting, and the CATT-L, which evaluates transfers using lift-based technologies. Seven items were identified as being important to both manual and lift-based transfers, including a clear transfer environment, transfer surfaces being secured, not pulling on the care recipient's arms, the transfer being well controlled, communicating during the transfer, the care recipient being secure at the end of the transfer, and no additional pain experienced by caregiver or care recipient.

2.4.4.1 Refinement of the CATT-M

The items from the preliminary CATT were used to inform changes to the CATT-M, as most items were developed around manual lifting technique. Items 1, 5, and 16 were reworded based on participant feedback. Items 8 ("The caregiver uses a transfer device") was removed since transfer devices would be covered by the CATT-L. Items 9 ("The caregiver asks for help from another individual if someone is available") was removed due to 'low importance' and Item 14 ("The caregiver uses a forward and backward rocking motion to gain momentum for lifting the care recipient") was removed as it was identified as a good strategy for lifting, but not the only strategy that would be acceptable. Response options were changed for items 3, 4, 6, 7, 10, 13, 17, and 18. Additionally, the response structure was changed for items 2, 3, 5, 6, 10, and 13. Visual aids were added directly into the tool to support Items 2, 3, and 7 and supplemental materials were

updated. The order of items was rearranged based on participant feedback, as the initial ordering of CATT items did not match the order in which transfer components would be assessed.

2.4.4.2 Development of the CATT-L

Feedback from stakeholders and experts was used to develop 10 new items for the CATT-L. New items dealt with proper positioning of a sling and technique when using lift-based technologies. Additionally, supplemental materials were developed to support new items. Figure 3 summarizes changes made to the CATT based on stakeholder feedback.

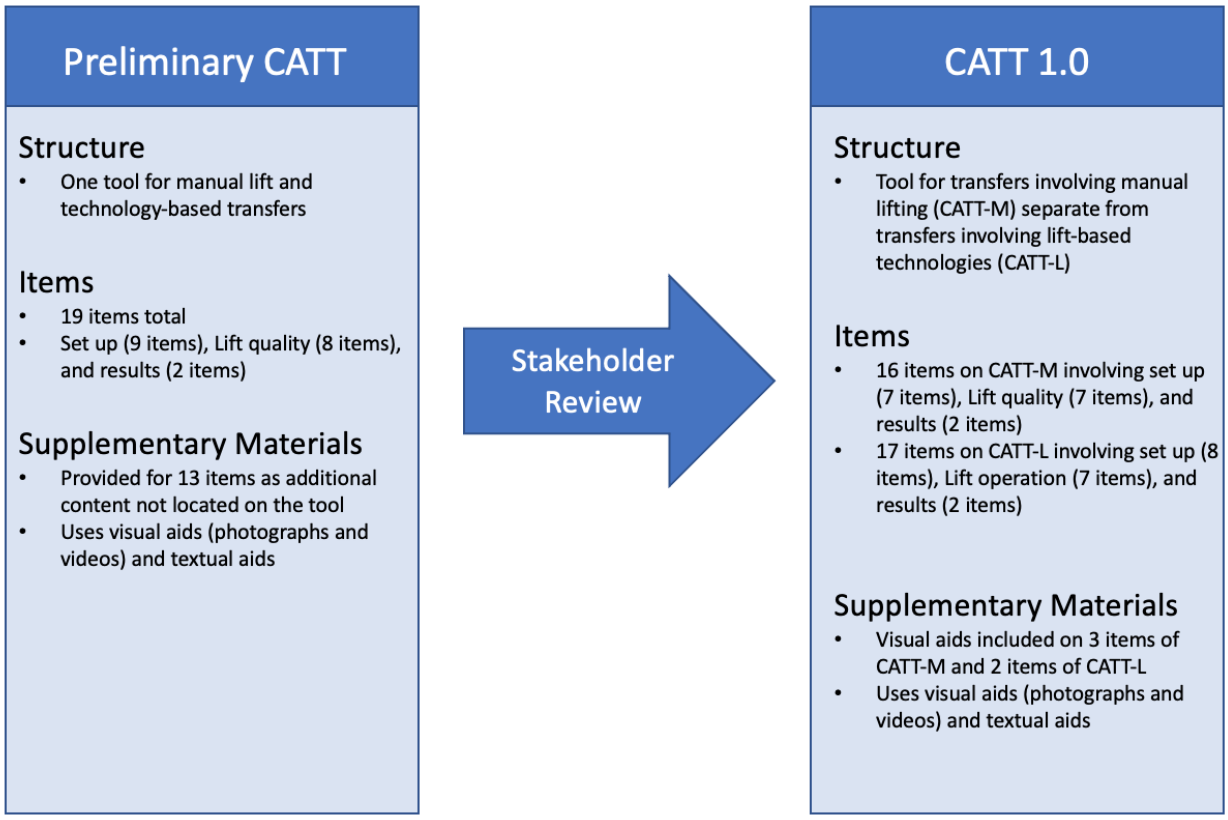


Figure 3. Refinements made to the CATT based on content validity study and expert panel feedback

2.4.5 Pilot Study Results

Percent agreement between the three raters ranged from 59% to 100% between the four transfer set ups (Table 5), with the manual transfer with perfect technique having the most agreement between the three raters and the manual transfer with technique deficits having the least agreement between raters.

Table 5. Percent agreement between raters when evaluating assisted transfers across all items.

	Percent agreement between all raters	
	Manual transfer	Lift-based transfer
Perfect Technique	100%	82.2%
Technique Deficits	59.4%	73.3%

Based on feedback from the novice raters, further changes were made to the CATT-M and CATT-L to improve understanding and ease of use. Additional supplemental materials were created to support the CATT-M and CATT-L to address items that scored differently by novice and expert CATT raters. Revised versions of the CATT-M and CATT-L can be seen in Appendix B and Appendix C.

2.5 Discussion

This study describes the development and initial validation of a new outcome measure designed evaluate the quality of assistive transfer techniques which can be used to support informal caregiver assessment, education and to document the effectiveness of training interventions.

In general, the CATT received excellent ratings for item importance, clarity, and response appropriateness, supporting the content validity of the instrument. High ratings from multiple stakeholders suggest a broader level of acceptance for future implementation (Guba & Lincoln, 1989). While homogeneous and heterogeneous samples are acceptable when establishing content validity, feedback provided by participants groups differed in certain circumstances. The expert panel was utilized to address conflicting feedback between stakeholder groups and ensure the techniques evaluated were consistent with best practice guidelines for lifting.

An important finding identified by participants when establishing content validity of the CATT was the inability of the original tool to properly evaluate lift-based transfers. Appropriate techniques for manual lifting and technology assisted transfers can differ greatly, and were not fully encompassed by one tool, (Garg, Owen, Beller, & Banaag, 1991). To address this problem, two separate versions of the CATT were created. The new items for CATT-L were generated using a combination of feedback from stakeholder and expert feedback. Having separate tools for manual and lift-based techniques simplifies the evaluation process for raters. Because instrument complexity and time requirements are barriers to successful outcome measure adoption in clinical practice, separating techniques into two tools minimizes barriers while ensuring that techniques representative of multiple transfer types are encompassed within the CATT's framework (E. C. Nelson et al., 2015).

2.5.1 Study Limitations and Future Work

A convenience sample of rehabilitation professionals, informal caregivers, and individuals with SCI/D recruited, with most participants from western Pennsylvania. Because the techniques taught can vary greatly across rehabilitation clinics and healthcare systems, it is possible that the

results of this study may have some location bias. Additionally, only individuals with SCI/D were surveyed in the content validity assessment, with may limit the generalizability of the results, as many populations use transfer assistance and individuals with SCI/D tend to receive higher amounts of transfer training than other populations. Future assessment of the measurement properties of the CATT should attempt to recruit a more representative sample of participants.

A variety of accepted practices were used to develop and pretest the CATT through a systematic process. Although it had high scores for content validity, it is possible that aspects of assisted transfer technique may not be included in the CATT. Future work will consist of establishing the reliability and validity of the CATT for a variety of transfers, including transfers that involve manual lifting, assistive technologies, and to a variety of surface types. This will enable further understanding of the CATT's potential as a tool for clinical evaluation and may highlight additional areas for revisions.

2.6 Conclusion

The results of this study supported and improved the content validity of the CATT to evaluate assisted transfer technique, indicating that it may be a useful tool for assessment of informal caregivers. Future work will involve further establishing the basic psychometric properties of the CATT when assessing assisted wheelchair transfers.

3.0 Reliability and Validity of the Caregiver Assisted Transfer Technique Instrument

3.1 Introduction

Assisted wheelchair transfers are one of the most commonly performed ADLs, with over 40% of all informal caregivers performing assisted transfers (*Caregiving in the U.S.*, 2020). However, transfers are one of the most strenuous ADLs and are associated with high levels of musculoskeletal pain and injury in informal caregivers (Darragh et al., 2013). One of the best ways to reduce the risk of musculoskeletal pain and injury during assisted transfers, either during manual lifting or when using assistive technologies, is by using proper technique (Cheung et al., 2020; Hodder, MacKinnon, Ralhan, & Keir, 2010). Additionally, prior research has shown that increased training regarding techniques for lifting and transferring care recipients in order to avoid low back strain would be beneficial in decreasing informal caregiver burden (Adelman et al., 2014).

Currently, informal caregivers receive little training and education on proper techniques by professionals, often leaving individuals underprepared for performing assisted transfers outside of a clinical setting (Roth et al., 2015). Additionally, current standard of care involves subjective assessment of a caregiver's assisted transfer skills by a clinician. Prior research on wheelchair skill assessment for both manual and power wheelchair users has shown that subjective evaluation is less precise than objective measurement tools (Rushton, Kirby, & Miller, 2012; Rushton, Kirby, Routhier, & Smith, 2016), indicating the need for a reliable and valid tool for objective assessment of assisted transfer technique.

The Caregiver Assisted Transfer Technique Instrument (CATT) was developed to serve as an objective indicator for assisted transfer techniques in informal caregivers. While the CATT has

undergone extensive content validity testing, other important psychometric properties, including the interrater reliability, intrarater reliability, and construct validity have not been assessed. The purpose of this study was to establish the psychometric properties (interrater reliability, intrarater reliability, and construct validity) of the CATT for both live and taped assessments. We hypothesized that based on our previous content validity analysis, both the CATT-M and CATT-L would exhibit acceptable levels of reliability for both total scores (ICC $\geq$ 0.6) and item-level reliability (K $\geq$ 0.4). Additionally, we hypothesized that there would be a strong correlation (r $\geq$ 0.8) between CATT scores and a global rating by an expert in assisted transfer technique. We also expected to see significant correlations between CATT scores and demographic, socioeconomic, and health-related characteristics of caregivers and care recipients that have previously been associated with caregiver burden. Finally, we hypothesized that assessments viewed via recordings would have higher levels of interrater and intrarater reliability when compared to those viewed in realtime, as the features associated with taped assessments, such as the ability to rewind, pause, and rewatch transfers, may make transfer skill deficits easier to identify.

3.2 Methods

This study received approval from the University of Pittsburgh Institutional Review Board, and testing took place at the Human Engineering Research Laboratories (HERL) and at participants' homes in Pittsburgh, Pennsylvania between March 2022 and February 2023. Participants were recruited through several local research registries, including the HERL research registry and the Clinical and Translational Science Institute's (CTSI) research registry (Pitt+Me). Participants were also recruited through social media outlets, flyers posted in local rehabilitation

facilities, outpatient facilities, independent living facilities, and disability organizations, and approved text in print media, and web-based postings.

3.2.1 The Caregiver Assisted Transfer Technique Instrument

The CATT used during this study was consistent with the version of the CATT detailed in Chapter 2. Two versions of the CATT were developed as a result of content validity testing: the 16-item CATT-M to assess manual wheelchair transfers (Appendix B) and the 17-item CATT-L for evaluating transfer using lift-based technologies such as floor lifts and ceiling lifts (Appendix C).

Both versions of the CATT are scored on a scale of 0 to 10, where 0 indicates the worst quality transfer possible and 10 indicates the best quality of transfer possible. For each item a score of 1 indicates perfect technique while a score of 0 indicates poor technique. Some items allow for partial credit (0.5) or "not applicable" responses. All items are added, multiplied by 10, then averaged, with items scored as not applicable removed from the total score calculation, resulting in a score from 0 to 10 points (Equation 4).

Equation 4. Total Score Calculation for both CATT-M and CATT-L

$$CATT\ Total\ Score = \frac{Total\ \ Score}{Total\ number\ of\ applicable\ items}\ x\ 10$$

3.2.2 Human subjects

Caregiver and care recipient dyads were recruited for the study. Participants were encouraged to participate in pairs, with the caregiver or care recipient who they usually transferred

with. However, if participants were determined to be eligible for the study and either did not have a usual caregiver or care recipient that they transferred with or their usual caregiver or care recipient did not wish to participate, individuals could be paired together by the study team. Dyads were matched by their preferred transfer method (i.e. manual lifting, transfer board, floor lift, ceiling lift, etc). Participants in the study met the following inclusion and exclusion criteria.

3.2.2.1 Caregiver Inclusion/Exclusion criteria

Caregivers were included in the study if they: 1) were at least 18 years old, 2) routinely provided transfer assistance to an adult with a physical disability for a minimum of two transfers per week, 3) had been serving as a caregiver for at least three months or were currently undergoing supervised transfer training, and 4) had not received any formal didactic or structured training on assisted transfer techniques as part of a professional degree or program. These inclusion criteria were chosen for caregivers to ensure that they were performing transfers regularly at the time of the study and had enough experience transferring individuals with disabilities to safely complete the study. Caregivers with current or recent history of back or neck injuries within the last six months that would be exacerbated by performing an assisted transfer were excluded from the study.

3.2.2.2 Care Recipient Inclusion/Exclusion Criteria

Care recipients were included in the study if they: 1) were at least 18 years old, 2) used a mobility device (e.g. wheelchair, scooter, walker, cane, etc.) as a primary means of mobility for at least 30 hours per week, 3) had a physical disability diagnosis, 4) required assistance with transfers, and 5) currently received care from an informal caregiver. Care recipients with current or recent pressure ulcers within the last three months were excluded from the study.

3.2.2.3 Sample size determination

A power analysis was performed using G*Power Version 3.1 to determine the sample size needed to achieve 80% power for the concurrent validity statistical analysis in this study. Because the CATT is the first tool of its kind, real world data for this population was not available. Therefore, a large effect size was chosen based on recommendations by Cohen's guidelines for Pearson's r (Cohen, 1992). To detect a large effect size (H1=0.5) at a level of significance of a=0.05 at 80% power with a null hypothesis of no correlation (H0=0), a minimum of 29 subject dyads was needed.

The sample size requirement needed to estimate values of ICCs for reliability testing was determined using the methods developed by Bujang & Baharum (Bujang & Baharum, 2017). The formula used to determine required sample size is shown in Equation 5. The formula below derives a sample size estimation from the need to quantify the extent of agreement among a specified number of raters for at least two quantitative agreements. Power was set to 0.80 and the level of significance (alpha) was specified to be 0.05. The number of raters (k) for each observation was set to five. R0 and R1 represent the ICC values for the null and alternative hypotheses. Our null hypothesis was that there will be no agreement between our raters, so R0 is equal to 0.0. Our alternative hypothesis (Specific Aim 2) states that we expect to see good reliability between our raters with ICCs of 0.8 or greater, meaning that R1=0.8. Finally, we factored in the number of observations that will occur for each participant (4). Additional information on formula derivation and use cases for powering studies using ICCs is detailed in Bujang & Baharum (Bujang & Baharum, 2017). Based on the method detailed above, a total of 18 dyads would be needed for intraclass correlation with power at 80%, alpha at 0.05, five raters, and four observations per subject for estimating the desired effect size of ICCs for each tool (CATT-M and CATT-L).

Equation 5. Equations for Determining Sample Size Using ICCs

$$n = 1 + \frac{2(Z_\alpha + Z_\beta)^2\, k}{(\iota_n C_0\,)(k-1)}$$

where,

$$C_0 = \frac{1 + k\theta_0}{1 + k\theta_1}$$

$$\theta_0 = \frac{R_0}{1 + R_0}\;;\quad \theta_1 = \frac{R_1}{1 + R_1}$$

3.2.3 CATT raters

Prior to conducting the study, five rehabilitation professionals were chosen to serve as CATT raters for the study. While reliability can be established with as few as two raters, five raters were chosen based on recommendations for powering reliability studies with smaller samples of human subjects (Walter, Eliasziw, & Donner, 1998). Additionally, a sixth rehabilitation professional who was unfamiliar with the CATT served as a global rating scale (GRS) rater to evaluate construct validity. In addition to their rehabilitation-related profession, all six raters selected were actively engaged with research related to biomechanics and/or human movement. Because the CATT was meant to be used as a clinical tool by clinicians of all experience levels, the raters selected had a wide variety in their years of transfer-related experience, ranging from 2 to 26 years. Detailed information on each rater can be seen below in Table 6.

Table 6. Information on CATT and GRS Raters

	Age (years)	Profession	Years of Experience
Rater 1	29	Bioengineer	8
Rater 2	25	Biomedical Engineer	2.5
Rater 3	34	Occupational Therapist	8
Rater 4	24	Biomedical Engineer	2
Rater 5	52	Rehabilitation Engineer	26
GRS Rater	35	Biomechanist and physiatrist	4.5

Prior to rating study participants, all CATT raters were trained on the use of the CATT by the research team in a one-hour training session. During this session, each item on the CATT-L and CATT-M was reviewed in detail, with example videos and pictures being shown for correct and incorrect technique for each item. After the initial training session, the raters were given access to mock transfers, developed by the research team, to practice rating. The transfer videos consisted of both manual and lift-based transfers with varying quality of transfer technique so that the raters were exposed to a variety of transfer deficits. The raters then reconvened after assessing the practice videos, to discuss their scoring and ensure they were confident when rating all CATT items. CATT raters were given access to all training materials and supplemental materials developed to reference as needed for the full duration of the study. The GRS rater was not given access to any CATT materials during their ratings but was familiar with general best practice guidelines for proper manual lifting and lift-based technology transfer techniques.

3.2.4 Experimental Protocol

All participants provided their electronic informed consent before any study procedures occurred. Participants completed basic demographic survey to provide information about their age, gender, race, height, and weight. Caregivers also provided information about their annual household income, level of education, information about who they provide direct care to, how long they have been serving as a caregiver, and information on how they perform assisted transfers in their daily lives. Care recipients were asked to provide information on their disability, mobility device use, and transfer activities. Caregivers and care recipients also filled out a series of surveys about their current health status and quality of life. Additionally, caregivers filled out a series of questionnaires regarding their current pain, burden, and coping mechanisms used.

3.2.4.1 Surveys on General Health and Function

Both caregivers and care recipients completed the 36-Item Short Form Health Survey (SF-36), Beck Depression Inventory (BDI), and Patient-Reported Outcomes Measurement Information System Global Health Scale (PROMIS Global-10) to establish a baseline health status for participants. Caregivers also completed a five time sit to stand test (5XSTS).

The SF-36 is a patient reported outcome measure that quantifies health status and measures health related quality of life using eight subscales: physical functioning, role limitations due to physical problems, role limitations due to emotional problems, energy and fatigue, emotional well-being, social functioning, pain, and general health. Each of the eight subscales is scored on a scale of 0 (negative health) to 100 (positive health). The SF-36 has been used widely to assess health related quality of life in both the general population and populations with physical disabilities, including spinal cord injuries, traumatic brain injury, and stroke (Elena M Andresen, Fouts,

Romeis, & Brownson, 1999; Cabral et al., 2012; Emanuelson, Andersson Holmkvist, Björklund, & Stålhammar, 2003; Ware Jr, 2000). It has been found to have high reliability and validity in these populations (Anderson, Laubscher, & Burns, 1996; Brazier et al., 1992; Findler, Cantor, Haddad, Gordon, & Ashman, 2001; Lin, Hwang, Chen, & Chiu, 2007).

The BDI is a self-report measure consisting of 21 items that quantify the severity of depression through identification of overt behavioral characteristics of depression. Items are scored on a four-point scale, ranging from 0 to 3. Ratings for each item are summed, providing a total score that ranges from 0 to 63, where scores greater than 10 generally meet the threshold for a diagnosis of depression. It has been shown to have excellent internal consistency, adequate to excellent validity, and adequate to excellent reliability in non-specific patient populations (Beck, Steer, & Carbin, 1988; Poole, Bramwell, & Murphy, 2006).

The PROMIS Global-10 in a health assessment tool consisting of 10 items that assess domains of health and functioning, including physical health, mental health, social health, pain, fatigue, and overall perceived quality of life (Hays, Bjorner, Revicki, Spritzer, & Cella, 2009). The scoring system of the PROMIS Global-10 allows for each item to be examined separately, where nine questions are measured on a 5 point numerical rating scale, where ‘5’ equals maximum health of quality of life and ‘1’ equals minimum health or quality of life., and one question regarding pain is measured on a 11-point rating scale, where ‘0’ indicates no pain and ‘10’ equals worst pain imaginable. Another useful feature of the PROMIS Global Health Scale is that it can be converted into two 4-item summary scores measuring Global Physical Health (GPH) and Global Mental Health (GMH) to arrive at a “bottom-line” summary about health and mental status (Hays, Schalet, Spritzer, & Cella, 2017). The GPH and GMH scores can be converted to a T-Score metric, allowing for comparisons to a general population. Finally, the PROMISE Global Health Scale can be

converted into an EQ-5D index scoring by linear combination of eight Global-10 items. The PROMIS Global-10 has shown to have high levels of internal consistency, reliability, and concurrent validity with the EQ-5D (Hays et al., 2017).

A 5XSTS is a commonly used measure to evaluate the strength, balance, and fall risk of an individual (Bohannon, 1995). To administer the test, the rater asks the individual to sit with their arms folded across their chest with their back against a chair. The rater then instructs the individual to stand up and sit down five times as quickly as they can. Timing begins when the rater says 'Go' and ends after the buttocks touches the chair after the fifth repetition. The time it takes the participant to complete the 5XSTS is recorded. The 5XSTS has been used in a variety of populations, including adults with back pain, joint pain and fractures, and community-dwelling older adults with adequate to excellent reliability and validity (Piva et al., 2011; Schaubert & Bohannon, 2005; Simmonds et al., 1998; Tiedemann, Shimada, Sherrington, Murray, & Lord, 2008).

3.2.4.2 Surveys on Pain

Caregiver participants completed the Oswestry Low Back Disability Index (ODI) and a Numerical Rating Scale (NRS) of pain intensity in the back and upper extremities to gain an understanding of the level of pain they are experiencing in their daily lives.

The ODI consists of 10 items that assess the symptoms and severity of low back pain and the degree to which back pain impacts functional abilities (Fairbank & Pynsent, 2000). Each item consists of six statements with correlating scores from 0 to 5, where a score of '0' indicates the least disability and a score of '5' represents the greatest disability. Each item score is summed, divided by the total possible score, and multiplied by 100 to give a score from 0% to 100%, where 0% represents minimal disability and 100% represents maximum disability. The ODI has been

shown to have excellent internal consistency for overall ODI, excellent reliability, and adequate to excellent validity for individuals who are experiencing low back pain (H. Frost, Lamb, & Stewart-Brown, 2008; Grotle, Garratt, Krogstad Jenssen, & Stuge, 2012; Wittink, Turk, Carr, Sukiennik, & Rogers, 2004).

Participants were asked to rate their average, most severe, and least severe pain in their right and left shoulder, neck, upper back, and lower back during the past 24 hours using an 11-point scale (i.e. 0-10) anchored at the ends by "no pain" and "worst pain ever experienced". NRS pain measures are widely used and have been shown to be a valid and reliable assessment of pain (Bijur, Latimer, & Gallagher, 2003; Lundeberg et al., 2001).

3.2.4.3 Caregiving Measures

Caregiver participants completed the Zarit Burden Interview (ZBI) to gain insight into how caregiving affects their lives. The ZBI assesses caregiver perceptions of burden that affect health, personal, social, and financial wellbeing (Bédard et al., 2001). It contains 22 items that ask the caregiver to indicate the extent of burden experienced while providing care on a 5-point scale (0-4), where '0' indicates "never" (no burden) and 4 indicates "nearly always" (high burden). Item scores are summed to obtain a total score, ranging from 0-88, where 0 indicates the least amount of burden possible and 88 represents the highest amount of burden possible. The ZBI has excellent internal consistency in caregivers of individuals with a variety of diagnoses, including physical disabilities (Siegert, Jackson, Tennant, & Turner-Stokes, 2010). Participants who were serving as care attendants (i.e. not family or friends of the care recipient) were not asked to complete the ZBI, as it is geared towards family caregivers.

3.2.4.4 Transfer Assessment

Participant dyads who participated at HERL were asked to perform a series of four transfers to surfaces that they typically transfer to as part of their everyday life. Dyads were able to choose to use a transfer assist device if they wish to facilitate the transfer, including transfer boards and mechanical lifts. Participant dyads who participated in the care recipient's home were asked to perform four transfers in places in the home where they normally perform such activities. During the transfers, five rehabilitation professionals rated each transfer using the CATT-M for transfers involving manual lifting and the CATT-L for transfers involving lift-based technologies. During the transfers, at least one rater rated the transfers in person to monitor the participants and make sure all study procedures were done safely. Other raters rated the transfers remotely via Zoom to minimize contact between the participants and the study team during the COVID 19 pandemic. Participant dyads were asked to return to the lab or participate from their homes between 4 hours and two weeks later to perform the transfer portion of the protocol again by performing the same four transfers a second time. This time frame was chosen to short enough that transfer technique would not change drastically between visits and long enough that scores were not affected by rater memory, as is seen in previous studies looking at independent transfer technique assessment (McClure et al., 2011; Tsai et al., 2013). All raters independently scored each transfer in real time using the CATT, even when viewing the transfer protocol via Zoom.

CATT raters scored recordings of the same transfers for a third assessment a minimum of 14 days after the initial assessment to ensure that repeat administration of the CATT was not affected by rater memories of the initial assessment (M. H. Frost et al., 2007). Additionally, a sixth rater who was unfamiliar with the CATT rated the transfers using a global rating scale, anchored by ‘0’ (worst transfer quality possible) and ‘10’ (best transfer quality possible) to assess the

CATT's construct validity via video recordings. During the taped assessments, raters were able to use features associated with video recordings, including pausing, rewinding, rewatching, etc, to evaluate the transfers. The order that the transfers videos were viewed by the raters was randomized via block randomization to minimize order bias, with five participant dyads (20 total transfers) in each block. A flowchart of study activities can be seen in Figure 4.

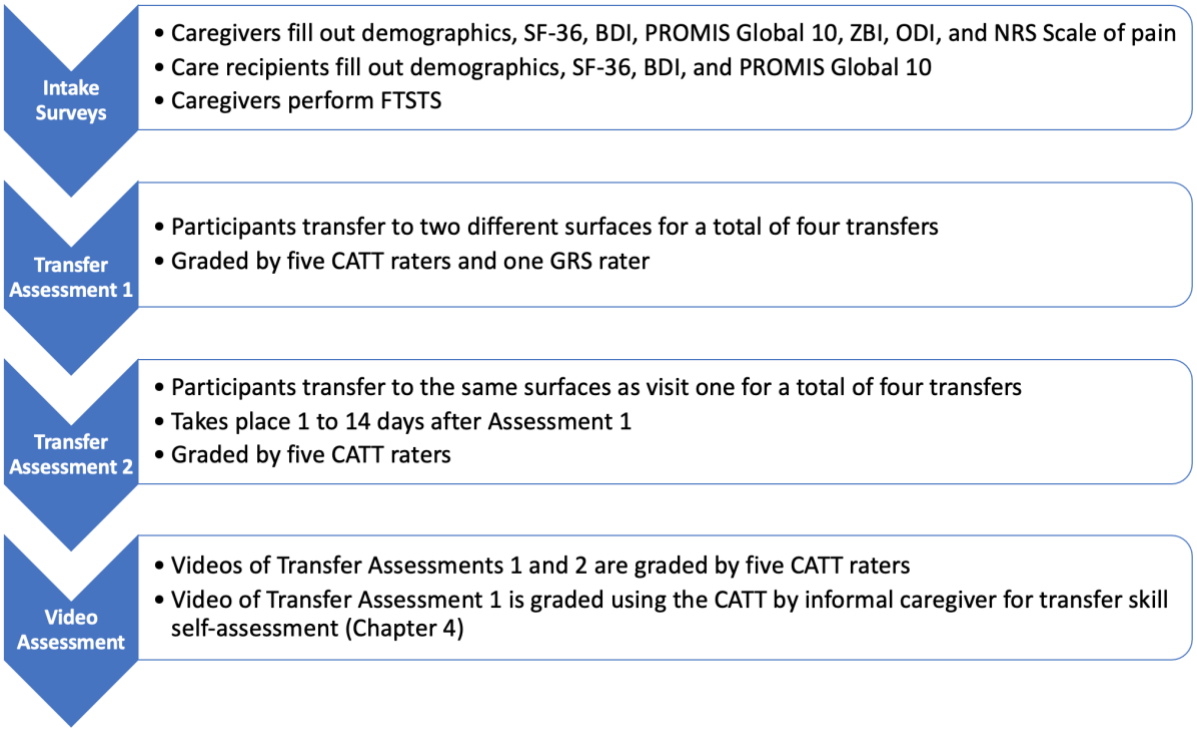


Figure 4. Flowchart depicting study activities

3.2.5 Data Collection

Outcome measures including surveys, questionnaires, and CATT scores from raters were collected and managed using REDCap electronic data capture tools (REDCap) hosted at the University of Pittsburgh (Harris et al., 2019). Zoom was used as a video conferencing service for raters to remotely evaluate transfers, with the sessions recorded so that the raters could evaluate

both live evaluations and video recordings of the transfers using the CATT. One camera was used to capture the transfer and was placed directly in front of the transfer surface so that the entire transfer process could be captured. The in-person rater who was responsible for setting up the camera for remote raters would verbally confirm with all raters that they had a clear view of the transfer area before testing began. Recordings were clipped and transferred to a secure folder in Sharepoint (Microsoft) hosted at the University of Pittsburgh so that both the global ratings scale rater and the CATT raters could access recordings needed to rate all transfers.

3.2.6 Data Analysis

All statistical analysis was performed in SPSS Version 27 (IBM). Frequency histograms of responses for each CATT item were examined to evaluate ceiling and floor effects, distribution of item responses, and outliers. Descriptive statistics were computed for the CATT total scores. Standard error of measurement (SEm) (Equation 6) and minimal detectable change (MDC) (Equation 7) were calculated to provide an indicator of accuracy and relative stability of the responses as well as determine population estimates. Internal consistency was evaluated using Cronbach's alpha and item-total correlations. Cronbach's alpha should be above 0.7; values above 0.9 suggest a high-level of item redundancy (MP, 2009). An independent t-test was used to compare total CATT scores of individuals who participated with a care recipient they had worked with previously to individuals who were paired with a new individual, total CATT scores of individuals who participated with multiple caregivers versus only one caregiver, and total CATT scores of individuals who participated in their own home versus individuals who chose to participate in a laboratory setting, with the level of significance set to $p=0.05$.

Equation 6. SEm calculation, where SD= standard deviation and r= interrater ICC.

$$SEm = SD\ x\ \sqrt{1 - r}$$

Equation 7. MDC calculation, where SEm= standard error of measurement

$$MDC = 1.96\ x\sqrt{2}\ x\ SEm$$

Interclass correlation coefficients (ICCs) (ICC(3,k); two way mixed effects, consistency, multiple raters/measurements) were calculated to determine intra-rater and interrater reliability of total scores, with an ICC of 0.8 or higher defined as good reliability, 0.6 to 0.79 as acceptable reliability, 0.4 to 0.59 as moderate reliability, and less than or equal to 0.39 as weak reliability (Bland & Altman, 2007; McGraw & Wong, 1996). Fleiss's Kappa was used to determine the interrater reliability (ICC(2,k); two way mixed effects, absolute agreement, multiple raters/measurements) and Cohen's Kappa was used to determine intrarater reliability (ICC(2,1); two way mixed effects, absolute agreement, single rater) of individual items, with K of greater than 0.8 defined as very good reliability, 0.61 to 0.8 as good reliability, 0.41 to 0.60 as moderate reliability, 0.21 to 0.4 as fair reliability, and 0.2 or lower as poor reliability (Altman, 1990). The "Not applicable" responses of items were included in the reliability analysis. Items that did not achieve at least moderate reliability (K > 0.4) were flagged for revision.

GRS scores were compared to total CATT scores for each transfer in visit one, with the average transfer score between the five raters for each transfer used for the comparison. Spearman rank correlation coefficients were calculated to determine the strength of the relationship between the total score on the CATT and GRS scores. A spearman rank correlation coefficient of greater than or equal to 0.8 was considered very strong correlation, between 0.79 and 0.6 strong

correlation, between 0.59 and 0.4 moderate correlation, between 0.39 and 0.2 weak correlation, and equal to or below 0.19 very weak correlation.

Relationships or differences in total CATT scores for each task with respect to informal caregiver and care recipient demographics, caregiver and care recipient general health and function, caregiver pain, caregiver strength, and caregiver burden were examined. These factors were compared to the average CATT score received across all raters for all transfers performed. Demographic factors including caregiver age, gender, level of education, level of income, and hours spent caregiving as well as care recipient weight were analyzed, as these factors have all been shown to influence burden (Adelman et al., 2014). Analysis depended on the nature of the independent variable, with Pearson's correlation test implemented for continuous variables and a Spearman's test for categorical variables. Differences in CATT scores and caregiver and care recipient general health and function were examined. General health and function were assessed via the SF-36 and PROMIS Global-10 for both the caregiver and care recipient. Specifically, the physical functioning, role limitations due to physical health, energy and fatigue, pain, and general health SF-36 domains were examined for both caregivers and care recipients. For the PROMIS Global-10, GPH scores and GMH scores were examined for both caregivers and care recipients. Caregiver and care recipient mental wellbeing was assessed using BDI scores. A Pearson's correlation test was performed to correlate SF-36, PROMIS Global-10, and BDI and CATT scores. Additionally, caregiver specific metrics included ZBI scores to examine caregiver burden, ODI scores for lower back disability, and 5XSTS times for caregiver strength. A Pearson's correlation was performed for ODI scores and ZBI scores to correlate these measures with CATT scores. The level of significance for all comparative analyses was set to alpha=0.05.

Interclass correlation coefficients (ICCs) were calculated to determine intra-rater reliability and interrater reliability of total scores between the live assessment and taped assessments (ICC(3,k); two way mixed effects, consistency, multiple raters/measurements) (McGraw & Wong, 1996). Total scores were compared between live and taped transfers for each rater using the Bland Altman Limits of agreement methods (Bland & Altman, 2007).

3.3 Results

3.3.1 Participants

Twenty-four participant dyads of caregivers and care recipients were recruited to participate in the study (Table 7). Twelve participant dyads chose to perform the study in their own home (50%) and twelve dyads chose to participate at the Human Engineering Research Laboratories (50%). Three care recipients participated multiple times with different caregivers: one with two caregivers, one with three caregivers, and one with five caregivers. Eight of the 24 caregivers participated with an individual who they did not normally transfer with but used the same transfer method as they were used to transferring (33%). Caregivers were all informal caregivers who cared for a spouse or partner (29.2%), sibling (4.2%), child (4.2%), or a client or friend while working as a paid care attendant without professional training (62.5%). The majority of caregivers had an income of less than $30,000 per year (61.5%) and a highest degree earned of a Bachelor's degree (57.7%). Caregivers had between 6 months and 17 years of experience providing caregiving services, and the majority spent over 8 hours a week caregiving (83%), with 33.3% of the caregivers reporting they spent more than 40 hours a week providing caregiving

services. Caregivers used a wide variety of methods to transfer their care recipients, including with a mechanical floor lift when transferring (41.7%), manual lifting without assistive technology (25%), manual assistance with a transfer board (20.8%), and ceiling lifts (12.5%).

Care recipients (n=17) had a wide variety of disabilities, including spinal cord injury (47.1%), orthopedic impairments (17.7%), multiple sclerosis (11.8%), cerebral palsy (11.8%), spina bifida (5.9%), and Friedreich's ataxia (5.9%). Participants had been living with a disability for between 1 and 55 years, with an average time since diagnosis of 18.9 ± 14.4 years and an average time of using a mobility device of 15.5 ± 13.4 years. Most participants (76.5%) only used one assistive device for mobility, but 23.5% used multiple devices. The types of mobility devices used by participants consisted of power wheelchairs (64.7%), manual wheelchairs (29.4%), canes (11.8%), and walkers (11.8%). Twenty-nine percent of participants reported falling at least once while transferring, with half of those individuals reporting falling due to caregiver inexperience or mistake while transferring.

Table 7. Demographic characteristics of caregiver and care recipient participants

	Caregivers (n=24)	**Care recipients** (n=17)	**All participants** (n=41)
Age (years)	39.4 ± 18.3	47.8 ± 14.3	42.9 ± 16.7
Gender			
Male (%)	5 (20%)	10 (58.8%)	15 (36.6%)
Female (%)	20 (80%)	7 (41.2%)	26 (63.4%)
Race			
Caucasian (%)	18 (72%)	12 (70.6%)	29 (70.7%)
African American (%)	3 (12%)	2 (11.8%)	5 (12.2%)
Asian (%)	3 (12%)	1 (5.8%)	4 (9.8%)
Other (%)	1 (4%)	2 (11.8%)	3 (7.3%)
Weight (kg)	75.8 ± 23.7	84.0 ± 29.3	79.5 ± 26.2
Height (cm)	167.8 ± 8.2	164.4 ± 19.2	166.5 ±13.8
Transfers per week	15.5 ± 14.0	31.3 ± 19.0	22.4 ± 17.9
Years of caregiving experience	5.1 ± 5.3		
Years using a mobility device		15.5 ± 13.4	

Overall, caregiver participants were in good health and had high quality of life based on their survey responses, with care recipients reporting lower levels of physical health, mental health, and quality of life than their caregiver counterparts (Table 8). Caregiver averages on the SF-36 were consistent with general population estimates for all eight domains of the SF-36 (Stewart, 1992). Care recipient reported SF-36 scores were also consistent with population estimates, with the exception of the physical functioning domain, which was lower than that of the general population (Stewart, 1992). Most caregivers (84.6%) and care recipients (47.1%) reported having normal ups and downs with their mood on the BDI. Three (11.5%) caregivers reported mild mood disturbances and one (3.8%) had signs of moderate depression on the BDI. Four (23.5%) care recipients reported a mild mood disturbance, four (23.5%) had symptoms of borderline depression and one (5.9%) had signs of severe depression based on BDI scoring. PROMIS Global 10 scores for caregivers were consistent with the U.S. General population for both global physical health (52.7 ± 7.8) and mental health (53.3 ± 8.2), in which a "T-Score" of 50.0 ± 10.0 is representative of the United States population (Hays et al., 2017). While care recipients had within the normative range for global mental health (43.0 ± 8.1), they reported below average global physical health (37.0 ± 8.1), indicating they had lower physical health-related quality of life than that of the general U.S. population (Hays et al., 2017).

Table 8. General health survey responses for caregivers and care recipients

	Caregivers (n=24)		**Care Recipients** (n=17)	
	Average ± Standard deviation	Range	Average ± Standard deviation	Range
SF-36				
Physical Functioning	96.5 ± 4.8	85.0 - 100	12.9 ± 23.6	0- 90.0
Role Limitations due to Physical Health	91.7 ± 17.5	50.0 - 100	56.6 ± 41.5	0- 100
Role Limitations due to emotional problems	95.8 ± 11.3	66.7 - 100	66.7 ± 44.1	0- 100
Energy/Fatigue	59.0 ± 21.4	10.0- 100	49.1 ± 30.6	5.0- 95.0
Emotional wellbeing	75.3 ± 15.1	48.0- 96.0	76.7 ± 14.8	56.0- 100
Social functioning	86.8 ± 18.4	50.0- 100	73.5 ± 25.7	25.0- 100
Pain	84.7 ± 19.4	45.0- 100	66.5 ± 34.6	0- 100
General Health	79.2 ± 17.4	30.0- 100	53.5 ± 25.8	0- 90.0
BDI	4.5 ± 5.9	0- 23	11.6 ± 9.4	0- 36
PROMIS				
Global Physical Health- Raw Score	16.3 ± 2.3	12- 20	10.9 ± 3.1	6- 15
Global Physical Health- T-Score	52.7 ± 7.8	39.8- 67.7	37.0 ± 8.1	23.5- 47.7
Global Mental Health- Raw Score	15.7 ± 3.0	9- 20	11.8 ± 3.2	5- 17
Global Mental Health- T-Score	53.3 ± 8.2	36.3- 67.6	43.0 ± 8.1	25.1- 56.0

Caregivers, on average, reported low levels of pain and mild burden (Table 9). Eight caregivers chose not to fill out the ZBI, as they worked with clients and felt that the ZBI did not apply to their relationship with their care recipient. Of the caregivers that did complete the ZBI (n=15), 46.7% reported no to mild burden, 40% reported mild to moderate burden, and 13.3% reported high levels of burden. Most caregivers (83.4%) reported minimal low back disability on the ODI, but 8.3% reported moderate disability and 8.3% reported severe disability due to low back pain. On average, caregivers reported low levels of pain in their shoulders, neck, upper back, and lower back on an NRS pain scale, with 38.5% of the caregivers reporting no pain in any body part. The highest levels of pain were reported in the lower back (average pain: 2.0 ± 2.9; most severe pain: 2.6 ± 3.5; least severe pain: 1.3 ± 2.5); It should be noted that the caregivers enrolled in the study reported a large range of different pain levels, especially in the low back where scores ranged from 0- 10. The average 5XSTS time for caregivers was 12.2 ± 4.7 seconds.

Table 9. Caregiver burden and pain survey responses

	Average (± standard deviation)	**Range**
ZBI (n=15)	12.7 ± 9.0	0- 34
ODI	9.9 ± 14.9	0- 52
NRS Pain Scale		
Right shoulder average	0.8 ± 1.6	0- 7
Right shoulder most severe	1.2 ± 2.1	0- 8
Right shoulder least severe	0.4 ± 0.9	0- 3
Left shoulder average	0.5 ± 1.1	0- 4
Left shoulder most severe	0.7 ± 1.4	0- 5
Left shoulder least severe	0.2 ± 0.5	0- 2
Neck average	1.0 ± 1.8	0- 7
Neck most severe	1.5 ± 2.6	0- 9
Neck least severe	0.4 ± 1.1	0- 4
Upper back average	1.3 ± 2.0	0- 6
Upper back most severe	1.9 ± 2.7	0- 8
Upper back least severe	0.6 ± 1.2	0- 4
Lower back average	2.0 ± 2.9	0- 10
Lower back most severe	2.6 ± 3.5	0- 10
Lower back least severe	1.3 ± 2.5	0- 10
5XSTS (seconds)	12.2 ± 4.7	7.01 – 23.29

Of the 24 dyads recruited, 20 dyads completed both transfer assessments. One of the dyads who was assessed with the CATT-L only completed three of four transfers due to fatigue. One of the dyads who completed the assessment with the CATT-M elected to perform six transfers, as the physical environment of their home required an additional set of transfers to safely maneuver about the home. The average between CATT assessments for participant dyads was 7.6 days (SD= 3.2). One dyad was an outlier and had 78 days between visit 1 and visit 2 due to an unexpected hospitalization. However, it was confirmed that the dyads transfer habits and method had not changed post hospitalization prior to scheduling visit 2.

3.3.2 Descriptive statistics for CATT total Scores

The average CATT score across all transfers performed by participants (total transfer assessed=180) was 8.6 (SD= 1.2). Thirteen of the dyads were assessed using the CATT-L and eleven were assessed with the CATT-M. Average scores for the CATT-M (n=78) were 8.0 (SD= 1.5) and for the CATT-L (n= 102) were 9.0 (SD= 0.7). No participants scored a minimum on the scale (0%), but 141 instances of perfect scores out of a possible 892 scores were recorded by CATT raters (15.8%). While this is under the 20% threshold used to define ceiling effects, it should be noted that in general, many participants enrolled in the study had excellent technique when transferring (Elena M. Andresen, 2000).

3.3.3 Interrater and Intrarater Reliability of the CATT

Interrater and intrarater reliability for in-person visits 1 and 2 are shown in Table 10. For the CATT total score, good interrater reliability was found when using the CATT-M for both visit

1 (n=11) and visit 2 (n=8) and visit 1 (n=13) of the CATT-L, while visit 2 (n=13) using the CATT-L showed acceptable interrater reliability, indicating that overall, the five CATT raters agreed on the total scores assigned to participants. ICCs for intrarater reliability varied. Four of the five raters exhibited acceptable intrarater reliability when using the CATT-M and one exhibited good intrarater reliability, with ICCs ranging from 0.751 to 0.828. However, intrarater reliability of the CATT-L varied greatly. Two raters had acceptable intrarater reliability, with ICC values of 0.648 and 0.721. However, three raters had weak reliability, with their ICCs ranging between 0.155 and 0.385. When examining the ICCs of all total CATT Scores (i.e. combining total scores for both the CATT-M and CATT-L), two raters had good reliability, two had acceptable reliability, and one had moderate reliability.

Table 10. ICCs for Interrater and Intrarater reliability for total CATT Scores, where n = the number of dyads assessed.

	Interrater Reliability [95% CI]				
	Session 1			**Session 2**	
Total CATT-M Score	0.867 [0.795- 0.919]			0.921 [0.868- 0.957]	
Total CATT-L Score	0.860 [0.788- 0.913]			0.664 [0.492- 0.790]	
Total all CATT forms	0.845 [0.784- 0.893]			0.895 [0.855- 0.927]	
	Intrarater Reliability [95% CI]				
	Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
Total CATT-M Score (n=8)	0.826 [0.666- 0.913]	0.791 [0.606- 0.755]	0.779 [0.585- 0.888]	0.751 [0.540- 0.873]	0.767 [0.566- 0.882]
Total CATT-L Score (n=13)	0.385 [-0.077 – 0.649]	0.721 [0.557- 0.831]	0.648 [0.458- 0.783]	0.155 [-0.123- 0.411]	0.209 [-0.068- 0.456]
Total all CATT forms (n=21)	0.748 [0.634- 0.830]	0.849 [0.775- 0.900]	0.802 [0.707- 0.868]	0.531 [0.355- 0.671]	0.692 [0.559- 0.791]

For individual items, interrater reliability varied, with a summary of item results for the CATT-M and CATT-L shown in Table 11. Four items on the CATT-M and 11 items on the CATT-L exhibited low variability in the rater responses, with over 90% of all responses were the same outcome. Due to low variability, interrater reliability could not be determined for these items. For the CATT-M, two items had good reliability, four had moderate reliability, and five had fair reliability, based on the lowest Fleiss's Kappa calculated for Visits 1 and 2. For the CATT-L, one items had very good reliability, two had good reliability one had fair reliability, and two had low reliability based on the lowest Fleiss's Kappa calculated for Visits 1 and 2. More details on individual items for the CATT-M and CATT-L can be seen in Appendix D and Appendix E, respectively, including individual score response agreements.

Table 11. Summary of individual item interrater reliabilities for CATT-M and CATT-L

CATT-M		
	Visit 1 (K [95% CI])	Visit 2 (K [95% CI])
Items with good reliability (0.79>K> 0.6)		
Item 2: The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface	0.757 [0.690- 0.842]	0.682 [0.602- 0.761]
Item 3: The care recipient is close to the object to which they are transferring	0.730 [0.656- 0.803]	0.792 [0.704- 0.880]
Items with moderate reliability (0.59 >K> 0.4)		
Item 4: The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface	0.598 [0.528- 0.667]	0.513 [0.430- 0.596]
Item 5: The transfer is set up to be a level or downhill transfer	0.537 [0.455- 0.618]	0.573 [0.474- 0.672]
Item 9: Caregiver grasps the care recipient securely around hips, buttocks or transfer belt	0.527 [0.437- 0.617]	0.682 [0.575- 0.790]
Item 11: The caregiver does not pull on the care recipient's arms during set up or the transfer	0.578 [0.465- 0.692]	0.578 [0.477- 0.696]
Item 16: The transfer does not cause any pain or discomfort to the caregiver or care recipient	0.938 [0.859- 1.085]	0.498 [0.406- 0.591]
Items with fair reliability (0.4 >K> 0.21)		
Item 7: The care recipient's feet and legs are positioned on the floor or stable surface prior to transfer	0.290 [0.209- 0.317]	0.392 [0.297- 0.487]
Item 8: Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient	0.440 [0.349- 0.531]	0.265 [0.155- 0.374]
Item 10: Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface	0.461 [0.394- 0.528]	0.316 [0.236- 0.397]
Item 12: Caregiver performs pivoting movements of their feet while moving the care recipient	0.329 [0.239- 0.419]	0.269 [0.162- 0.377]
Item 13: The transfer is well controlled	0.496 [0.404- 0.587]	0.253 [0.143- 0.363]
Items that could not be calculated due to low variability of rater responses		

Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer		
Item 6: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer		
Item 14: The caregiver and care recipient communicate throughout the transfer process		
Item 15: The care recipient is in a safe and secure position at the end of the transfer		
CATT-L		
Items with very good reliability (K> 0.8)		
Item 6: The caregiver locks castors and wheels of the lift before lifting and lowering the care recipient	0.845 [0.781- 0.908]	0.839 [0.775- 0.902]
Items with good reliability (0.79>K> 0.6)		
Item 4: The caregiver avoids unnecessary lifting of the care recipient when fitting the sling.	0.703 [0.631- 0.774]	0.701 [0.623- 0.779]
Item 12: The lift base (width) is adjusted appropriately during the transfer process	0.640 [0.589- 0.619]	0.660 [0.608- 0.711]
Items with fair reliability (0.4 >K> 0.21)		
Item 3: The surface where the care recipient and sling are being fitted is level with the caregiver's waist	0.304 [0.222- 0.386]	0.325 [0.240- 0.411]
Items with poor reliability (0.2 >K)		
Item 9: The care recipient when lifted is in an upright position relative to the transfer surface	0.422 [0.335- 0.509]	0.067 [-0.020- 0.154]
Item 15: The caregiver and care recipient communicate throughout the transfer process	0.131 [0.044- 0.217]	0.240 [0.154- 0.327]
Items that could not be calculated due to low variability of rater responses		
Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer		
Item 2: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer.		
Item 5: The caregiver does not pull on the care recipient's arms during set up or the transfer		

Item 7: The caregiver lowers the swivel bar close to the care recipient before attaching the sling and does not hit the care recipient's face or head		
Item 8: The caregiver attaches the sling straps to the swivel bar in the correct position		
Item 10: The sling is appropriately sized and fitted for the care recipient.		
Item 11: The care recipient's feet and legs are secured appropriately upon initial lift and transfer		
Item 13: The caregiver maintains a neutral posture when operating the lift and moving the care recipient to the target surface		
Item 14: The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.**		
Item 16: The care recipient is in a safe and secure position at the end of the transfer		
Item 17: The transfer does not cause any pain or discomfort to the caregiver or care recipient		

The total percent agreement among raters was calculated to further elucidated items that may need improvement or additional instruction for raters. Table 12 details percent agreement between raters for the CATT-M and CATT-L. Further information on percent agreement of individual items can be found in Appendix D and Appendix E for the CATT-M and CATT-L, respectively.

Table 12. Percent agreement between all raters for CATT-M and CATT-L items

CATT-M
Items with over 90% agreement for both sessions
Item 6: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer
Items with over 80% agreement for both sessions
Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer
Item 2: The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface
Item 3: The care recipient is close to the object to which they are transferring
Item 11: The caregiver does not pull on the care recipient's arms during set up or the transfer
Item 13: The transfer is well controlled
Item 14: The caregiver and care recipient communicate throughout the transfer process
Item 15: The care recipient is in a safe and secure position at the end of the transfer
Item 16: The transfer does not cause any pain or discomfort to the caregiver or care recipient
Items with over 70% agreement for both sessions
Item 4: The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface
Item 5: The transfer is set up to be a level or downhill transfer
Item 7: The care recipient's feet and legs are positioned on the floor or stable surface prior to transfer
Item 9: Caregiver grasps the care recipient securely around hips, buttocks or transfer belt
Items with below 70% agreement for both sessions
Item 8: Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient
Item 10: Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface
Item 12: Caregiver performs pivoting movements of their feet while moving the care recipient

CATT-L
Items with over 90% agreement for both sessions
Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer
Item 2: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer.
Item 5: The caregiver does not pull on the care recipient's arms during set up or the transfer
Item 6: The caregiver locks castors and wheels of the lift before lifting and lowering the care recipient
Item 7: The caregiver lowers the swivel bar close to the care recipient before attaching the sling and does not hit the care recipient's face or head
Item 8: The caregiver attaches the sling straps to the swivel bar in the correct position
Item 10: The sling is appropriately sized and fitted for the care recipient.
Item 11: The care recipient's feet and legs are secured appropriately upon initial lift and transfer
Item 13: The caregiver maintains a neutral posture when operating the lift and moving the care recipient to the target surface
Item 14: The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.**
Item 16: The care recipient is in a safe and secure position at the end of the transfer
Item 17: The transfer does not cause any pain or discomfort to the caregiver or care recipient
Items with over 80% agreement for both sessions
Item 4: The caregiver avoids unnecessary lifting of the care recipient when fitting the sling.
Item 9: The care recipient when lifted is in an upright position relative to the transfer surface
Items with over 70% agreement for both sessions
Item 3: The surface where the care recipient and sling are being fitted is level with the caregiver's waist
Item 12: The lift base (width) is adjusted appropriately during the transfer process
Item 15: The caregiver and care recipient communicate throughout the transfer process

Table 13 shows the standard error of measurement and the minimal detectable change for the CATT-M and CATT-L. The calculated SEm for the CATT-M total scores ranged from 0.56 (visit 1) to 0.41 (visit 2) with associated MDCs of 1.55 (visit 1) and 1.15 (visit 2). The SEM for the CATT-L total scores were 0.27 (visit 1) and 0.37 (visit 2) with associated MDCs of 0.76 (visit 1) and 1.03 (visit 2). Both versions of the CATT demonstrated acceptable internal consistency without high levels of item redundancy, with Chronbach's alpha ranging from 0.720 to 0.872 across versions of the CATT and across visits. There were no significant difference found between total CATT scores for individuals who had previously worked with their care recipient and individuals who were paired with a care recipient as part of the study, total CATT scores for individuals who had participated with multiple caregivers, or individuals who participated in their home versus in a laboratory setting (Table 14).

Table 13. Standard error of measurement and minimum detectable change of CATT-M and CATT-L for visits 1 and 2

	CATT-M	**CATT-L**
Visit 1		
SEm	0.56	0.27
MDC	1.55	0.76
Visit 2		
SEm	0.41	0.37
MDC	1.15	1.03

Table 14. Summary Statistics of total CATT Score comparisons, where n = the number of dyads in the specified group

Group	Mean total CATT score	p-value
Caregivers who previously worked with care recipient (n=16)	8.3 ± 1.3	0.101
Caregivers who were paired with a care recipient (n=8)	9.0 ± 0.7	
Care recipients who participated with only one caregiver (n= 14)	8.2 ± 1.3	0.137
Care recipients who participated with multiple caregivers (n= 10)	8.9 ± 0.7	
Dyads who participated at home (n= 12)	8.4 ± 1.3	0.320
Dyads who participated in a laboratory setting (n= 12)	8.9 ± 1.1	

3.3.4 Construct Validity of the CATT

The relationship between CATT total scores and global rating scale scores were examined (Table 15). Overall CATT total scores had a strong correlation with GRS scores by an expert in assisted transfer techniques ($r = 0.714$; $p < 0.001$). When breaking down correlations by the version of the CATT used, the CATT-M had strong a correlation with GRS score ($r = 0.643$; $p < 0.001$) and the CATT-L showed moderate correlation ($r = 0.529$; $p = 0.001$) between CATT total scores and GRS mean scores.

Table 15. Correlations between CATT Scores and GRS Scores for the CATT-M, CATT-L, and all Transfers, where n= the number of dyads assessed

	CATT Score Mean (± st. dev)	**GRS Score Mean** (± st. dev)	**r**	**P-value**
CATT-M (n= 11)	8.0 ± 1.2	6.1 ± 2.0	0.643	<0.001
CATT-L (n= 13)	9.0 ± 0.5	8.3 ± 0.8	0.529	<0.001
All Transfers (n=24)	8.6 ± 1.0	7.2 ± 1.9	0.714	<0.001

The relationship between demographic, socioeconomic, and health-related factors of the caregivers and care recipient dyads (n=24) and total CATT Scores were examined (Table 16 and Table 17). The mean (± standard deviation) of the CATT scores used for this analysis was 8.6 ± 1.0. Higher CATT scores were strongly correlated with caregiver age (r=-0.725). Lower CATT scores were associated with greater caregiver age (r = -0.725) and hours of care provided by the caregiver (r_s = -0.619), where caregivers who provided less hours of weekly care had higher CATT scores. Higher CATT scores were moderately correlated with higher levels of caregiver education (r_s=0.402), caregiver general health based on SF-36 (r=0.480), level of burden based on ZBI scores (r = -0.523), and higher strength as determined by lower 5XSTS times (r=-0.480). Additionally, a strong correlation was seen between CATT scores and the relationship between the caregiver and care recipient, where caregivers who cared for a client or friend tended to have higher CATT scores than individuals who were caring for a relative (r_s=0.601) No other significant associations were found between demographic, socioeconomic, and health-related characteristics of caregivers and care recipients and total CATT Scores ($p > 0.05$).

Table 16. Correlation between total CATT Scores and Demographic, Socioeconomic, and Health-Related Factors of Caregivers

	Mean (± st. dev)	**Correlation coefficient**	**P-value**
Age (years)	39.5 ± 17.8	-0.725	<0.001*****
Gender		0.389	0.045
Income		-0.098	0.626
Level of Education		0.402	0.038*
Hours of Care provided		-0.619	<0.001*****
Relationship to CR (family versus PCA)		0.601	<0.001*****
Years of caregiving experience	4.9 ± 5.3	-0.356	0.068
Transfers performed per week	15.9 ± 13.9	0.116	0.566
SF-36 Physical Functioning	96.5 ± 4.8	0.368	0.059
SF-36 Role Limitations due to Physical Health	91.7 ± 17.5	0.104	0.605
SF-36 Energy and Fatigue	60.0 ± 22.5	0.156	0.436
SF-36 Pain	84.7 ± 19.4	0.252	0.205
SF-16 General Health	79.2 ± 17.4	0.480	0.009*
BDI	4.5 ± 5.9	-0.221	0.292
PROMIS GPH	16.3 ± 2.3	0.143	0.476
PROMIS GMH	15.7 ± 3.0	0.064	0.752
ZBI (n=14)	13.4 ± 8.9	-0.523	0.038*
ODI	10.5 ± 14.9	-0.335	0.088
5XSTS (seconds)	12.2 ± 4.7	-0.482	0.011*

*****indicates significance at $p < 0.05$

Table 17. Correlation between total CATT Scores and Demographic, Socioeconomic, and Health-Related Factors of Care Recipients

	Mean (± st. dev)	**Correlation coefficient**	**P-value**
Weight (kg)	85.3 ± 24.9	-0.146	0.352
SF-36 Physical Functioning	19.2 ± 23.3	-0.102	0.612
SF-36 Role Limitations due to Physical Health	45.3 ± 39.5	0.028	0.889
SF-36 Energy and Fatigue	52.4 ± 28.8	0.078	0.700
SF-36 Pain	62.5 ± 31.5	0.102	0.613
SF-16 General Health	53.5 ± 25.5	0.118	0.559
BDI	12.5 ± 8.0	-0.141	0.482
PROMIS GPH	10.8 ± 3.8	0.239	0.230
PROMIS GMH	11.4 ± 3.5	0.330	0.092

3.3.5 Comparison of Live Versus Recorded Assessments

Live versus taped assessments were compared for the first fifteen participants enrolled in the study for a total of 61 transfers, eighteen manual and forty-three lift-based (Table 18). The average total CATT score live assessments was 8.6 ± 1.2 and the average for taped assessments was 8.4 ± 1.3. For the CATT total score, interrater reliability was found to improve between live and taped assessments when examining all transfers, transfers assessed using the CATT-M, and transfers assessed using the CATT-L, with interrater ICCs ranging from 0.722 to 0.887 for live assessment, indicating acceptable to good interrater reliability and ICCs ranging from 0.861 to 0.968 for taped assessments, indicating good interrater reliability. Two raters exhibited good

intrarater reliability, two exhibited acceptable reliability, and one exhibited weak reliability between live and taped assessments, with ICCs ranging from 0.356 to 0.879.

Table 18. ICCs for Live versus Taped CATT Assessment, where n = the number of dyads assessed.

	Interrater Reliability [95% CI]				
	Live Assessment			**Taped Assessment**	
Total CATT-M Score (n= 4)	0.722 [0.450- 0.883]			0.861 [0.725- 0.941]	
Total CATT-L Score (n= 11)	0.887 [0.824- 0.933]			0.935 [0.898- 0.962]	
All Transfers (n=15)	0.857 [0.792- 0.907]			0.968 [0.954- 0.979]	
	Intrarater Reliability [95% CI] (Taped assessments only)				
	Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
Total CATT-M Score (n= 4)	0.726 [0.404- 0.888]	0.505 [0.064- 0.781]	0.498 [0.055- 0.777]	0.118 [- 1.359- 0.670]	0.661 [0.294- 0.858]
Total CATT-L Score (n= 11)	0.819 [0.689- 0.898]	0.502 [0.241- 0.696]	0.659 [0.450- 0.800]	0.534 [0.281- 0.717]	0.756 [0.592- 0.860]
All Transfers (n=15)	0.879 [0.807- 0.926]	0.865 [0.785- 0.917]	0.797 [0.682- 0.873]	0.356 [- 0.074- 0.613]	0.714 [0.565- 0.818]

A one-sample t-test was used to determine if there were significant differences between taped and live assessments and found a mean difference of 0.19 ± 0.93, which was significantly different from a difference of zero ($p<0.001$). The Bland Altman Plot can be seen in Figure 5 and shows that difference in total CATT scores was not within the range of 95% limits of agreements. A linear regression was performed and showed proportional bias between the difference in scores and measurement mean ($p=0.001$), where scores from the live assessment were higher than scores during the taped assessment.

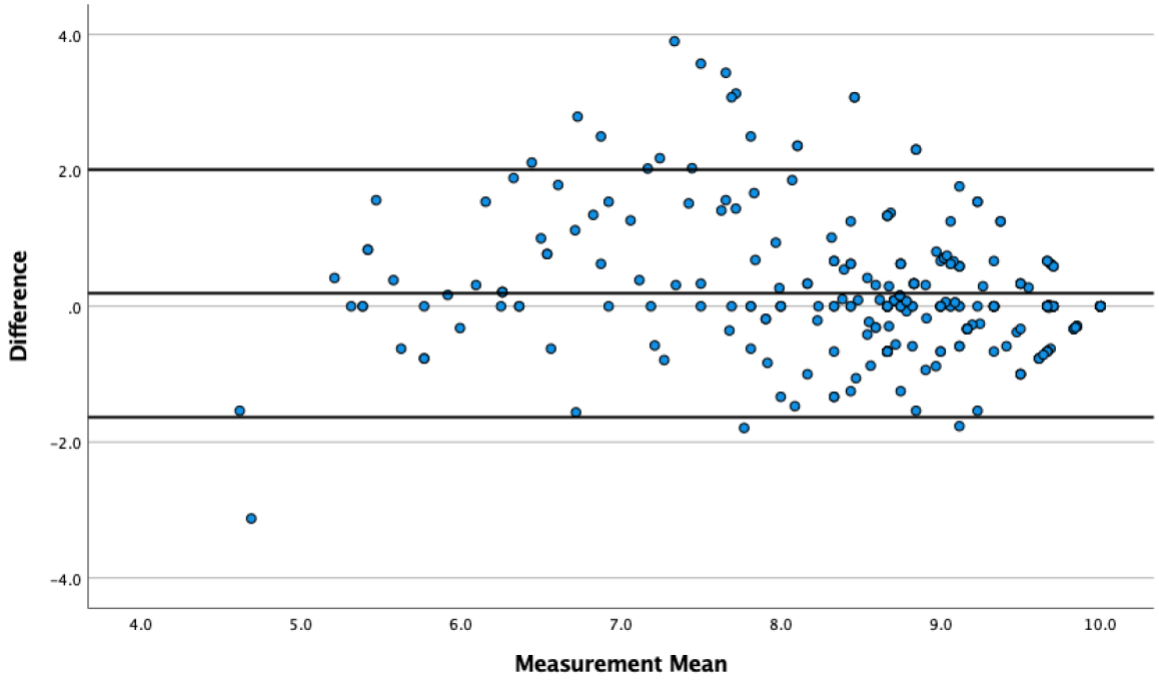


Figure 5. Bland Altman Plot for Taped Versus Live CATT Scores. The middle black bar represents the mean difference in the data set and the outside black bars represent the 95% confidence interval.

3.4 Discussion

The purpose of this study was to establish the psychometric properties of the CATT. The results suggest that the CATT may be a reliable and valid tool for assessing assisted transfer technique of informal caregivers. This preliminary reliability and validity analysis revealed some areas of improvement for the CATT that will need to be addressed via item revision, overall tool revision, and/or increased rater training.

High levels of interrater reliability seen with low levels of intrarater reliability between visits 1 and 2 suggest that the technique of caregivers may have been differing between visits. Imperfect intrarater ICCs between visits 1 and 2 were generally expected due to slight variations in transfer technique between visits. However, the low intrarater reliability on the CATT-L with high scores and small standard deviation in total CATT scores suggests that there may have been low variation among item responses in the data set. Eleven items on the CATT-L were frequently identified as having proper technique: Items 1, 2, 5, 7, 8, 10, 11, 13, 14, 16, and 17. These items largely had to do with clearing and securing transfer surfaces, lowering, attaching, and ensuring the sling is the correct size for the care recipient, and the results of the transfer. Larger variation in item responses were seen when using the CATT-M to assess transfer skills versus the CATT-L, with only four items on the CATT-M exhibiting low variation: Items 1, 6, 14, and 15. In some ways, greater variation in technique during manual transfers is not surprising, as lift-based technologies tend to promote better biomechanical techniques based on their design alone (Daynard et al., 2001). The small variation in CATT-L total score combined with eleven items not having many technique deficits identified by raters may indicate either a high number of unnecessary items on the CATT-L or a high skill level in transfer technique for recruited participants. Enrollment of additional caregiver participants, ideally with more varied transfer skills, will help to elucidate which items, if any, should be removed for the CATT-L. Specifically, additional enrollment of caregivers who are related to the care recipients, including spouses, parents, and children of care recipients, may be beneficial, as family caregivers tend to have higher levels of burden, and as demonstrated in this study when examining the construct validity of the CATT, lower CATT scores when transferring (Adelman et al., 2014; Darragh et al., 2013).

To help further determine if specific items had low ICCs due to low reliability versus low variation in the dataset, the percent agreement for specific raters was also examined. This approach will allow for a better understanding of what items may need revisions (low ICCs and low percent agreement) versus items that may need more variation in transfer techniques captured within the study population for further analysis (low or incalculable ICCs but high percent agreement). For example, several items on the CATT-L were unable to be calculated but exhibited over 90% rater agreement (Items 1, 2, 5, 7, 8, 10, 11, 13, 14, 16, and 17). Although ICCs could not be calculated for these items, high percent agreement among raters indicates that the five raters were often in agreement that they were not noticing technique deficits. Items with low ICCs and low agreement (For example, CATT-L Item 9 and Item 15), are less likely to be from low variability in the data, but disagreement between raters. Items that fall into this category will be revised to either improve by revising the item itself or improving rater training and education around those items to ensure higher reliability on those items moving forward.

Interrater and intrarater reliability of specific CATT items was mixed, which may indicate the need to revise items for clarity, remove specific items on the tool if transfer deficits are not being seen for those items, or improve rater training surrounding specific items. It is important to note that participation in this study may have introduced some bias around specific items that may have caused specific items on the CATT to not be scored as deficits. For example, clutter has been identified as a common barrier to medical care in non-clinical settings, including during assisted transfers, yet clearing the transfer surface and environment of obstacles was rarely scored as a technique deficit on both the CATT-M and CATT-L (Darragh et al., 2013; Hess et al., 2007). This may be in part due to the study design, which asks individuals to report to a laboratory setting or have research assistants perform the study in their homes. For participants performing the study in

a laboratory, transfer surfaces are often set up by research staff in large, open spaces where clutter is limited. Additionally, when travelling to participants homes, the participants had to accommodate the study team's equipment, which may have affected their normal transfer habits slightly. While this is one example, additional items may have also been affected by bias introduced by the research team. Additional participant enrollment in home or community settings may allow for a better understanding if certain items with low variability are unnecessary or were scored well due to potential bias.

The SEM and MDC values calculated for both the CATT-M and CATT-L indicates that meaningful differences in technique may be able to be detected using the CATT. A smaller SEM is indicative of better absolute reliability, while a small MDC indicates a more sensitive measure (Ries, Echternach, Nof, & Gagnon Blodgett, 2009; Weir, 2005). Small SEMs were seen for both the CATT-M and CATT-L, with MDCs ranging from 0.76 to 1.55. Because the CATT is measured on a 10-point continuous scale, a difference in total score within this range is feasible, which may indicate that the CATT is reliable and sensitive enough measure to detect true changes in transfer techniques. For example, a 1.5-point change on the CATT-M (i.e. an improvement of three out of sixteen possible items), and 1-point change on the CATT-L (i.e. an improvement of two out of seventeen possible items) would be considered a discernable change in assisted transfer technique according to the MDC values calculated in this study. Improvement on two to three aspects of transfer technique after intervention is feasible, and may indicate that the CATT, in its current form, is sensitive enough to detect changes to technique.

Strong correlation was observed between total CATT Scores and GRS Scores from a rehabilitation professional which supports the tool's concurrent validation property. Additionally, correlation between total CATT Scores and several demographic metrics was observed, including

caregiver age, level of education, hours of care provided, general health, self-reported burden, and strength as measured by a 5XSTS test. This is consistent with previous research on general caregiver burden, which showed that factors including age, lower education, more care hours, caregiver self-rated health, and caring for a family member can be associated with higher burden in informal caregivers (Adelman et al., 2014). The associations seen between total CATT scores and demographic variables were as expected based on this previous research, which may support the construct validity of the CATT. However, other factors associated with general caregiver burden, including caregiver depressive symptoms and mental health, caregiver quality of life, caregiver financial wellbeing, and care recipient physical and mental health did not correlate with total CATT Scores (Adelman et al., 2014). This may be because while general caregiver burden is defined by aspects of physical, mental, and financial wellbeing, transfers are a highly physical task. Therefore, factors that affect general burden may not be associated with a highly physically strenuous ADL.

When comparing taped to live assessments, the hypothesis of scores being within the 95% limits of agreement was not met, and a linear regression showed proportional bias between total CATT Scores, with scores from the live assessment tending to trend higher than those from taped assessments. This may because raters were able to better identify transfer skill deficits when viewing the transfers via recordings. This, in combination with improved interrater reliability when rating via recordings, may suggest that raters were better able to identify transfer deficits when viewing the transfers in this manner. Future work with the CATT should consider allowing raters to rate via taped assessments, as it may better allow for the identification of transfer technique deficits over a live assessment.

One important limitation to note is that the raters did not rate the transfers for Visits 1 and 2 in the same way. One rater (Rater 1) was physically present during each transfer session and rated the transfers in person while the other four raters rated remotely via Zoom. This was done to minimize contact with participants during the COVID-19 pandemic, with the in-person rater there to monitor the sessions and make sure the transfers were performed safely. While this choice was made with participant safety in mind, it is important to note the potential observer bias that it may have introduced in the study design, as the raters used different observation methods. For example, raters that viewed the study live may have better view of certain aspects of transfer technique and wouldn't be affected by technical issues (i.e. dropped live stream connection, delay, limitations in video quality due to environmental or internet issues). Rater 1 had somewhat higher ICCs when rating live versus taped sessions of the transfers, which may indicate that bias was introduced by the study design. While efforts were made to minimize this bias, including confirming with remote raters that they had a clear view, making sure the video quality was high enough before starting, and giving remote raters the opportunity to ask questions about the environment and set up of the transfers, future work should consider having all raters view the transfer in the same way. Additionally, one rater (Rater 4) tended to have lower ICCs than the other rehabilitation professionals. It should be noted that this rater had the least clinical experience out of the group of five raters. This may indicate that more novice clinicians or rehabilitation professionals may require additional training and education in order to use the CATT reliably

An additional limitation involving the raters is the fact that most raters (80%) were rehabilitation engineers. While these raters were experts in human biomechanics and transfer techniques specifically, the CATT would ideally be used by physical therapists or physicians in a clinical setting. Future work will involve having therapist rate the recordings of the transfers in

this study to ensure that there is no difference in the CATT's reliability and/or validity when used by a majority clinician population.

The CATT raters who participated in this study engaged in a one-hour training session, followed up a follow up session to ask any additional questions on the use of the CATT. It is important to note that this method of implementation would be unlikely to be used in clinical practice, as therapists and physicians are often limited on time. As the CATT is revised to improve reliability and validity, it will also be important to develop the rater training in a way that is better suited for clinical use. Some potential solutions to lowering rater training time while maintaining rater knowledge and confidence while using the tool would be incorporating more of the supplementary items into the tool itself and condensing the supplementary materials for clinical use. Future work will consider implementing a shorter training period, or eliminating the need for training to be more consistent with clinical practice while seeking to maintain the tool's reliability and validity when used by clinicians.

Another important limitation to note is that not all participants transferred with individuals they routinely transferred with. Per the inclusion and exclusion criteria of this study, eligible individuals were able to participate with other eligible individuals if their usual care recipient or caregiver did not wish to participate in the study, and participants would be paired with others who used the same transfer method. It is possible that by pairing individuals, transfer technique of the caregivers was impacted. While this study design decision was made to maximize participation in the study during the COVID-19 pandemic so that initial reliability and validity analysis would be sufficiently powered, future work may want to only enroll dyads who regularly work together to limit potential performance bias introduced into the study.

In general, the caregivers in this study reported low levels of bodily pain and levels of physical and mental health consistent with the general adult U.S. population. However, previous research has shown that informal characters are less healthy than the general population and report lower physical and mental health that the average U.S. adult (*Caregiving in the U.S.*, 2020). Because the caregivers who participated in this study tended to be healthier than the average caregiver, it is possible that additional relationships between total CATT scores and caregiver characteristics would be identified with a study population more consistent with that of informal caregivers in general. This study assessed 24 dyads of caregivers and their care recipients, with 20 dyads fully completing both transfer assessments. The number of participants falls short of the original targeted sample size of 40 dyads to adequately power reliability statistics due to delays and difficulties experienced with subject recruitment due in part to the COVID-19 pandemic. Low power inflates Type II error, increasing the risk that the study was unable to detect some significant findings. However, preliminary analysis of CATT Scores provides insight into the item relevance and reveals some inconsistencies in scoring, which will be important to address with scale revisions and rater training.

3.5 Conclusion

Overall, initial reliability and validity testing with the CATT indicated that the CATT may be a reliable and valid tool for assessing informal caregiver assisted transfer techniques. While the CATT-M showed acceptable reliability for total scores, results for the CATT-L were mixed, indicating that revisions are needed to the tool before it can be implemented as a clinical outcome measure. Item-level analyses revealed lack of variation in some items, which may indicate the

need to revise the tool or recruit a more diverse population of caregiver and care recipient dyads. Both versions of the tool strongly correlated with transfer scores when assessed by a GRS and correlated with some aspects inherent to caregiver demographics and health-related characteristics, which may support the CATT's validity. This study would benefit from additional dyad enrollment with a more diverse set of transfer skills, specifically when using lift-based transfer technologies. The results from this study will be used to refine and/or condense items on the CATT, rework the CATT's structure for ease of use, and identify which items on the CATT need additional supplementary materials and/or rater training.

4.0 Use of the Caregiver Assisted Transfer Technique Instrument as a Self-Assessment Tool for Informal Caregivers

4.1 Introduction

As of 2020, an estimated 48 million Americans provide unpaid care to an adult with a disability in the United States, with 60% of those caregivers providing assistance with ADLs, including transfers to and from different surfaces (*Caregiving in the U.S.*, 2020). Many informal caregivers learn the skills they need to support their care recipient in community settings from clinicians, with 55% of all informal caregivers reporting that they rely on health care professionals as a source of help or information for caring for their loved one, and help from health care professionals as the most commonly used source of support (*Caregiving in the U.S.*, 2020). However, research has shown that very few clinicians are having care-based conversations with caregivers, with only 30% reporting that health care providers have asked about if they have the necessary tools to care for their care recipient, and only 15% reporting that a health care professional has asked if they have the necessary tools to take care of themselves (*Caregiving in the U.S.*, 2020). Current standard of care involves limited in-person training for informal caregivers with physical or occupational therapists, as the majority of the rehabilitation process is client-focused, despite research showing that physicians should be playing a greater role in family caregiver skill and wellness assessments (Adelman et al., 2014; Roth et al., 2015). In a study examining caregivers' needs assessments in primary care settings, clinicians cited insufficient time in clinic, issues with reimbursement, liability concerns, lack of awareness of community resources, and concerns with care recipient autonomy as barriers to assessing caregiver needs (Riffin, Wolff,

Estill, Prabhu, & Pillemer, 2020). Therefore, there is a need to provide caregivers with opportunities for educational and training interventions for their care recipient and themselves outside of traditional clinical settings. One such way to do this may be through self-administered assessment tools (Riffin et al., 2020).

Self-assessments have many benefits to caregivers and their care recipients, as they do not require in-person contact with a clinician. Individuals with disabilities face many barriers to travel, especially individuals with mobility impairments, and approximately 80% of informal caregivers report to supporting their care recipient with transportation (*Caregiving in the U.S.*, 2020). In a study of community dwelling wheelchair users, individuals with higher limitations reported less community involvement in both medical and non-medical settings (Hoenig, Landerman, Shipp, & George, 2003). A variety of factors have been identified as barriers to participation in community settings for wheelchair users, including but not limited to issues with transportation, accessibility of the built environment, and caregiver-related concerns (E. M. Smith, Sakakibara, & Miller, 2016). Additionally, when undergoing an in-clinic assessment of transfer skills, the transfers performed may not accurately reflect what caregivers and their care recipients do in everyday life. Clinical settings are often equipped with assistive technologies to reduce workload during transfers, but assistive technologies are not always immediately available, convenient, or intuitive to use in home and community settings (Owen & Garg, 1990; Sun et al., 2018). Nonmedical settings have also been shown to provide additional challenges with provision of care, with characteristics of the physical environment, like small available spaces, challenging layouts, and excessive clutter, providing additional barriers when performing transfers (Darragh et al., 2013; Hess et al., 2007). Therefore, clinical assessments may not accurately reflect the transfer skills used by informal caregivers outside of a healthcare setting.

An estimated 62% of informal caregivers report wishing they had more information on caregiving topics, with 26% reporting wanting more information on how to keep their care recipient safe and 26% reporting wanting more information on how to manage their own physical stress (*Caregiving in the U.S.*, 2020). Therefore, access to a self-assessment tool on transfer skills that can be done outside of a clinical setting may be of benefit to both informal caregivers and their care recipients. While the Caregiver Assisted Transfer Technique Instrument (CATT) was developed to objectively assess informal caregiver assisted transfer performance, it was designed to be used by rehabilitation professionals. Its ability to act as a tool for self-assessment has not been examined.

The purpose of this study was to determine the intra-rater reliability of the CATT as a self-assessment tool as well as determine the level of agreement between informal caregivers and rehabilitation professional CATT ratings of their transfer skills. An additional goal was to determine the feasibility of performing a remote, online assessment of transfer skills by assessing the practicality, implementation, and overall satisfaction of caregivers performing a self-assessment of their transfer skills.

4.2 Methods

This study received approval from the University of Pittsburgh Institutional Review Board, and testing took place at the Human Engineering Research Laboratories (HERL) and at participants' homes in Pittsburgh, Pennsylvania between March 2022 and February 2023. Caregivers who completed both transfer sessions of the protocol described in Chapter 3 were asked to complete a self-assessment of their transfer skills.

4.2.1.1 Caregiver Inclusion/Exclusion criteria

Caregivers were included in the study if they: 1) were at least 18 years old, 2) routinely provided transfer assistance to an adult with a physical disability for a minimum of two transfers per week, 3) had been serving as a caregiver for at least three months or were currently undergoing supervised transfer training, and 4) had not received any formal didactic or structured training on assisted transfer techniques as part of a professional degree or program. Caregivers with current or recent history of back or neck injuries within the last six months that would be exacerbated by performing an assisted transfer were excluded from the study.

4.2.1.2 Sample size determination

A power analysis was performed using G*Power Version 3.1 to determine the sample size needed to achieve 80% power for the concurrent validity statistical analysis in this study (i.e. mean differences in informal caregiver CATT scores versus professional CATT scores). Because the CATT is the first tool of its kind, real world data for this population was not available. Therefore, a large effect size was chosen based on recommendations in Cohen's guidelines (Cohen, 1992). To detect a strong effect size (d=0.8) at a level of significance of a=0.05 at 80% power, a minimum of 26 caregivers were needed.

The sample size requirement needed to estimate values of ICCs for reliability testing was determined using the methods developed by Bujang & Baharum (Bujang & Baharum, 2017), shown in Equation 5 (Chapter 3).. Power was set to 0.80, the level of significance (alpha) was specified to be 0.05, and four observations were factored in per rater (n=4). Additional information on formula derivation and use cases for powering studies using ICCs is detailed in Bujang & Baharum (Bujang & Baharum, 2017). Based on the method detailed above, a total of 35 caregivers

would be needed for intraclass correlation with power at 80%, alpha at 0.05, and four observations per rater for estimating the desired effect size of ICCs.

4.2.2 Experimental protocol

After participating in the in-person transfer portion of the study described in Chapter 3, all recruited participants were asked to perform a self-assessment of their transfer skills using the CATT. Caregivers were sent a video recording of their transfer between 7 and 14 days after the first in-person transfer assessment based on their availability. They were sent either the CATT-M or CATT-L based on their in-person transfer technique and associated supplemental materials to review before assessing their transfer. Caregivers did not receive feedback or correction on their technique from CATT raters at any point during the in-person transfer evaluation.

Participants received their transfer videos, CATT, and supplementary materials via a secure OneDrive link sent to their email (Microsoft). Participants were then asked to watch video recordings of their four transfers from their first in person visit, then score the quality of each transfer using the CATT. Participants were instructed that they could use the features associated with video recordings, including pausing, rewinding, and re-watching the transfers to best score the transfer during the self-evaluation. Between 2 and 14 days later, they were asked to rate the same four transfers again using the CATT.

After completing the self-evaluations, participants completed a ten-question survey to determine the feasibility of performing a self-assessment when using the CATT to rate their own transfer skills using a 10-point numerical rating scale (NRS). The survey asked their satisfaction with using the CATT to assess their transfer, with the CATT's supplementary materials, with the setup, performance, and confidence they felt with using the technology while using the CATT,

how accurately the items on the CATT reflected their usual transfer habits, and their likelihood of participating in a remote transfer evaluation using the CATT in the future. The survey also collected open ended feedback on their experiences with using the CATT as a self-assessment tool. Participants were also asked to report any technical issues they experienced while completing the self-assessments.

4.2.3 Data Collection

All surveys and CATT scores from caregivers and raters were collected and managed using REDCap electronic data capture tools (REDCap) hosted at the University of Pittsburgh (Harris et al., 2019). Zoom was used as a video conferencing service to record all live transfer sessions. One camera was used to capture the transfer and was placed directly in front of the transfer surface so that the entire transfer process could be captured. The in-person rater who was responsible for setting up the camera for remote raters would verbally confirm with all raters that they had a clear view of the transfer area before testing began. Recordings were clipped into four separate transfers for ease of use for the participants during self-evaluation and transferred to a secure folder in OneDrive (Microsoft) hosted at the University of Pittsburgh.

4.2.4 Data Analysis

All statistical analysis was performed in SPSS Version 27 (IBM). Descriptive statistics were calculated for all self-assessment CATT total scores and item scores. ICCs were calculated to determine intra-rater reliability (ICC(3,k); two way mixed effects, consistency, multiple raters/measurements) of the CATT as a self-assessment tool, with an ICC of 0.8 or higher defined

as good reliability, 0.6 to 0.79 as acceptable reliability, 0.4 to 0.59 as moderate reliability, and less than or equal to 0.39 as weak reliability (McClure et al., 2011; L. Worobey et al., 2018). The concurrent validity of the CATT as a self-assessment tool was established by comparing the CATT scores of informal caregivers to the CATT scores of a rehabilitation expert's ratings of the same transfer who was familiar with the CATT. The average CATT score among the five raters who participated in the reliability study on the CATT (Chapter 3) was chosen to assess concurrent validity. Total scores for CATT self-assessment and professional assessment were compared using the Bland Altman Limits of agreement methods (Bland & Altman, 2007). The level of significance for all analyses was set to p= 0.05 Individual items were assessed between the informal raters and rehabilitation professionals through percent agreement, where the informal caregiver's individual items scores were compared to each professional rater across the four transfers assessed. The average percent agreement for all informal caregivers for a specific item was averaged for each item across all informal caregiver and transfers.

Feasibility data analysis followed recommendations for feasibility and pilot studies with small samples (Bowen et al., 2009; Moore, Carter, Nietert, & Stewart, 2011). For the assessment to be deemed feasible, 80% of the recruited participants will have completed the self-assessment (practicality), 80% of the participants will have experienced no technical issues during the assessment (implementation), and 80% of the participants will have reported that they are satisfied with the self-assessment method and likely to recommend it to others, defined by a NRS score of 8 or higher on self-assessment survey questions (acceptability). Descriptive statistics and graphical approaches were utilized to examine variables of interest.

4.3 Results

4.3.1 Participants

Of the 20 caregiver participants who completed the in-person transfer assessment, 16 agreed to be contacted about the self-assessment after participating in the in-person portion of the study. Of the 16 caregivers sent information on completing a self-assessment, eight caregivers completed both transfer assessments (50%) and a total of 32 transfers were scored (Table 19). All caregivers who completed the assessment cared for a client or a friend. The majority of the caregivers completing the assessment earned less than $30,000 per year (75%) and had a Bachelor's degree (75%). Half of the caregivers (50%) spent at least 20 hours per week providing caregiving services to their care recipient. The caregivers had a wide variety of transfer method experience, with 37.5% using floor lifts, 37.5% using ceiling lifts, 37.5% using manual lifting, and 25% using transfer boards regularly to transfer their care recipients.

Table 19. Demographic information on caregivers who completed both self assessments (n=8).

	Average or Count	Range
Age (years)	32.8 ± 15.4	21 - 57
Gender		
Male (%)	1 (12.5%)	
Female (%)	7 (87.5%)	
Race		
Caucasian (%)	5 (62.5%)	
African American (%)	1 (12.5%)	
Asian (%)	2 (25%)	
Weight (kg)	71.7 ± 18.2	54.5 – 106.9
Height (cm)	169.5 ± 10.2	160.0 – 190.5
Transfers per week	16.8 ± 19.5	2 – 60
Years of caregiving experience	2.3 ± 1.8	1 - 6

Of the caregivers who completed the assessment, six used the CATT-L and two used the CATT-M. Caregivers who completed both transfer assessments completed them an average (± SD) of 10.8 ± 7.6 days apart, with time between transfer assessments ranging from 6 to 28 days.

4.3.2 Reliability of the CATT as a self-assessment instrument

The average total CATT score for all self-assessed transfer was 9.3 ± 0.7. Because of a lack of power for item-level analysis due to the use of both the CATT-M and CATT-L, only total CATT scores were examined for intrarater reliability. Additionally, total scores were combined when assessing intrarater reliability because both the CATT-M and CATT-L use identical methods to calculate total score. The CATT demonstrated acceptable intrarater reliability when used as a self-assessment tool, with an ICC of 0.626. Additional details on the participants' self-assessment scores and intrarater reliability can be seen in Table 20.

Table 20. Intrarater reliability of the CATT for caregiver self assessment, where n = number of caregivers who completed the assessment

	Mean	**Range**	**ICCs [95% CI]**
Informal Caregiver CATT total score (n=8)	9.3 ± 0.8	7.4 – 10.0	0.626 [0.465 – 0.786]
Rehabilitation CATT total score (n=8)	9.1 ± 0.7	6.1 – 10.0	

4.3.3 Agreement between informal caregivers and experts

Validity of the self-assessment was assessed by comparing total CATT Scores from caregivers to expert CATT raters (Table 21). The average (± SD) total CATT Score assigned by rehabilitation

professionals for the self-assessed transfers was 9.1 ± 0.7. A one sample t-test revealed no significant difference in mean scores between caregiver and CATT expert ratings (p= 0.292) with a mean difference (± SD) of 0.2 ± 0.9 between ratings when compared to '0' difference, indicating the two groups showed a useful level of agreement in their CATT Scores. The Bland Altman Plot is shown in Figure 6, showing that a majority of the scores were within the 95% limits of agreement. A linear regression was performed and showed no proportional bias between the difference in scores and measurement mean (p=0.524). Percent agreement between informal caregivers and rehabilitation professionals was analyzed at the item level and is summarized in Table 22.

Table 21. CATT ratings for Informal Caregivers and Rehab Professionals

	Average rating	**Average difference**	**P-value**
Informal Caregivers	9.3 ± 1.0	0.2 ± 0.9	0.292
Rehab Professionals	9.1 ± 0.7		

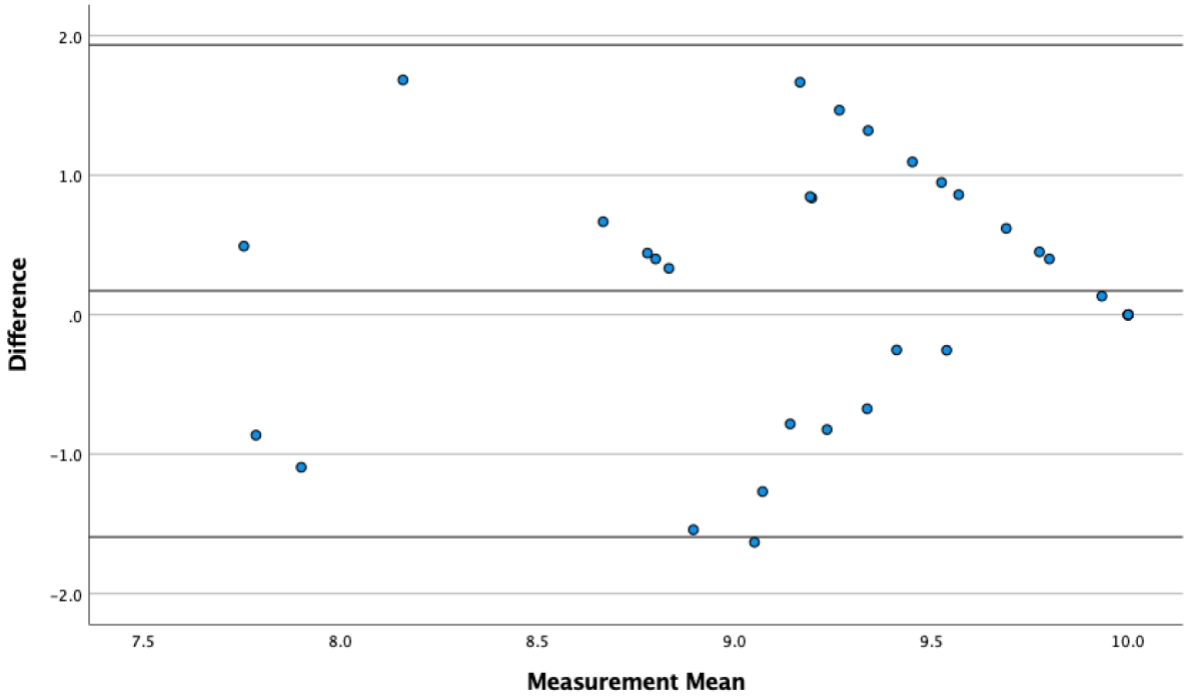


Figure 6. Bland Altman Plot for Informal Caregiver Versus Expert Rater CATT Scores. The middle black bar represents the mean difference in the data set and the outside black bars represent the 95% confidence interval.

Table 22. Percent agreement of individual items between informal caregivers and rehabilitation professionals

CATT-M (n=2)
Items with over 90% agreement
Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer
Item 2: The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface
Item 3: The care recipient is close to the object to which they are transferring
Item 6: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer
Item 14: The caregiver and care recipient communicate throughout the transfer process
Item 15: The care recipient is in a safe and secure position at the end of the transfer
Item 16: The transfer does not cause any pain or discomfort to the caregiver or care recipient
Items with over 80% agreement
Item 4: The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface
Item 5: The transfer is set up to be a level or downhill transfer
Item 8: Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient
Item 11: The caregiver does not pull on the care recipient's arms during set up or the transfer
Item 12: Caregiver performs pivoting movements of their feet while moving the care recipient
Item 13: The transfer is well controlled
Items with over 70% agreement
Item 7: The care recipient's feet and legs are positioned on the floor or stable surface prior to transfer
Item 9: Caregiver grasps the care recipient securely around hips, buttocks or transfer belt
Items with below 70% agreement
Item 10: Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface
CATT-L (n=6)
Items with over 90% agreement

Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer
Item 2: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer.
Item 3: The surface where the care recipient and sling are being fitted is level with the caregiver's waist
Item 6: The caregiver locks castors and wheels of the lift before lifting and lowering the care recipient
Item 7: The caregiver lowers the swivel bar close to the care recipient before attaching the sling and does not hit the care recipient's face or head
Item 8: The caregiver attaches the sling straps to the swivel bar in the correct position
Item 11: The care recipient's feet and legs are secured appropriately upon initial lift and transfer
Item 13: The caregiver maintains a neutral posture when operating the lift and moving the care recipient to the target surface
Item 14: The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.**
Item 15: The caregiver and care recipient communicate throughout the transfer process
Item 16: The care recipient is in a safe and secure position at the end of the transfer
Item 17: The transfer does not cause any pain or discomfort to the caregiver or care recipient
Items with over 80% agreement
Item 5: The caregiver does not pull on the care recipient's arms during set up or the transfer
Item 12: The lift base (width) is adjusted appropriately during the transfer process
Items with over 70% agreement
Item 4: The caregiver avoids unnecessary lifting of the care recipient when fitting the sling.
Item 9: The care recipient when lifted is in an upright position relative to the transfer surface
Item 10: The sling is appropriately sized and fitted for the care recipient.

4.3.4 Feasibility of CATT self-assessment

No technical issues were reported by participants (100%) who completed either one or both self- assessment (implementation). Overall, participants reported high levels of satisfaction when completing the self-assessment (Figure 7). All surveyed metrics around satisfaction with using the CATT for self-assessment and confidence when using the CATT and associated materials for self-assessment had an average rating of at least 8 out of 10 on a NRS. Caregivers reported that items on the CATT accurately represented their transfer technique (8.25 ± 1.6) but reported less than an 8 out of 10 on the accuracy of the supplementary materials provided (7.9 ± 1.6). Caregivers who completed the self-assessment were highly likely to participate in a remote transfer evaluation of their transfer skills using the CATT, with an average rating of 9.0 ± 1.7 on a 10-point NRS.

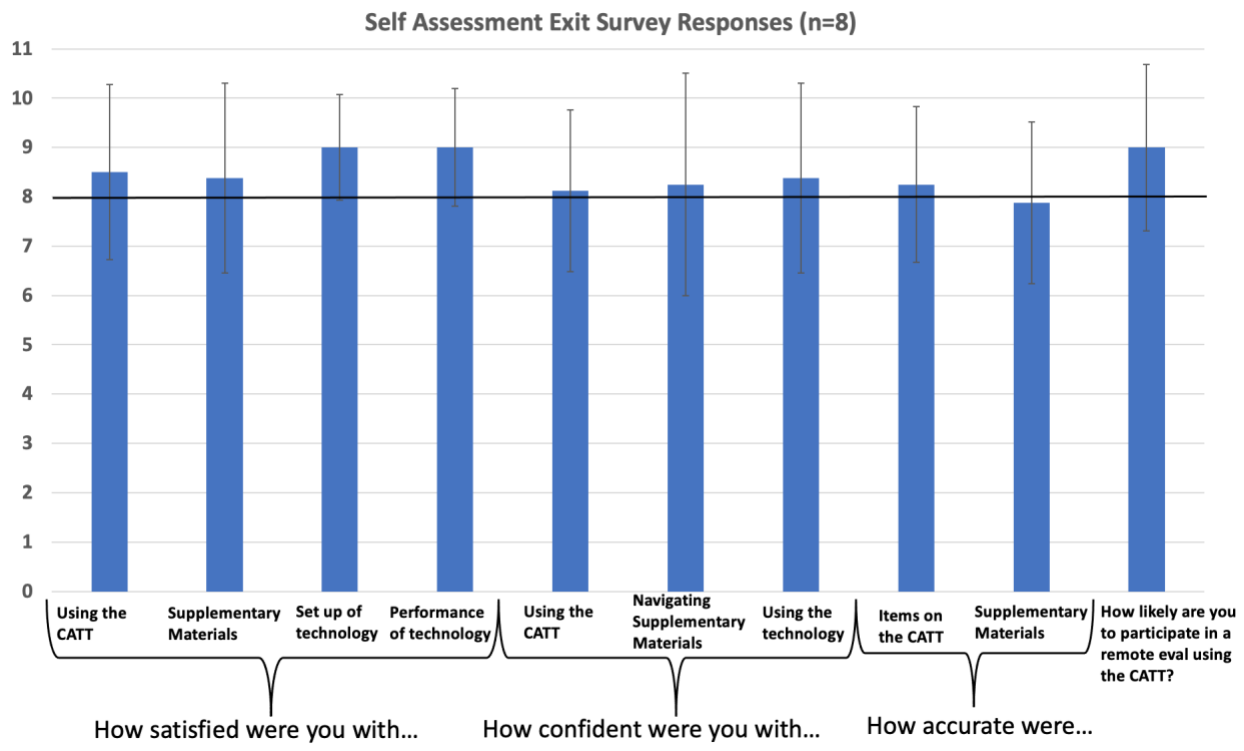


Figure 7. Self Assessment satisfaction survey responses. The error bars represent the standard deviation of responses. The black bar represents success criteria defined before testing.

4.4 Discussion

This study sought to address whether the CATT, originally developed for clinical assessment, would make a reliable and valid tool for informal caregiver self-assessment of assisted transfer techniques. CATT total scores demonstrated acceptable intrarater reliability (ICC= 0.626). No significant differences were found between informal caregiver ratings and average professional ratings of the same transfer, which may support its validity as a self-assessment tool. Informal caregivers enrolled in the study had slightly higher average ratings for their own transfers than professionals, which is consistent with previous research that demonstrated that individuals tend

to rate their own wheelchair-related skills higher on skill assessments than clinicians (R. Lee Kirby et al., 2016). However, this difference was not significant. A major difference between the informal caregiver and professional analysis was that informal caregivers rated their transfer skills via recordings while rehab professionals rated a live transfer assessment. Because the method of assessment differed slightly between groups, this may explain some of the differences noted between groups. Future research should consider implementing the same observation method (i.e. both rating video recordings) to eliminate potential bias introduced by the study design. This study had informal caregivers using the CATT independently of clinical guidance, as the CATT was originally intended to be used independently by clinicians. It is possible that the reliability and validity of the CATT as a self-assessment tool may improve with some clinical intervention via remote assessments. Over the last several years, the electronic health resources have become more accessible to both the general population and individuals with disabilities, with 88.1% of individuals with traumatic SCI in 2018 reporting they are internet users (Jones, Morris, & Deruyter, 2018; Rigot et al., 2022). It is also important to note that expert CATT raters and informal caregivers received different training on the CATT, with informal caregiver receiving no in-person instruction versus professionals receiving a one hour training session, which is a limitation of the study design. Initial support from a rehabilitation professional remotely when learning to use the CATT for self-assessment may improve the CATT's validity when used as a self-assessment tool while maintaining the ability to perform the assessment outside of a clinical setting.

The self-assessment did not meet the predetermined criteria for assessing practicality of the assessment, with only 50% of recruited caregivers completing the assessment of their transfer skills. It should be noted that most of the caregivers who completed the self-assessment were

younger and may have been more comfortable using the technology required to complete the assessment than older individuals. As of January 2020, only 20% of all caregivers reported watching videos online to learn about caregiving skills, with younger caregivers reporting more use of online tasks to gain more information on caregiving (*Caregiving in the U.S.*, 2020). A recent study reported that 21.1% of older adults reported using telehealth services, which is lower than the 35.1% rate reported among all outpatients during the same time frame (Choi, DiNitto, Marti, & Choi, 2022). While telehealth usage has greatly increased in older adults following the COVID-19 pandemic, with reported usage increasing from 4.6% to 21.1% post COVID-19 pandemic, low participation in the CATT self-assessment by older participants suggests that additional methods for implementing self-assessments more geared towards older individuals should be considered for future studies (Choi et al., 2022). For example, offering participants the choice to perform the self-assessment online or in-person, where a member of the research staff can assist with technology use, may appeal to a wider variety of individuals and allow for a more robust analysis of a self-assessment protocol when using the CATT.

Although only 50% of recruited caregivers completed at least part of the self-assessment, those who did complete the assessment had, overall, positive receptions to self-assessing their skills with the CATT. No technical difficulties were reported by participants, and pre-determined goals around satisfaction, confidence, accuracy, and likelihood to participate again with the CATT were met, with the exception of the accuracy of the CATT supplemental materials. Further development of the CATT item-associated supplementary materials while engaging informal caregivers should be considered when revising the CATT to make it a more suitable self-assessment tool. The results of this study are mostly within success criteria in feasibility studies with small samples of subjects and may indicate that self-assessment in this manner is feasible for

informal caregivers (Bowen et al., 2009). However, small sample feasibility studies typically enroll 10- 12 individuals if possible to fully assess feasibility (Bowen et al., 2009). Additional informal caregivers should be recruited to self-assess their transfer skills to fully assess feasibility of an online self-assessment of transfer technique using online videos.

Due to the low number of caregivers who decided to participate in the self-evaluation study, we were unable to achieve sufficient power to assess individual item intrarater reliability. This is a major limitation of the current study, as item-level analysis would provide further insight as to what items may need revision in order to improve reliability and validity of the CATT as a self-assessment tool. Future work will consist of recruiting additional caregivers to examine item-specific reliability to better determine if the CATT is a suitable tool for caregiver transfer self-assessment and determine what changes need to be made to the tool to ensure it more suitable to informal caregivers for the purpose of self-assessment.

4.5 Conclusion

The CATT demonstrated acceptable levels of intrarater reliability as a self-assessment tool and showed meaningful agreement between informal caregivers and expert CATT raters, which may support its validity. However, due to low participation in self-assessment using the CATT, item-level analyses were minimal. Additional analyses will need to be performed to determine if the CATT is suitable as a self-assessment measure for caregivers. Based on caregiver feedback, the supplementary materials associated with the CATT may need to be redesigned for an informal caregiver audience. Furthermore, remote feedback from a clinician when learning to use the CATT may help improve the validity of the CATT in future studies. Further work will consist of enrolling

additional caregivers into the study to determine what changes should be made to the CATT and its associated supplementary materials to increase its usability for informal caregivers so that they may assess their own transfer skills.

5.0 Conclusion

The overall goal in the development of the CATT was to create a reliable and valid measure to assess the performance of informal caregivers when performing assisted transfers. The results of these studies indicate that the CATT may be a reliable and valid option for assessing the technique of caregivers during assisted transfers.

High levels of content validity were established prior to full psychometric testing with the CATT. One of the strengths of this study is the use of multiple stakeholder groups in the development of the CATT to assess its content validity, which is a process that is often overlooked. Overall, clinicians, informal caregivers, and individuals with SCI/D reported that the CATT was accurate, clear, and had appropriate response options, while also citing specific areas for improvement in the structure of the CATT and specific items. As a result, two versions of the CATT, the CATT-M and CATT-L, were created to best assess informal caregiver transfer technique with or without the use of assistive technologies.

Mixed results were seen with the CATT's interrater and intrarater reliability. Good interrater reliability was found for total CATT Score when using the CATT-M and good to acceptable reliability was found for the CATT-L, indicating that overall, the five CATT raters agreed on the total scores assigned to participants. While intrarater reliability was good to acceptable for the CATT-M, the CATT-L had intrarater reliability that varied from good to weak, with three raters exhibiting weak reliability. This is likely due to the generally high quality technique levels exhibited when using the CATT-L, with low variation in the item scoring between transfers. Furthermore, items varied on their inter- and intrarater reliability, with some unable to be assessed because of low variance in the data set. Additional participants will be recruited to

determine tool if high CATT scores and low variance between transfers may be affecting interpretation of the reliability of specific items. Recruitment via community organizations that serve family caregivers specifically may help with recruitment of this population.

Total CATT scores were strongly correlated with Global VAS scores by an expert transfer technique, which may support its concurrent validity. Additionally, certain factors associated with the caregiver, including age, hours of weekly care provided, level of education, and strength correlated with CATT Scores. Because these measures have been previously shown to relate to higher levels of caregiver strain, this may indicate that the CATT is a valid measure for measuring informal caregiver transfer technique. The results from this analysis may also help identify caregiver groups who are at higher risk for lower quality transfer performance, which in the future would allow for training and educational interventions to be implemented appropriately.

Additionally, when comparing live assessments to taped assessments of transfer technique using the CATT, higher levels of interrater reliability were seen when raters assessed transfer technique using recordings of transfers versus the live transfers. When comparing total CATT Scores, live and taped assessments did not meet the 95% limits of agreement, and, in general, live assessments were scored higher than taped assessments of the same transfer. This, along with higher levels of interrater reliability when viewing taped transfers, may indicate that raters were better able to identify transfer deficits using this method. Future research involving the CATT should consider making use of recordings for more accurate transfer assessments.

The CATT had acceptable levels of intrarater reliability (ICC = 0.626) when caregivers performed self-assessments of their technique and was deemed valid when comparing CATT ratings between informal caregivers and expert raters using the Bland-Altman limits of agreement. However, low participation prevented an item-level analyses for reliability and validity, limiting

the conclusions that can be drawn about the use of the CATT as a self-assessment tool. Caregivers tended to rate their own skills higher than rehabilitation professionals, which is consistent with previous research. Further development of the CATT is needed to fully assess its reliability and validity as a self-assessment tool.

The overarching goal of this project was to deliver a psychometrically sound outcome measure that could be used to assess assisted transfer techniques of informal caregivers. The results from this study have highlighted the strengths and weaknesses of the CATT in its current form and have allowed us to identify areas for improvement to improve reliability and validity of the CATT.

5.1 Significance and Potential Uses for the CATT

As the population ages, especially as baby boomers begin to age, the demand for informal caregivers is expected to increase steadily over the next several decades (Redfoot, Feinberg, & Houser, 2013). While the demand for caregivers is expected to increase, the supply of caregivers is unlikely to keep pace with demand due to a smaller ratio of younger individuals to older individuals in the United States, barriers associated with paid caregiving, including low wages and high job turnover, and the high levels of physical and emotional strain associated with providing caregiving services (Murray, Edwards-Orr, Highsmith, Morris, & Ujvari, 2021; Redfoot et al., 2013). Therefore, there is a need to develop effective training and educational services that can assist caregivers in an effective manner. Assisted transfer are one such task that may require additional supports for caregivers to keep both caregivers and their care recipients safe and healthy when performing ADLs. There is an increased need for educational resources and an objective tool

for transfer technique assessment that accommodates those providing continuous care to family members or clients in both home and clinical settings.

One potential area to target CATT-based training and educational interventions is in inpatient and outpatient clinical settings, where informal caregivers are likely to receive transfer training by a clinical. Clinicians have minimal time to prepare informal caregivers to be able to perform transfers safely and effectively in a home setting, as health care policy limits the amount of time that clinicians can spend with clients and caregivers. This leaves informal caregivers underprepared to take on the roles and responsibilities associated with transfer-related ADLs, putting both the caregiver and care recipient at a greater risk for pain and injury. The CATT has the potential to serve as a quick and easy to use checklist for clinicians, making it appropriate to be implemented in clinical settings where time spent with patients and their caregivers may be limited. By providing clinicians and caregivers with a tool meant to assess transfer quality from the caregiver perspective, transfer deficits can be identified quickly, and appropriate training and educational materials can be provided.

Another potential use for CATT-based training and education would be in the form of caregiver directed self-evaluation and training. This would allow informal caregivers to receive feedback on their transfer technique using a validated tool without necessarily needing to visit a healthcare system or see a trained professional. One of the major challenges associated with an aging population is that medical, lifestyle, and personal healthcare needs will need be accessible by more people, increasing the use of health care resources (Kelly, Campbell, Gong, & Scuffham, 2020). One way to meet these challenges is through empowering individuals to manage and improve their health and well-being through health innovations (Mitchell & Kan, 2019). Many wireless digital devices are widely available and can collect, send and receive, and store health-

related data over a network without direct human interaction, including computers, mobile applications, wearable technologies, and other portable devices (Kelly et al., 2020). CATT-based training and intervention on assisted transfer techniques may be able to be implemented using web-based applications or devices in order to assist caregivers and their care recipients on their assisted transfer technique.

5.2 Study Limitations

As most of the human subjects testing for this study occurred during the COVID-19 pandemic, issues with recruitment arose as a direct result. While we attempted to mitigate the challenges of human subjects testing in the study design, we still ran into difficulty with subject recruitment due to 1) the need to recruit dyads of individuals, 2) the need for multiple study visits, and 3) most the care recipients in the study being considered "high risk" for COVID-19 complications. To achieve sufficient power, we trained five CATT raters and had four observations per rater. However, we did not meet our initial recruitment goal of 40 dyads.

One major limitation of this study is the lack of gold standard outcome measure to assess concurrent validity. Similar studies evaluating task performance have used a global rating scale as a criterion measure (R Lee Kirby et al., 2004; McClure et al., 2011; Tsai et al., 2013; L. Worobey et al., 2018). While there are some reliable and valid tools that evaluate tasks associated with informal caregiver stress and strain, there are no tools that solely evaluate transfer technique like the CATT.

5.3 Future Work

Refinements will be made to both the CATT-M and the CATT-L based on reliability and validity assessment. Specifically, both expert raters and informal caregivers will be consulted so that the CATT can be developed into a more reliable and valid measure for both clinical evaluations and self-assessments. However, prior to edits, we plan to recruit additional individuals to meet our initial recruitment goal of enrolling 40 dyads of caregivers and care recipients. Additionally, based on limited variability within in certain items on both versions of the CATT, effort will be made to recruit caregivers with a wider variety of transfer techniques. Specifically, a high number of paid care attendants were enrolled in the initial 20 dyads recruited for the study. Additional efforts will be made to recruit family caregivers, as their technique may differ from individuals who, while they have not received formal training, perform transfers as part of their profession.

Because of the shortcomings with using a GRS to evaluate the concurrent validity of the CATT, we are piloting a biomechanical analysis of caregiver assisted transfers using wearable sensors to further validate the CATT. Previous studies have correlated specific movements with outcome measure items to validate the measure (Tsai et al., 2013). However, these validations were completed in a laboratory setting with motion capture and force plates. Markerless motion capture systems, like the Microsoft Kinect and smartphone-based movement applications, are sometimes used to capture biomechanical measures outside of laboratory settings. However, these sensors often have a difficult time distinguishing between multiple individuals when they are operating in close proximity to each other. Assisted transfers provide a unique challenge because they often occur in home and community settings and involve close interactions between two or more individuals. Therefore, we are working to validate a sensor set up using inertial measurement

units, electromyography, and pressure insoles that accurately captures caregiver movements while being able to be used outside of a laboratory setting. Once validated, we plan to use information on caregiver ground reaction forces, joint forces, moments, joint angles, and erector spinae muscle activity to validate specific items on the CATT.

The results from this study will be used to refine and/or condense items on the CATT, rework the CATT's structure for ease of use, and identify which items on the CATT need additional supplementary materials and/or rater training. The overall goal of this project is to develop an outcome measure that can be used as a successful clinical and self-assessment tool to guide training and educational interventions, improving assisted transfer technique and reducing the risks associated with performing transfers for both caregivers and care recipients.

Appendix A Preliminary CATT

THE CAREGIVER ASSISTED TRANSFER TECHNIQUE INSTRUMENT (CATT)

Please evaluate each transfer separately.

	Transfer 1 Score	**Transfer 2 Score**
Set Up		
1. The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer (bed rails, arm rests, footrests, cords) • The transfer surface and environment are clear (1) • The transfer surface and environment are not clear, but components of the environment are used to facilitate the transfer (e.g. footrests, bed rails) (1) • The transfer surface and environment are not clear (0) • The transfer surface is not clear but bed rails, arm rests, footrests, or other obstacle on either transfer surface cannot be removed (N/A)		
2. The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface* • Between 0-19 degrees (1 for power wheelchair, 0 for manual wheelchair) • Between 20-45 degrees (1 for manual wheelchair, 0 for power wheelchair) • Between 45-90 degrees (0) • The environmental surroundings prevent the wheelchair from being positioned at an optimal angle (N/A)		
3. The care recipient is close to the object to which they are transferring* • The front corner of the wheelchair and the transfer surface are less than 3 inches apart (1) • The front corner of the wheelchair and the transfer surface are 3-5 inches apart (0.5) • The front corner of the wheelchair and the transfer surface are 5 inches apart or greater (0) • The environmental surroundings prevent the wheelchair from being positioned less than 3 inches from the surface (N/A)		
4. The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface. • The care recipient is positioned in this way (1) • The care recipient is not positioned in this way (0)		

• The care recipient cannot be positioned this way due to stability concerns (N/A)		
5. The care recipient's feet are placed securely on a stable surface or on the ground. • Both feet are secure prior to the transfer (1) • One foot is secure and one foot is not secure prior to the transfer (0.5) • Neither feet are secure prior to the transfer (0) • A single limb amputee is being transferred with the sound limb secure (1) • Transferring a double limb amputee (N/A)		
6. Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer. • Both surfaces are secured (1) • One surface is secured but one surface is not (0.5) • Neither surface is secured (0)		
7. The transfer is set up to be a level or downhill transfer* • The current surface is at least level with the surface to which the subject is transferring (1) • The current surface is uphill from the surface to which the subject is transferring (0) • The transfer surface cannot be adjusted to level or downhill height (N/A)		
8. The caregiver uses a transfer device (examples include transfer board, Hoyer Lift, ceiling lift, sit to stand device, pivot disk etc) • The caregiver uses a transfer device (1) • The caregiver does not use a transfer device if one is present (0) • An assistive device is unavailable or if available caregiver does not know how to operate the device (N/A)		
9. The caregiver asks for help from another individual if someone is available (two-person assisted transfer) • The caregiver asks for help (1) • The caregiver does not ask for help (0) • A second caregiver is not available (N/A)		
Lift Quality		
10. Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient • The caregiver uses this method when lifting (1) • The caregiver does not use this method when lifting (0) • If performing a two-person assisted transfer, one caregiver uses this method and one caregiver does not (0.5)		
11. Caregiver grips the care recipient securely around hips, buttocks or transfer belt • The caregiver uses this method to move the care recipient (1) • The caregiver does not use this method to move the care recipient (0)		

• If performing a two-person assisted transfer, one caregiver grips securely around the trunk and one caregiver grips securely around the legs (1) • If performing a two-person assisted transfer, one caregiver grips securely but one caregiver does not (0.5)		
12. The caregiver does not pull on the care recipient's arms during set up or the transfer***** • The caregiver does not pull on the arms (1) • The caregiver pulls on the arms (0)		
13. Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface • The care recipient is leaned forward (1) • The care recipient is not leaned forward (0)		
14. Caregiver uses a forward and backward rocking motion to gain momentum for lifting the care recipient • The caregiver uses a rocking motion (1) • The caregiver does not use a rocking motion (0) • If performing a two-person assisted transfer, one caregiver uses a rocking motion for momentum but one does not (0.5)		
15. Caregiver performs pivoting movements of their feet while moving the care recipient • The caregiver pivots their feet when moving (1) • The caregiver does not pivot their feet when moving (0) • If performing a two-person assisted transfer, one caregiver pivots their feet but one does not (0.5)		
16. The transfer is well controlled (care recipient is transferred with smooth, coordinated movement) ***** • Caregiver can break down the transfer into smaller motions to keep movements coordinated • The transfer is smooth and controlled (1) • The transfer is not smooth or controlled (0)		
17. The caregiver and care recipient communicate throughout the transfer process***** • If performing a two-person transfer, the caregiver communicates with assisting caregiver • The caregiver and care recipient communicate (1) • The caregiver and care recipient do not communicate (0)		
Results		
18. The care recipient is in a safe and secure position at the end of the transfer* • The care recipient is secure on the intended transfer surface and experienced no loss of movement (1) • The care recipient or caregiver experienced loss of balance during the transfer but did not land on an undesired surface (experience a fall) (0.5) • The care recipient or caregiver experienced loss of balance during the transfer and landed on an undesired surface (0)		

19. The transfer does not cause any pain or discomfort to the caregiver or care recipient • The transfer did not cause additional pain or discomfort to the caregiver or care recipient (1) • The care recipient experienced pain or discomfort during the transfer but caregiver did not (or vice versa) (0.5) • Both care recipient and caregiver experienced additional pain or discomfort during the transfer (0)		
Total Score		

***indicates items adopted from the Transfer Assessment Instrument (TAI)**

Scoring:
Each column represents one transfer (e.g. transfer to a surface OR from a surface). "Not applicable" items are removed from scoring. The item scores are added together, divided by the applicable items, and then multiplied by 10 to get a score from 0 to 10 points for each transfer.

$$CATT\ Score = \frac{Total\ \ Score}{Total\ number\ of\ applicable\ items}\ x\ 10$$

Appendix B CATT-M 1.0

THE CAREGIVER ASSISTED TRANSFER TECHNIQUE INSTRUMENT (CATT)
Manual Technique Version (CATT-M)

CAREGIVER NAME OR SUBJECT ID: _____
RATER NAME OR ID: _____

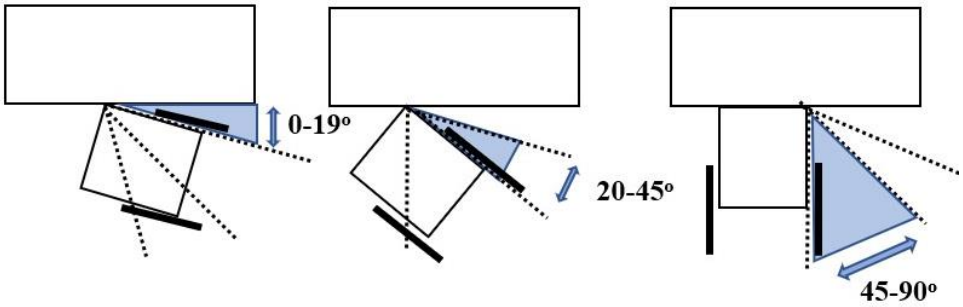
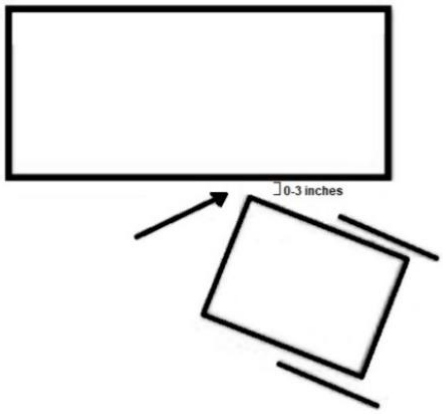
Type of transfer performed:
- ☐ **Manual, one person assisted (no technology being used)**
- ☐ **Manual, two person assisted (no technology being used)**

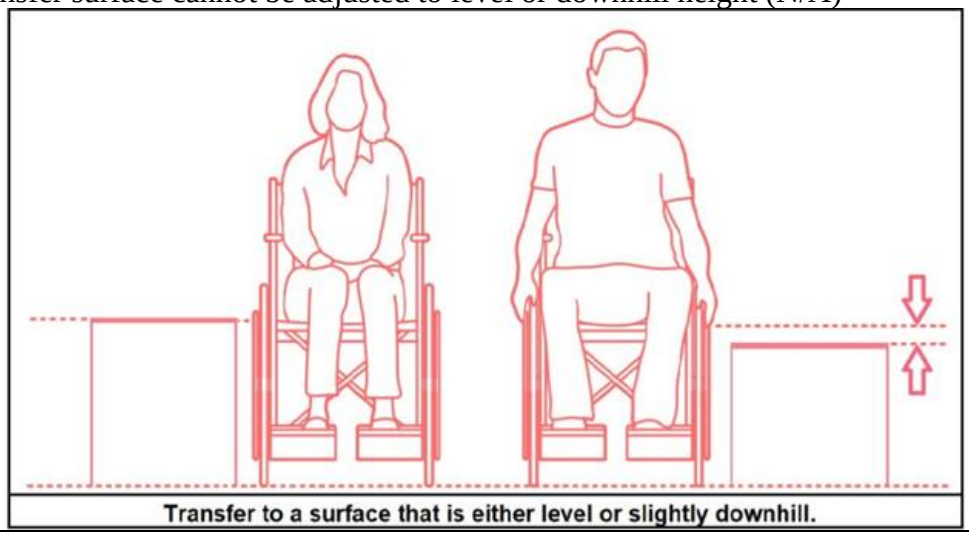
Transfer surfaces:
- ☐ **Wheelchair to chair**
- ☐ **Wheelchair to bed**
- ☐ **Wheelchair to toilet**
- ☐ **Other: _____**

Is any assistive technology being used?
- ☐ **Transfer board**
- ☐ **Gait/Transfer belt**
- ☐ **Other: _____**
- ☐ **No assistive technology**

Please evaluate each transfer separately. Additional columns can be added if more than two transfers are being performed or evaluated within a session. Scoring options are provided within each item.

	Transfer 1 Score	**Transfer 2 Score**
Set Up		
1. The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer (medical tubing, bed rails, arm rests, footrests, electrical cords, carpets, etc.) • The transfer surface and surrounding environment are clear (1) • The transfer surface and surrounding environment are not clear, because components of the environment are used to assist with the transfer appropriately (e.g. footrests, bed rails, arm rests) (1) • The transfer surface and environment are not clear (0) • The transfer surface is not clear because bed rails, arm rests, footrests, or other obstacles on either transfer surface or environment cannot be removed (N/A)		

2. The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface* If the person uses a manual wheelchair: • Between 0-19 degrees (0) • Between 20-45 degrees (1) • Between 45-90 degrees (0) If the persons uses a power wheelchair: • Between 0-19 degrees (1) • Greater than 20 degrees (0) Conditions where the wheelchair orientation guidance is not applicable: • The environmental surroundings prevent the wheelchair from being positioned at an optimal angle (N/A) 		
3. The care recipient is close to the object to which they are transferring* For manual transfers: • The front corner of the wheelchair and the transfer surface are less than 3 inches apart (1) • The front corner of the wheelchair and the transfer surface are greater than 3 inches apart (0) • The environmental surroundings prevent the wheelchair from being positioned less than 3 inches from the surface (N/A) 		
4. The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface • The care recipient is positioned in this way (1) • The care recipient is not positioned in this way (0)		

• The care recipient cannot be positioned this way due to decreased sitting balance and stability concerns (N/A) • The care recipient is using a power wheelchair (N/A)		
5. The transfer is set up to be a level or downhill transfer* • The current surface is at least level or slightly downhill with the surface to which the subject is transferring (1) • The current surface is uphill from the surface to which the subject is transferring (0) • The transfer surface cannot be adjusted to level or downhill height (N/A)  Transfer to a surface that is either level or slightly downhill.		
6. Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer. • Both surfaces are secured (1) • One or more surface is not secured (0)		
7. The care recipient's feet and legs are positioned on the floor or stable surface prior to transfer • Both feet and legs are secure prior to the transfer (1) • A single limb amputee is being transferred with the sound limb secure (1) • One or both feet and legs are not secure prior to the transfer (0) • Transferring a double limb amputee (N/A)		
Lift Quality		
8. Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient • The caregiver uses this method when lifting (1) • The caregiver does not use this method when lifting (0)		
9. Caregiver grasps the care recipient securely around hips, buttocks or transfer belt • The caregiver uses this method to move the care recipient (1) • The caregiver does not use this method to move the care recipient (0) • If performing a two-person maximal assist transfer, one caregiver grips securely around the trunk and one caregiver grips securely around the legs (1)		

• If performing a two-person assisted transfer, one caregiver grips securely but one caregiver does not (0.5)		
10. Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface • The care recipient is leaned forward (1) • The care recipient is leaned forward but is leaned in an inappropriate direction (toward caregiver's shoulder or hip closest to transfer surface) (0.5) • The care recipient is not leaned forward (0)		
11. The caregiver does not pull on the care recipient's arms during set up or the transfer********** • The caregiver does not pull on the arms (1) • The caregiver pulls on the arms (0)		
12. Caregiver performs pivoting movements of their feet while moving the care recipient • The caregiver pivots their feet when moving (1) • The caregiver does not pivot their feet when moving (0) • If performing a two-person assisted transfer, one caregiver pivots their feet but one does not (0.5)		
13. The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.** Caregiver can break down the transfer into smaller motions to keep movements coordinated (i.e. smaller scoots, using a forward and backward rocking motion to gain momentum, etc.)* • The transfer is smooth and controlled (1) • The transfer is not smooth or controlled (0)		
14. The caregiver and care recipient communicate throughout the transfer process********** • The caregiver and care recipient communicate (1) • The caregiver and care recipient do not communicate (0) • If performing a two-person transfer, the caregiver communicates with the other caregiver and care recipient (1) • If performing a two-person transfer, the caregiver does not communicate with the other caregiver or care recipient (0)		
Results		
15. The care recipient is in a safe and secure position at the end of the transfer* • The care recipient is secure on the intended transfer surface and experienced no loss of balance (1) • The care recipient or caregiver experienced loss of balance during the transfer but did not experience a fall (0.5) • The care recipient or caregiver experienced loss of balance during the transfer and landed on an undesired surface (0)		
16. The transfer does not cause any pain or discomfort to the caregiver or care recipient • The transfer did not cause additional pain or discomfort to the caregiver or care recipient (1) • Either care recipient or caregiver experienced additional pain or discomfort during the transfer, but not both (0.5) • Both care recipient and caregiver experienced additional pain or discomfort during the transfer (0)		

Total Score		

***indicates items adopted from the Transfer Assessment Instrument (TAI)**

Scoring:
Each column represents one transfer (e.g. transfer to a surface OR from a surface). "Not applicable" items are removed from scoring. The item scores are added together, divided by the applicable items, and then multiplied by 10 to get a score from 0 to 10 points for each transfer.

$$CATT\ Score = \frac{Total\ \ Score}{Total\ number\ of\ applicable\ items}\ x\ 10$$

Appendix C CATT-L 1.0

THE CAREGIVER ASSISTED TRANSFER TECHNIQUE INSTRUMENT (CATT)
Lift Technique Version (CATT-L)

CAREGIVER NAME OR STUDY ID: _____
RATER NAME OR ID: _____

Type of transfer performed:
- ☐ **Technology assisted using a mechanical or powered lift device and sling**
- ☐ **Technology assisted using other types of assistive technologies (please list) _____**

Transfer surfaces:
- ☐ **Wheelchair to chair**
- ☐ **Wheelchair to bed**
- ☐ **Wheelchair to toilet**
- ☐ **Other (please list): _____**

Type of sling used:
- ☐ **Universal- shaped sling**
- ☐ **Full body sling**
- ☐ **Other sling (please list): _____**
- ☐ **Not applicable**

Number of Caregivers Assisting:
- ☐ **One**
- ☐ **Two**

Is a seat elevator being used?
- ☐ **Yes**
- ☐ **No**

Please evaluate each transfer separately. Additional columns can be added if more than two transfers are being performed or evaluated within a session. Scoring options are provided within each item.

	Transfer 1 Score	**Transfer 2 Score**
Set Up		
1. The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer (medical tubing, bed rails, arm rests, footrests, electrical cords, carpets, etc.)		

• The transfer surface and surrounding environment are clear (1) • The transfer surface and surrounding environment are not clear, because components of the environment are used to assist with the transfer appropriately (e.g. footrests, bed rails, arm rests) (1) • The transfer surface and environment are not clear (0) • The transfer surface is not clear because bed rails, arm rests, footrests, or other obstacles on either transfer surface or environment cannot be removed (N/A)		
2. Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer. • Both surfaces are secured (1) • One or more surface is not secured (0)		
3. The surface where the care recipient and sling are being fitted is level with the caregiver's waist. • The surface where the sling is being fitted is at the same level as the caregiver's waist (1) • The surface where the sling is being fitted is higher or lower than the caregiver's waist (0) • The surface where the sling is being fitted cannot be adjusted level with caregiver's waist (N/A) • The sling was already on the care recipient for this transfer (N/A)		
4. The caregiver avoids unnecessary lifting of the care recipient when fitting the sling. • If care recipient is lying down, the caregiver uses a rolling method to attach the sling (1) • If the care recipient is sitting up, the care recipient is leaned to the side and/or forward when positioning the sling (1) • If the care recipient is sitting up, the caregiver is leaned forward, the sling is placed behind the back to cover the buttocks, and the care recipient is leaned back while the caregiver lifts the legs side to side (1) • The caregiver does a full body lift of the care recipient when positioning the sling (0)		
5. The caregiver does not pull on the care recipient's arms during set up or the transfer • The caregiver does not pull on the arms (1) • The caregiver pulls on the arms (0)		
6. The caregiver locks castors and wheels of the lift before lifting and lowering the care recipient. • The caregiver locks the lift castors and wheels (1) • The caregiver does not lock the lift castors and wheels (0) • The lift or technology being used does not have a locking mechanism (i.e. ceiling lift, robotic transfer lifts, etc.) (N/A)		

7. The caregiver lowers the swivel bar close to the care recipient before attaching the sling and does not hit the care recipient's face or head. • The caregiver lowers the swivel bar close to the care recipient and makes sure the bar does not hit the face or head (1) • The caregiver lowers the swivel bar close to the care recipient, but the swivel bar hits the face or head (0) • The caregiver does not lower the swivel bar close to the care recipient (0) 		
8. The caregiver attaches the sling straps to the swivel bar in the correct position. • Shorter straps are placed closer to the head of the care recipient while longer straps are placed further away (closer to the legs) (1) • The straps are not placed in the correct position (0) 		
Lift Operation		
9. The care recipient when lifted is in an upright position relative to the transfer surface • The care recipient is in an upright position (1)		

• The care recipient is tilted too far forward or backward, but caregiver makes adjustments to their position so they are upright (1) • The care recipient is tilted too far forward or backward and the caregiver does not correct their position (0)		
10. The sling is appropriately sized and fitted for the care recipient. • The care recipient appears secure in the sling (1) • The sling appears too big or too small (0)		
11. The care recipient's feet and legs are secured appropriately upon initial lift and transfer • Both feet and legs are secure prior to the transfer (1) • One or both feet and legs are not secure, but the caregiver makes adjustments to their position to make secure prior to transfer (0) • The feet and legs hit the lift at any point during the transfer (0)		
12. The lift base (width) is adjusted appropriately during the transfer process • Base is made wider for stability when stationary and made narrower when in motion (1) • Base is made wider for stability when stationary and the lift is not in motion during the transfer (1) • The base is made wider for stability when stationary but not made narrower when in motion (0.5) • The base was not adjusted to a wide position when stationary (0) • A ceiling based lift is being used (N/A)		
13. The caregiver maintains a neutral posture when operating the lift and moving the care recipient to the target surface. • The caregiver maintains a neutral posture (no excessive bending or twisting motions) when operating the lift (1) • The caregiver uses a flexed posture or twisting motions when operating the lift (0)		
14. The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.** • The transfer is smooth and controlled (1) • The transfer is not smooth or controlled (0)		
15. The caregiver and care recipient communicate throughout the transfer process***** • The caregiver and care recipient communicate (1) • The caregiver and care recipient do not communicate (0) • If performing a two-person transfer, the caregiver communicates with the other caregiver and care recipient (1) • If performing a two-person transfer, the caregiver does not communicate with the other caregiver or care recipient (0)		

Results		
16. The care recipient is in a safe and secure position at the end of the transfer* • The care recipient is secure on the intended transfer surface and experienced no loss of balance (1) • The care recipient or caregiver experienced loss of balance during the transfer but did not experience a fall (0.5) • The care recipient or caregiver experienced loss of balance during the transfer and landed on an undesired surface (0)		
17. The transfer does not cause any pain or discomfort to the caregiver or care recipient • The transfer did not cause additional pain or discomfort to the caregiver or care recipient (1) • Either the care recipient or caregiver experienced pain or discomfort during the transfer but not both (0.5) • Both care recipient and caregiver experienced additional pain or discomfort during the transfer (0)		
Total Score		

***indicates items adopted from the Transfer Assessment Instrument (TAI)**

Scoring:
Each column represents one transfer (e.g. transfer to a surface OR from a surface). "Not applicable" items are removed from scoring. The item scores are added together, divided by the applicable items, and then multiplied by 10 to get a score from 0 to 10 points for each transfer.

$$CATT\ Score = \frac{Total\ \ Score}{Total\ number\ of\ applicable\ items}\ x\ 10$$

Appendix D CATT-M Item Reliability

Individual item reliability for the CATT-M was calculated for 78 transfers by 5 raters for a total of 390 ratings for each item

Percent agreement was calculated based on the following formula:

$$\%\ agreement = \frac{\sum raters\ in\ agreement}{\sum all\ rater\ combinations}\ x\ 100\%$$

ICCs for individual item interrater reliability were calculated using a two-way mixed effects, absolute agreement, multiple raters model (ICC(3,k) and intra-rater reliability with a two-way mixed effects, absolute agreement, single rater model (ICC,(3,1)) (McGraw & Wong, 1996).

Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer (medical tubing, bed rails, arm rests, footrests, electrical cords, carpets, etc.)

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	211	145	356	91.3%
0	10	5	15	3.8%
N/A	9	10	19	4.9%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**

89.6% ± 25.4%	87.8% ± 27.0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.327 [0.255- 0.398]	0.299 [0.211- 0.387]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.164 [0.072- 0.255]	0.071 [-0.039- 0.181]
1	0.484 [0.392- 0.575]	0.448 [0.339- 0.558]
N/A	0.191 [0.099- 0.282]	0.200 [0.090- 0.310]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
1.000	0.898	1.000	0.615	LV*

***indicates no variance in response- K could not be calculated**

Item 2: The care recipient's wheelchair is oriented at an appropriate angle relative to the transfer surface

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**

1	134	77	211	54.1%
0	46	33	79	20.3%
N/A	50	50	100	25.6%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
86.1% ± 24.4%	80.0% ± 26.9%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.757 [0.690- 0.842]	0.682 [0.602- 0.761]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.565 [0.472- 0.657]	0.389 [0.280- 0.499]
1	0.714 [0.623- 0.805]	0.599 [0.490- 0.709]
N/A	1.000 [0.909- 1.091]	1.000 [0.890- 1.110]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.900	1.000	1.000	0.863	0.797

Item 3: The care recipient is close to the object to which they are transferring

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	162	95	257	65.9%
0	18	15	33	8.5%
N/A	50	50	100	25.6%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
87.8% ± 21.4%	88.8% ± 18.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.730 [0.656- 0.803]	0.792 [0.704- 0.880]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.156 [0.065- 0.248]	0.338 [0.228- 0.447]
1	0.708 [0.616- 0.799]	0.905 [0.657- 0.876]
N/A	1.000 [0.909- 1.091]	1.000 [0.890- 1.110]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**

0.643	0.500	1.000	0.864	0.764

Item 4: The care recipient positions themselves or is positioned so that their hips are brought forward to the front of the seat so that a third of the thigh is off the surface

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	29	22	51	13.1%
0	55	39	94	24.1%
N/A	146	99	245	62.8%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
78.9% ± 24.6%	75.6% ± 24.6%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.598 [0.528- 0.667]	0.513 [0.430- 0.596]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.642 [0.550- 0.733]	0.695 [0.585- 0.804]
1	0.388 [0.297- 0.480]	0.236 [0.126- 0.345]
N/A	0.662 [0.571- 0.754]	0.510 [0.400- 0.619]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.932	0.844	0.770	0.457	0.812

Item 5: The transfer is set up to be a level or downhill transfer

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	133	74	207	53.1%
0	10	6	16	4.1%
N/A	87	80	167	42.8%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
75.9% ± 24.6%	77.2% ± 26.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.537 [0.455- 0.618]	0.573 [0.474- 0.672]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.373 [0.281- 0.464]	0.134 [0.025- 0.244]

1	0.554 [0.463- 0.646]	0.560 [0.450- 0.670]
N/A	0.547 [0.456- 0.638]	0.650 [0.540- 0.760]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.817	0.604	0.862	0.510	0.807

Item 6: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	216	156	282	95.4%
0	14	4	18	4.6%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
91.7% ± 18.2%	94.4% ± 15.4%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.277 [0.186- 0.369]	0.103 [-0.007- 0.212]

Intrarater Reliability

Agreement on Individual Items K [95% CI]

Rating	Visit 1	Visit 2
0	0.277 [0.186- 0.369]	0.103 [-0.007- 0.212]
1	0.277 [0.186- 0.369]	0.103 [-0.007- 0.212]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
-0.034	-0.047	-0.053	LV*	LV*

***indicates no variance in response- K could not be calculated**

Item 7: The care recipient's feet and legs are positioned on the floor or stable surface prior to transfer

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	187	123	310	79.5%
0	31	31	62	15.9%
N/A	6	6	12	4.6%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
77.8% ± 22.1%	77.5% ± 22.0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**

0.290 [0.209- 0.317]	0.392 [0.297- 0.487]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.372 [0.281- 0.463]	0.520 [0.410- 0.629]
1	0.271 [0.179- 0.362]	0.367 [0.258- 0.477]
N/A	-0.027 [-0.118- 0.065]	-0.039 [-0.149- 0.071]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.793	0.667	LV*	0.590	0.833

***indicates no variance in response- K could not be calculated**

Item 8: Caregiver bends their knees and keeps back straight while lifting and positioning the care recipient

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	132	111	193	62.3%
0	98	49	147	37.7%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
71.7% ± 28.1%	68.8% ± 27.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.440 [0.349- 0.531]	0.265 [0.155- 0.374]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.440 [0.349- 0.531]	0.265 [0.155- 0.374]
1	0.440 [0.349- 0.531]	0.265 [0.155- 0.374]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.865	0.670	0.850	0.423	1.000

Item 9: Caregiver grasps the care recipient securely around hips, buttocks or transfer belt

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	147	93	240	61.5%
0.5	1	1	2	0.5%
0	82	66	148	38.0%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
78.0% ± 28.0%	84.4% ± 23.1%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.527 [0.437- 0.617]	0.682 [0.575- 0.790]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.526 [0.435- 0.618]	0.691 [0.581- 0.800]
0.5	-0.004 [-0.096- 0.087]	-0.006 [-0.116- 0.103]
1	0.538 [0.447- 0.630]	0.692 [0.582- 0.801]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.867	0.935	0.600	0.534	0.590

Item 10: Care recipient leans or is leaned forward towards the caregiver's shoulder or hip opposite of the transfer surface

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	130	90	220	56.4%
0.5	44	29	73	18.7%
0	56	41	97	24.9%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
68.0% ± 30.1%	61.3% ± 34.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.461 [0.394- 0.528]	0.316 [0.236- 0.397]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.292 [0.200- 0.383]	0.164 [0.054- 0.273]
0.5	0.747 [0.656- 0.838]	0.534 [0.322- 0.541]
1	0.407 [0.316- 0.499]	0.365 [0.256- 0.475]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.158	0.413	0.485	0.220	0.641

Item 11: The caregiver does not pull on the care recipient's arms during set up or the transfer

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	196	134	330	84.6%
0	34	26	60	15.4%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
92.6% ± 16.7%	86.9% ± 20.1%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.578 [0.465- 0.692]	0.578 [0.477- 0.696]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.578 [0.465- 0.692]	0.578 [0.477- 0.696]
1	0.578 [0.465- 0.692]	0.578 [0.477- 0.696]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
1.000	0.595	-0.047	1.000	0.793

Item 12: Caregiver performs pivoting movements of their feet while moving the care recipient

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	150	93	243	62.3%
0.5	1	1	2	0.5%
0	79	66	145	37.2%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
69.3% ± 25.0%	64.1% ± 24.6%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.329 [0.239- 0.419]	0.269 [0.162- 0.377]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.355 [0.243- 0.426]	0.265 [0.155- 0.375]
0.5	-0.004 [-0.096- 0.087]	-0.006 [-0.116- 0.103]
1	0.329 [0.238- 0.421]	0.281 [0.171- 0.391]

Intrarater Reliability (Cohen's Kappa)

Rater 1	Rater 2	Rater 3	Rater 4	Rater 5
0.783	0.510	0.478	0.216	0.780

Item 13: The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.** Caregiver can break down the transfer into smaller motions to keep movements coordinated (i.e. smaller scoots, using a forward and backward rocking motion to gain momentum, etc.)

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	192	153	345	88.5%
0	38	7	45	11.5%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
86.1% ± 23.0%	93.1% ± 18.7%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.496 [0.404- 0.587]	0.253 [0.143- 0.363]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**

0	0.496 [0.404- 0.587]	0.253 [0.143- 0.363]
1	0.496 [0.404- 0.587]	0.253 [0.143- 0.363]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.286	LV*	LV*	0.211	0.104

***indicates no variance in response- K could not be calculated**

Item 14: The caregiver and care recipient communicate throughout the transfer process

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	222	148	370	94.9%
0	8	12	20	5.1%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
93.9% ± 13.8%	88.2% ± 21.5%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.029 [-0.063- 0.120]	0.114 [0.035- 0.254]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.029 [-0.063- 0.120]	0.114 [0.035- 0.254]
1	0.029 [-0.063- 0.120]	0.114 [0.035- 0.254]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	0.366	LV*	LV*	0.634

***indicates no variance in response- K could not be calculated**

Item 15: The care recipient is in a safe and secure position at the end of the transfer

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	202	156	358	91.8%
0.5	27	4	31	7.9%
0	1	0	1	0.3%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
87.8% ± 22.7%	95.6% ± 14.1%

Interrater Reliability [95% CI]

Session 1	Session 2
0.433 [0.345- 0.522]	0.103 [-0.007- 0.212]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	-0.004 [-0.096- 0.087]	
0.5	0.413 [0.321- 0.504]	0.103 [-0.007- 0.212]
1	0.471 [0.380- 0.563]	0.103 [-0.007- 0.212]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.242	-0.043	LV*	0.167	LV*

***indicates no variance in response- K could not be calculated**

Item 16: The transfer does not cause any pain or discomfort to the caregiver or care recipient

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	203	132	335	85.9%
0.5	22	22	44	11.3%
0	5	6	11	2.8%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
98.7% ± 8.9%	85.3% ± 31.1%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.938 [0.859- 1.085]	0.498 [0.406- 0.591]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	1.000 [0.909- 1.091]	-0.039 [-0.149- 0.071]
0.5	0.925 [0.833- 1.016]	0.526 [0.416- 0.635]
1	0.937 [0.846- 1.028]	0.610 [0.501- 0.720]

Intrarater Reliability (Cohen's Kappa)				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.173	LV*	0.173	LV*	LV*

***indicates no variance in response- K could not be calculated**

Appendix E CATT-L Item Reliability

Individual item reliability for the CATT-L was calculated for 102 transfers by 5 raters for a total of 510 ratings for each item.

Percent agreement was calculated based on the following formula:

$$\%\ agreement = \frac{\sum raters\ in\ agreement}{\sum all\ rater\ combinations}\ x\ 100\%$$

ICCs for individual item interrater reliability were calculated using a two-way mixed effects, absolute agreement, multiple raters model (ICC(3,k) and intra-rater reliability with a two-way mixed effects, absolute agreement, single rater model (ICC,(3,1)) (McGraw & Wong, 1996).

Item 1: The transfer surface and the environment around the transfer surface are clear of obstacles that may interfere with the transfer (medical tubing, bed rails, arm rests, footrests, electrical cords, carpets, etc.)

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	252	250	502	98.4%
0	3	5	8	1.6%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
97.9% ± 10.4%	96.6% ± 11.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.157 [0.070- 0.244]	-0.020 [-0.107- 0.067]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.157 [0.070- 0.244]	-0.020 [-0.107- 0.067]
1	0.157 [0.070- 0.244]	-0.020 [-0.107- 0.067]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
-0.020	LV*	LV*	-0.055	LV*

***indicates no variance in response- K could not be calculated**

Item 2: Transfer surfaces (i.e. wheelchair, bed, toilet, etc) are secured and locked prior to transfer.

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	250	235	485	99.0%
0	5	0	5	1.0%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**

97.0% ± 11.8%	100% ± 0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.286 [0.199- 0.373]	LV*

***indicates no variance in response- K could not be calculated**

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.286 [0.199- 0.373]	LV*
1	0.286 [0.199- 0.373]	LV*

***indicates no variance in response- K could not be calculated**

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	LV*	LV*	LV*	LV*

***indicates no variance in response- K could not be calculated**

Item 3: The surface where the care recipient and sling are being fitted is level with the caregiver's waist

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	74	70	144	28.2%

0	4	1	5	1.0%
N/A	177	184	361	70.8%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
71.9% ± 28.1%	73.8% ± 26.0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.304 [0.222- 0.386]	0.325 [0.240- 0.411]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.125 [0.024- 0.198]	-0.004 [-0.091- 0.083]
1	0.315 [0.228- 0.401]	0.321 [0.234- 0.407]
N/A	0.307 [0.221- 0.394]	0.336 [0.250- 0.423]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.751	0.571	0.692	0.593	0.683

Item 4: The caregiver avoids unnecessary lifting of the care recipient when fitting the sling.

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	111	125	236	46.3%
0.5	14	6	20	3.9%
0	5	4	9	1.8%
N/A	125	120	245	48.0%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
84.5% ± 25.5%	84.7% ± 26.4%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.703 [0.631- 0.774]	0.701 [0.623- 0.779]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	-0.020 [-0.107- 0.067]	-0.016 [-0.103- 0.071]
0.5	0.320 [0.233- 0.407]	0.232 [0.145- 0.319]
1	0.713 [0.626- 0.800]	0.702 [0.615- 0.789]
N/A	0.827 [0.741- 0.914]	0.788 [0.701- 0.874]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.677	0.683	0.698	0.653	0.598

Item 5: The caregiver does not pull on the care recipient's arms during set up or the transfer

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	252	250	502	98.4%
0	3	5	8	1.6%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
99.1% ± 5.8%	97.0% ± 11.8%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
-0.012 [-0.099- 0.075]	0.286 [0.199- 0.373]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	-0.012 [-0.099- 0.075]	0.286 [0.199- 0.373]
1	-0.012 [-0.099- 0.075]	0.286 [0.199- 0.373]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	LV*	LV*	LV*	LV*

***indicates no variance in response- K could not be calculated**

Item 6: The caregiver locks castors and wheels of the lift before lifting and lowering the care recipient

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	88	60	148	29.0%
0	117	145	262	51.4%
N/A	50	50	100	19.6%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
91.9% ± 18.5%	95.7% ± 14.4%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.845 [0.781- 0.908]	0.839 [0.775- 0.902]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**

0	0.803 [0.716- 0.889]	0.808 [0.721- 0.895]
1	0.783 [0.696- 0.870]	0.738 [0.652- 0.825]
N/A	1.000 [0.913- 1.087]	1.000 [0.913- 1.087]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.742	0.876	0.777	0.837	0.746

***indicates no variance in response- K could not be calculated**

Item 7: The caregiver lowers the swivel bar close to the care recipient before attaching the sling and does not hit the care recipient's face or head

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	235	245	480	94.1%
0	20	10	30	5.9%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
100% ± 0%	97.0% ± 11.8%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.783 [0.696- 0.870]	0.532 [0.445- 0.618]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.783 [0.696- 0.870]	0.532 [0.445- 0.618]
1	0.783 [0.696- 0.870]	0.532 [0.445- 0.618]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.457	-0.030	-0.055	0.243	-0.034

Item 8: The caregiver attaches the sling straps to the swivel bar in the correct position

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	250	246	496	97.3%
0	5	5	10	2.0%
N/A	0	4	4	0.7%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
96.2% ± 12.9%	96.6% ± 11.3%

Interrater Reliability [95% CI]	
Session 1	**Session 2**

0.082 [-0.005- 0.169]	0.030 [-0.039- 0.098]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.082 [-0.005- 0.169]	0.082 [-0.005- 0.169]
1	0.082 [-0.005- 0.169]	0.021 [-0.066- 0.108]
N/A		-0.016 [-0.103- 0.071]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	LV*	LV*	LV*	LV*

***indicates no variance in response- K could not be calculated**

Item 9: The care recipient when lifted is in an upright position relative to the transfer surface

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	229	221	450	88.2%
0	26	34	60	11.8%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
88.9% ± 20.8%	80.0% ± 25.4%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.422 [0.335- 0.509]	0.067 [-0.020- 0.154]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.422 [0.335- 0.509]	0.067 [-0.020- 0.154]
1	0.422 [0.335- 0.509]	0.067 [-0.020- 0.154]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.647	-0.049	LV*	0.428	-0.032

***indicates no variance in response- K could not be calculated**

Item 10: The sling is appropriately sized and fitted for the care recipient.

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	255	249	504	98.8%
0	0	2	2	0.4%
N/A	0	4	4	0.8%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
100% ± 0%	92.3% ± 15.9%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
LV*	-0.019 [-0.089- 0.052]

***indicates no variance in response- K could not be calculated**

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	LV*	-0.008 [-0.095- 0.079]
1		-0.024 [-0.111- 0.063]
N/A		-0.016 [-0.103- 0.071]

***indicates no variance in response- K could not be calculated**

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	LV*	LV*	LV*	LV*

***indicates no variance in response- K could not be calculated**

Item 11: The care recipient's feet and legs are secured appropriately upon initial lift and transfer

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	243	242	485	95.1%
0.5	2	6	8	1.6%
0	10	7	17	3.3%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
91.7% ± 20.9%	91.5% ± 18.0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.242 [0.168- 0.316]	0.060 [-0.008- 0.128]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.222 [0.138- 0.305]	0.045 [-0.042- 0.132]
0.5	-0.007 [-0.091- 0.076]	0.061 [-0.026- 0.148]
1	0.303 [0.219- 0.386]	0.068 [-0.019- 0.155]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**

0.201	0.658	-0.020	0.306	-0.056

Item 12: The lift base (width) is adjusted appropriately during the transfer process

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	67	53	120	23.5%
0.5	82	102	184	36.1%
0	56	50	106	20.8%
N/A	50	50	100	19.6%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
73.4% ± 31.3%	75.5% ± 30.1%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.640 [0.589- 0.619]	0.660 [0.608- 0.711]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.359 [0.273- 0.446]	0.428 [0.341- 0.515]
0.5	0.730 [0.644- 0.817]	0.755 [0.668- 0.842]

1	0.494 [0.407- 0.581]	0.416 [0.330- 0.503]
N/A	1.000 [0.913- 1.087]	1.000 [0.913- 1.087]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.550	0.479	0.535	0.505	0.698

Item 13: The caregiver maintains a neutral posture when operating the lift and moving the care recipient to the target surface

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	240	244	484	94.9%
0	15	11	26	5.1%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
91.1% ± 19.0%	91.4% ± 19.4%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.115 [0.028- 0.201]	0.145 [0.058- 0.232]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.115 [0.028- 0.201]	0.067 [-0.020- 0.154]
1	0.115 [0.028- 0.201]	0.067 [-0.020- 0.154]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.113	-0.104	LV*	0.234	LV*

***indicates no variance in response- K could not be calculated**

Item 14: The transfer is well controlled (care recipient is transferred with smooth, coordinated movement)**.**

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	238	253	491	96.3%
0	17	2	19	4.7%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
97.4% ± 9.9%	98.3% ± 8.2%

Interrater Reliability [95% CI]

Session 1	Session 2
0.622 [0.535- 0.709]	-0.008 [-0.095- 0.079]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.622 [0.535- 0.709]	-0.008 [-0.095- 0.079]
1	0.622 [0.535- 0.709]	-0.008 [-0.095- 0.079]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
0.311	0.370	LV*	0.311	LV*

***indicates no variance in response- K could not be calculated**

Item 15: The caregiver and care recipient communicate throughout the transfer process

	Visit 1 Count	Visit 2 Count	Total Count	Total Percent
1	218	235	453	88.8%
0	37	20	57	11.2%

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
78.3% ± 26.3%	85.6% ± 23.6%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.131 [0.044- 0.217]	0.240 [0.154- 0.327]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0	0.131 [0.044- 0.217]	0.240 [0.154- 0.327]
1	0.131 [0.044- 0.217]	0.240 [0.154- 0.327]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
1.000	LV*	LV*	0.628	0.878

***indicates no variance in response- K could not be calculated**

Item 16: The care recipient is in a safe and secure position at the end of the transfer

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	252	249	501	98.2%
0.5	3	6	9	1.8%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**

97.9% ± 10.4%	95.3% ± 14.0%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.157 [0.070- 0.244]	0.061 [-0.026- 0.148]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0.5	0.157 [0.070- 0.244]	0.061 [-0.026- 0.148]
1	0.157 [0.070- 0.244]	0.061 [-0.026- 0.148]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
LV*	LV*	LV*	-0.055	LV*

***indicates no variance in response- K could not be calculated**

Item 17: The transfer does not cause any pain or discomfort to the caregiver or care recipient

	Visit 1 Count	**Visit 2 Count**	**Total Count**	**Total Percent**
1	245	238	483	94.7%
0.5	10	17	27	5.3%

***Low variance in data set (>90% one response)**

Interrater Reliability

Percent agreement between raters	
Session 1	**Session 2**
97.9% ± 10.4%	99.1% ± 5.8%

Interrater Reliability [95% CI]	
Session 1	**Session 2**
0.636 [0.549- 0.723]	0.874 [0.787- 0.961]

Intrarater Reliability

Agreement on Individual Items K [95% CI]		
Rating	**Visit 1**	**Visit 2**
0.5	0.636 [0.549- 0.723]	0.874 [0.787- 0.961]
1	0.636 [0.549- 0.723]	0.874 [0.787- 0.961]

Intrarater Reliability [95% CI]				
Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
-0.072	-0.030	-0.049	-0.052	-0.030

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