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Considerations for Walking Adaptive Devices Used by the Older Adult Population for Functional Mobility

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CONSIDERATIONS FOR WALKING ADAPTIVE DEVICES USED BY THE OLDER ADULT POPULATION FOR FUNCTIONAL MOBILITY

by

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ABSTRACT

CONSIDERATIONS FOR WALKING ADAPTIVE DEVICES USED BY THE OLDER ADULT POPULATION FOR FUNCTIONAL MOBILITY

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Statement of the problem: Walking adaptive devices (ADs) are commonly used by older adults to increase stability and prevent falls, yet the effectiveness and safety of these devices remain uncertain. This dissertation study investigates the impact of ADs on older adult falls through evidence-based practice concepts of best research evidence, patient values and circumstances, and clinician expertise. Methods: Three distinct studies were conducted, each addressing an essential aspect of EBP. The first study, representing the best research evidence, explored the effect of AD on gait spatiotemporal parameters and motions at the center of mass of twenty-five healthy participants. The second study, representing patient values and circumstances, surveyed 226 healthy older adult participants to examine the method of obtaining ADs (medical professional, private purchase, or second-hand) impact on patient perceptions and self-reported falls. The third study, representing clinical expertise, involved 108 rehabilitative clinicians exploring their preparedness and methods for recommending, assessing, and training patients to use ADs. Results: The study representing the best research evidence concept of EBP demonstrated that ADs alter healthy gait, highlighting decreased gait parameters and restricted center of mass (CoM) motions, which alter the natural biomechanics of gait. The patient value and circumstance study identified the importance of addressing issues related to fitting, training, patient involvement, and ongoing support to enhance the effectiveness of ADs and reduce fall incidence among older adult users. The clinical expertise study delved into the foundational

understanding of rehabilitative clinicians' perspectives, indicating a need for improved education and training regarding ADs for older adults, along with standardized testing methods and more precise assessment guidelines to ensure consistent and high-quality care. Conclusion: In summary, the evidence underscores the crucial need for comprehensive research grounded in and incorporating all three concepts of EBP. This research is essential for developing practical guidelines and interventions utilizing walking ADs to address older adult falls. The absence of EBP literature in the AD fall intervention might exacerbate falls among older adults, as the lack of research impedes the evolution of effective interventions.

This thesis is dedicated to my family, beginning with my late father, Bob Earl Wolfson, who was always my bridge over troubled waters. Though you may have departed, your memory remains eternally cherished and revered.

To my beloved eldest daughter Cecilia, whose grace and patience resemble that of an angel. Your presence in my life has been an invaluable source of strength and inspiration. Your wisdom taught me to confront challenges resiliently and maintain a positive perspective. Your calming influence has consistently uplifted and molded me into a better individual. Your unwavering determination to overcome obstacles is a beacon of hope and motivation. Each day, I find myself in awe of your resilience and am grateful for the lessons you impart, teaching me to become a better person. You have encouraged me to embrace my challenges, relishing in overcoming them. Your perspective has taught me to savor every moment, even amidst adversity, recognizing that the journey truly defines our progress. The 20 years spent by your side have shaped me in ways I cannot fully express.

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Barach Hashem

G-d will provide.

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NOMENCLATURE

ACOTE	Accreditation Council for Occupational Therapy Education
AD	Assistive device
ADL	Activity of Daily Living
AI	Artificial Intelligence
AMP	Amputee Mobility Predictor
ANOVA	Analyses of variance
AOTA	American Occupational Therapy Association
AP	Anterior- posterior
APTA	American Physical Therapy Association
Barthel	Barthel Index Score
BERG	Berg Balance Scale
BoS	Base of Support
CDC	Centers for Disease Control
CE	Continued education
CEBM	Center for Evidence-Based Medicine
CEC	Continued education course
CoM	Center of Mass
COTA	Certified occupational therapy assistant
CVI	Content Validity index
CVI-A	Content validity index average
DGI	Dynamic Gait Index
DME	Durable medical equipment

EBM	Evidence-based medicine
EBP	Evidence-based practice
FGA	Functional Gait Assessment
GS	Gait Speed
KT	Knowledge translation
LiFE	Lifestyle Integrated Functional Exercise
LoS	Limits of Stability
LTC	Long-term Care facility
m	meter
MD	Medical doctor
min	minute
ML	Medial-lateral
MSCIT	Modified Clinical Test of Sensory Interaction on Balance
MWT	Minute Walk Test
NCI	National Cancer Institute
NIH	National Institutes of Health
OEP	Otago Exercise Programme
OT	Occupational therapy (therapy)
PASS	Postural Assessment Scale for Stroke
PCP	Primary care physician
Ph.D.	Doctor of Philosophy
PP	Privately purchased
PROM	Patient-reported outcome measure
PT	Physical therapy (therapist)

PTA	Physical therapy assistant
PWS	Preferred walking speed
QoL	Quality of Life
RCT	Randomized control trial
RCT	Randomized control trial
RMS	Root mean square
s	second
SH	Second-hand
SLP	Speech-language pathologist
SNF	Skilled nursing facility
SoC	Standard of Care
ST	Speech therapy (therapist)
STS	Sit to Stand
STs	Standardized tests
Tinetti	Tinetti Balance and Gait Assessment
TUG	Timed up and go test
VT	Vertical
WHO	World Health Organization

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Falls in older adults have reached almost epidemic proportions due to the increasing lifespan of our population (Houry et al., 2016). As we age, our risk of falling, being diagnosed with a balance disorder, and needing assistance with basic activities of daily living (ADLs) increases (Barak et al., 2006). Trained specialized rehabilitative clinicians called physical therapists (PT) and occupational therapists (OT) access and treat older adults with balance disorders at risk for falling (Avin et al., 2015; Bleijlevens et al., 2010; Leland et al., 2012; Ng et al., 2019a). PTs and OTs implement fall prevention interventions aiming to increase independence with ADLs while simultaneously reducing the incidents of falls and fall risks (Cumming et al., 2001; Pirker & Katzenschlager, 2017; Shubert, 2011). The two primary categories of fall prevention interventions for older adults used by PTs and OTs are 1) balance and strengthening programs and 2) the incorporation of walking adaptive devices (ADs) (Bateni & Maki, 2005a; Pirker & Katzenschlager, 2017; Van Hook et al., 2003). The two interventions can be implemented independently or in conjunction (Leland et al., 2012; Lovarini et al., 2013; Papalia et al., 2020a; Shubert, 2011).

Unfortunately, fall data from the National Center for Injury Prevention and Control shows that older adults in The United States are reporting increased falls despite the distribution of walking ADs (E. R. Burns et al., 2016). Incorporating AD into older adults' ADLs has not solved the billion-dollar fall epidemic (Florence et al., 2018). On the contrary, falls have continued even with the use of ADs at an alarming rate, with thirty-six million falls and 32,000 deaths annually (Houry et al., 2016). Steven et at. (2009) recorded that from 2001 -2006 an average of 47,312 emergency room fall injuries for older adults were reported, consisting of 87.3% with walkers, 12.3% with canes, and 0.4% with a combination (Stevens et al., 2009a). Approximately one-third of those emergency room visits were hospitalized due to their sustained injuries (Stevens et al., 2009b). As stated previously, there has been an annual increase in the distribution of ADs in the older adult community, and there has also been an increase in older adults' falls and fall-related injuries with walking ADs (Florence et al., 2018; Kakara et al., 2023; Luz et al., 2015). The annual cost of older falls in America is over fifty billion dollars, which has made the topic of fall prevention interventions essential in the healthcare industry (Florence et al., 2018).

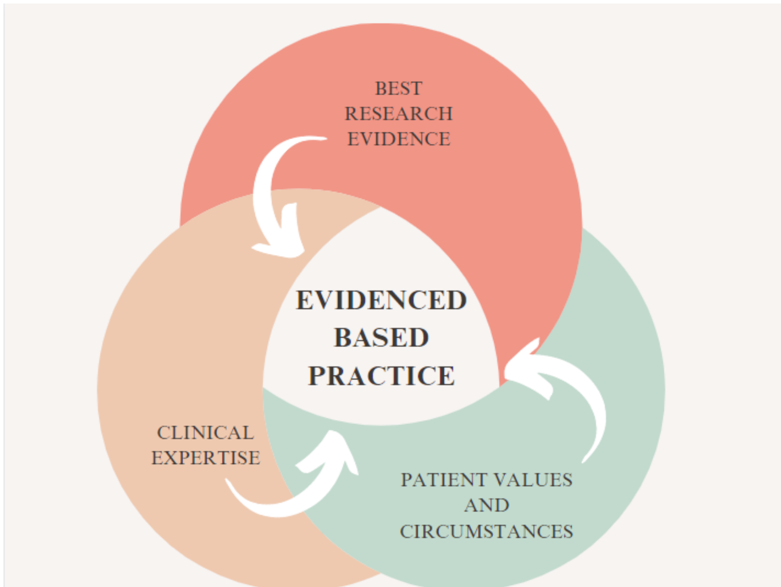
The motivation behind embarking on this dissertation stems from recognizing the significant and devastating ramifications of falls among older adults. Specifically, it aims to better comprehend the reasons behind the persistent increase in fall rates by focusing on two prevalent fall prevention strategies employed by PTs and OTs: balance and exercise programs and incorporating walking ADs. The objective is to identify potential avenues for improvement and enhance general knowledge regarding this health crisis. The methodologies PTs and OTs employ to design these common fall prevention interventions are central to this dissertation study. Both professions follow evidence-based practice (EBP) principles and literature in developing and implementing interventions as established in their professional curricula and guidelines (American Occupational Therapy Association, 2022b; "Guideline for the Prevention of Falls in Older Persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention," 2001; J. Moreland et al., 2003; *Schools – ACOTE*, 2023; *Standards of Practice for Physical Therapy*, 2019). Hence, it is reasonable to expect that both balance and strengthening programs and walking ADs should be established and reinforced by EBP. This dissertation aims to scrutinize the EBP literature underlying these interventions to extract factors contributing to the apparent ineffectiveness of fall prevention.

Evidenced-based practice

Healthcare providers adhere to a standard of care (SoC) or established practices when devising treatment plans for patients with congenital, chronic, or acute ailments. The National Institute of Health (NIH) defines SoC as an intervention widely accepted by medical experts as an effective remedy for a particular illness (Vanderpool, 2021). Although not a medical term, SoC was coined over a century ago about malpractice lawsuits (Vanderpool, 2021). These cases needed to establish the SoC with deviations from it constituted as legally negligent (Moffett & Moore, 2011). Clinicians rely on EBP to establish SoC and determine appropriate interventions for healthcare diagnoses. Employing SoC based on EBP ensures the proven effectiveness of healthcare interventions (Barkhordarian et al., 2011). EBP necessitates contemporary research through a systematic hypothesis-driven research synthesis and meta-analysis approach, facilitating informed clinical decision-making regarding diagnoses and prognoses (Chiappelli & Cajulis, 2009). The EBP model incorporates three contributing concepts: best research evidence, patient values and circumstances, and clinical (clinician) expertise (Figure 1.1).

Figure 1.1

Illustration of the Evidence-Based Practice Model.



Best research evidence, also known as experimental scientific method research, is derived from clinically relevant research studies conducted with a robust research design using the scientific research method (Bhargava & Bhargava, 2007). This type of research is typically peer-reviewed and disseminated through journal manuscripts (Bhargava & Bhargava, 2007; Gopalakrishnan & Ganeshkumar, 2013).

The significance of patient values and circumstances cannot be overstated in achieving successful treatment outcomes (Bhattad & Pacifico, 2022; Grocott & McSherry, 2018). Clinicians must prioritize the opinions of their patients to ensure effective interventions that include appropriate skill transfer (Grocott & McSherry, 2018). Subjective data collection methods, such as survey responses and patient interviews, capture patient perspectives that can be used for personalized intervention strategies (Burki, 2021; Hunt et al., 2011; Mercieca-Bebber et al., 2018). The data collected from subjective studies delve into complex research questions related to patient motivation, barriers to treatment, and cognitive learning strategies (Tempelaar et al., 2020). The findings from such studies on patient value and circumstance studies allow interventions to evolve based on patient-driven outcome reports and are, therefore, essential to EBP (Burki, 2021; Connor et al., 2023).

Clinical expertise refers to the clinician's cumulated education and experience shaping the clinician's rehabilitative skills (Zhang et al., 2022). It represents how clinicians integrate fundamental clinical skills and draw upon past and present clinical experiences to devise patient treatments (Wieten, 2018). Despite its conceptual nature, peer-reviewed journals often overlook the inclusion of clinical expertise in qualitative or quantitative research studies (Wieten, 2018). However, healthcare research advocators are challenging this outdated perspective and emphasizing the importance of increasing the publication of qualitative and quantitative studies that center on the clinical expertise of healthcare interventions (Lilienfeld & Basterfield, 2020). Incorporating quantifiable clinical expertise is pivotal for successful EBP practice interventions as it enhances the understanding of treatment plans formulated by multiple clinicians to improve patients' lives (Basu et al., 2019).

This introduction chapter establishes the groundwork for EBP, enabling clinicians to develop personalized (patient-centered) treatment approaches informed by current research, patient perspectives, and clinicians’ experiences used for healthcare interventions (Vanderpool, 2021). While Chapter 2 delves into further details regarding EBP, this introduction emphasizes that EBP extends beyond solely relying on experimental research. It encompasses patient perspectives and clinician expertise to formulate treatment plans that address real-world scenarios, often overlooked in laboratory research settings (Greenhalgh et al., 2004; Hunt et al., 2011; Unertl et al., 2018).

The lack of EBP for the use of walking ADs

Given that PTs and OTs rely on EBP for interventions, it is unsurprising that balance and strengthening programs have been established and continue to evolve with the EBP model (J. Moreland et al., 2003; Ng et al., 2019a; Papalia et al., 2020a; D. Tai et al., 2020; Van Rhyn & Barwick, 2019). The literature review in Chapter 2 will provide examples of studies that examined balance and strengthening intervention from all three concepts of the EBP model. It will summarize that these interventions have effectively prevented falls among older adults.

On the other hand, the literature review for the second intervention involving walking ADs used to enhance independence and decrease falls in older populations will yield different results (Bateni & Maki, 2005a; Bradley & Hernandez, 2011; Larsson Ranada & Lidström, 2019; H. (Howe) Liu et al., 2017). The literature review reveals that walking ADs as a fall prevention intervention lacks EBP support, despite the assumption that both interventions should have been established from EBP models and principles established in rehabilitative clinician curricula. This dissertation aims to contribute to the understanding and research that addresses this critical issue surrounding fall prevention interventions for this demographic.

1.2 Statement of the problem

EBP is the gold standard for establishing interventions addressing complex medical issues such as falls in older adults (Dijkers et al., 2012). Two primary interventions for older adult fall prevention are 1) promoting balance and strengthening programs and 2) integrating walking ADs into ADLs. A literature review found that EBP supports balance and strengthening programs for fall prevention in older adults (J. Moreland et al., 2003; Papalia et al., 2020a; Phelan et al., 2015a; Satariano et al., 2012; Sun et al., 2021) but not for walking ADs. As the distribution of walking ADs has increased to meet the demand of our aging population, falls have not decreased; instead, they occur more frequently (Vaishya & Vaish, 2020). The problem is an absence of acknowledgment regarding the lack of EBP support for this intervention. To the author's understanding, no study to date has investigated the deficiency of EBP supporting walking ADs as a potential factor contributing to falls among older adults.

1.3 The general purpose of the study

EBP is considered the foundation for healthcare interventions, including those imposed by PTs and OTs to combat older adult falls. However, through no nefarious intentions, the EBP model and literature are noticeably absent in the domain of walking ADs. In chapter 2 of this dissertation, the background and literature review will demonstrate the inconsistency of best research evidence, the outdated and unspecific patient value and circumstance studies, and the complete absence of peer-reviewed journal publications for clinical expertise studies. There is a critical gap in the literature regarding EBP in the context of interventions for older adults with mobility disorders, specifically focusing on walking ADs and their role in preventing falls. The deficiency of EBP literature potentially exacerbates the escalating incidence of falls within this demographic. By creating studies that investigate walking ADs with all three concepts of EBP, the general purpose of this dissertation is to enhance the knowledge and research of older adult falls with walking ADs to decrease this healthcare epidemic.

Specific Aims and Hypotheses

Experiment One: Walking Adaptive Devices Constrain Acceleration of the Center of Mass and Reduces Gait Speed in Healthy Adults

Specific Aim 1: This study examines if healthy adult gait measured via spatiotemporal parameters and measurement of center of mass (CoM) differs with the use of three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking with no AD.

Sub aim 1a: The study examines gait by measuring spatiotemporal parameters of gait speed when healthy participants walk with three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking with no AD.

Hypotheses 1ai: Healthy adults walking with a front-wheeled walker are hypothesized to have a slower gait speed than those walking without AD.

Hypotheses 1aii: It is hypothesized that healthy adults walking with a cane will have a slower gait speed compared with walking without AD.

Hypotheses 1aii: It is hypothesized that healthy adults walking with double canes will have a slower gait speed compared with walking without AD.

Sub aim 1b: The study examines gait by measuring cadence when healthy participants walk with a front-wheeled walker, cane, and double canes) compared to walking with no AD.

Hypotheses 1bi: It is hypothesized that healthy adults walking with a front-wheeled walker will have a decreased cadence compared with walking without AD.

Hypotheses 1bii: It is hypothesized that healthy adults walking with a cane will have a decreased cadence compared with walking without AD.

Hypotheses 1biii: It is hypothesized that healthy adults walking with double canes will have a decreased cadence compared with walking without AD.

Sub aim 1c: The study examines gait step length when healthy participants walk with three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking with no AD.

Hypotheses 1ci: It is hypothesized that healthy adults walking with a front-wheeled walker will have a decreased step length compared with walking without AD.

Hypotheses 1cii: It is hypothesized that healthy adults walking with a cane will have a decreased step length compared with walking without AD.

Hypotheses 1ciii: It is hypothesized that healthy adults walking with double canes will have a decreased step length compared with walking without AD.

Sub aim d: The study examines gait by measuring acceleration at the center of mass (CoM) in the anterior-posterior (AP) axis when healthy participants walk with three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking without an AD.

Hypotheses 1di: It is hypothesized that healthy adults walking with a front-wheeled walker will have decreased CoM acceleration at the AP axis compared with walking without an AD.

Hypotheses 1dii: It is hypothesized that healthy adults walking with a cane will have decreased CoM acceleration at the AP axis compared with walking without an AD.

Hypotheses 1diii: It is hypothesized that healthy adults walking with double canes will have decreased CoM acceleration at the AP axis compared with walking without AD.

Sub aim 1e: The study examines gait by measuring acceleration at the CoM in the medial-lateral (ML) axis in healthy participants when they walk with three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking without an AD.

Hypotheses 1ei: It is hypothesized that healthy adults walking with a front-wheeled walker will have decreased CoM acceleration in the ML axis compared with walking without an AD.

Hypotheses 1eii: It is hypothesized that healthy adults walking with a cane will have decreased CoM acceleration in the ML axis compared with walking without an AD.

Hypotheses 1eiii: It is hypothesized that healthy adults walking with double canes will have decreased CoM acceleration in the ML axis compared with walking without an AD.

Sub aim 1f: The study examines gait by measuring acceleration at the CoM in the VT axis when healthy participants walk with three common types of walking ADs (front-wheeled walker, cane, and double canes) compared to walking without an AD.

Hypotheses 1fi: It is hypothesized that healthy adults walking with a front-wheeled walker will have decreased CoM acceleration in the VT axis compared with walking without AD.

Hypotheses 1fii: It is hypothesized that healthy adults walking with a cane will have decreased CoM acceleration in the VT axis compared with walking without AD.

Hypotheses 1fiii: It is hypothesized that healthy adults walking with double canes will have decreased CoM acceleration in the VT axis compared with walking without AD.

Experiment Two: Patient Perspectives on Walking Adaptive Devices and the Relevance to Falls

Specific Aim 2: This study examines the effect of how walking ADs are obtained (from a medical doctor (MD), private purchase (PP), or second-hand (SH)) on patient perceptions of the process of acquiring ADs.

Sub aim 2a: The study examines how an AD obtained (MD, PP, SH) affects patients' perceptions of whether the AD was adequately fit for them when they received it.

Hypotheses 2ai: Participants who obtained AD from an MD will more frequently report that the device was adequately fit for them when it was obtained, compared to participants who received their AD from either 1) PP or 2) SH.

Hypotheses 2aii: Participants who obtained AD from PP will more frequently report that the device was fit for them adequately compared to participants who received their AD from SH.

Sub aim 2b: The study examines how an AD was obtained (MD, PP, SH) and whether the participant perceived adequate AD training when the device was received.

Hypotheses 2bi: Participants who obtained AD from an MD will more frequently report adequate AD training than participants who obtained AD from either 1) PP or 2) SH.

Hypotheses 2bii: Participants who obtained AD from PP will more frequently report adequate AD training than those who obtained their AD from SH.

Sub aim 2c: The study examines how an AD was obtained (MD, PP, SH) and whether the individual participant received educational materials about the AD when obtaining it.

Hypotheses 2ci: Participants who obtained AD from an MD will more frequently report receiving educational materials about the AD at the time of obtaining the device compared to participants who obtained their AD from either 1) PP or 2) SH.

Hypotheses 2cii: Participants who obtained AD from PP will more frequently report receiving educational materials about AD when obtaining their device than those who obtained their AD from SH.

Sub aim 2d: The study examines how an AD was obtained (MD, PP, SH) and how it affects the individual's perception of whether their opinion was asked about AD when obtaining it.

Hypotheses 2di: Participants who obtained AD from an MD will more frequently report that their opinion was asked about the AD at the time of receiving it compared to participants who obtained their AD from either 1) PP or 2) SH.

Hypotheses 2dii: Participants who obtained AD from PP will more frequently report that their opinion was asked about the AD when receiving it than those who obtained their AD from SH.

Sub aim 2e: The study examines how an AD obtained (MD, PP, SH) affects the participant's satisfaction scores regarding AD training when the device was first acquired.

Hypotheses 2ei: Participants who obtained AD from an MD will have significantly higher satisfaction scores for training with their AD than participants who received their AD from either 1) PP or 2) SH.

Hypotheses 2eii: There will be no significant differences in satisfaction scores for training when comparing participants who obtained their AD from PP or SH.

Sub aim 2f: This study examines how an AD obtained (MD, PP, SH) can significantly affect the number of self-reported falls in the six months leading up to the survey completion.

Hypothesis 2fi: Participants who obtain their walking AD via SH will have a significantly greater number of self-reported falls in the six months leading up to the survey completion than those who receive it from MD or PP.

Hypotheses 2fii: There will be no significant differences in the number of self-reported falls in the six months leading up to the completion of the survey when comparing participants who obtained their AD from MD and PP.

Sub aim 2g: This study examines potential significant differences in participants' age across groups based on the method by which the individual obtained their ADs (MD, PP, SH).

Hypothesis 2gi: Participants who obtain their walking AD via PP will be significantly younger than those who receive it from MD or SH.

Hypotheses 2gii: There will be no significant differences in age when comparing participants who obtained their AD from MD and SH.

Experiment three: Clinician expertise in walking Adaptive devices for older adults

Specific Aim 3a: The study aims to identify the participants' basic demographics, educational backgrounds, and current employment settings.

Hypothesis 3ai: This aim has no hypothesis as it is descriptive.

Specific Aim 3b: The study examines rehabilitative clinicians' opinions on their preparedness to "recommend, evaluate and train older adult patients to use walking ADs" based on their educational curriculum (Associate, Undergraduate, Master, and Doctorate/ Ph.D.).

Hypotheses 3bi: Clinicians with higher levels of education (post-undergraduate: Masters Doctorate/ Ph.D.) will report significantly greater preparedness scores for "recommending, evaluating and treating older adult patients to use walking ADs" when compared to 1) clinicians with educational levels at undergraduate degrees and 2) with associate degrees (with no significant differences seen between the Masters and Doctorate/ Ph.D. groups).

Hypotheses 3bii: Clinicians with undergraduate degrees will report significantly greater preparedness scores for “recommending, evaluating, and treating older adult patients to use walking ADs” when compared to clinicians with associate degrees.

Specific Aim 3c: The study aims to identify rehabilitative clinicians continued educational experiences (post-curriculum) related to walking ADs.

Hypothesis 3ci: This study has no hypothesis as it is descriptive.

Specific Aim 3d: The study examines rehabilitative clinicians (separated into groups based on education: Associate, Undergraduate, Master, and Doctorate/ Ph.D.) to determine their preparedness to “recommend, evaluate and train older adult patients to use walking ADs” after undertaking post-curriculum education on walking ADs.

Hypotheses 3di: Clinicians with higher levels of education (post-undergraduate: Masters and Doctorate/Ph.D.) will report significantly greater preparedness scores for “recommending, evaluating and treating older adult patients to use walking ADs” when compared to 1) clinicians with educational levels at undergraduate degrees and 2) with associate degrees after undertaking post curriculum education on walking ADs (with no significant differences seen between the Masters and Doctorate/ Ph.D. groups).

Hypotheses 3dii: Clinicians with undergraduate degrees will report significantly greater preparedness scores for “recommending, evaluating, and treating older adult patients to use walking ADs” when compared to clinicians with associate degrees after undertaking post-curriculum education on walking ADs.

Specific Aim 3e: The study aims to identify evaluation tools the participant clinicians use to assess older adult walkers who use walking ADs.

Hypothesis 3ei: This study has no hypothesis as it is descriptive.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Overview of Evidence-Based Practice (EBP)

History of Evidence-based medicine and evidence-based practice

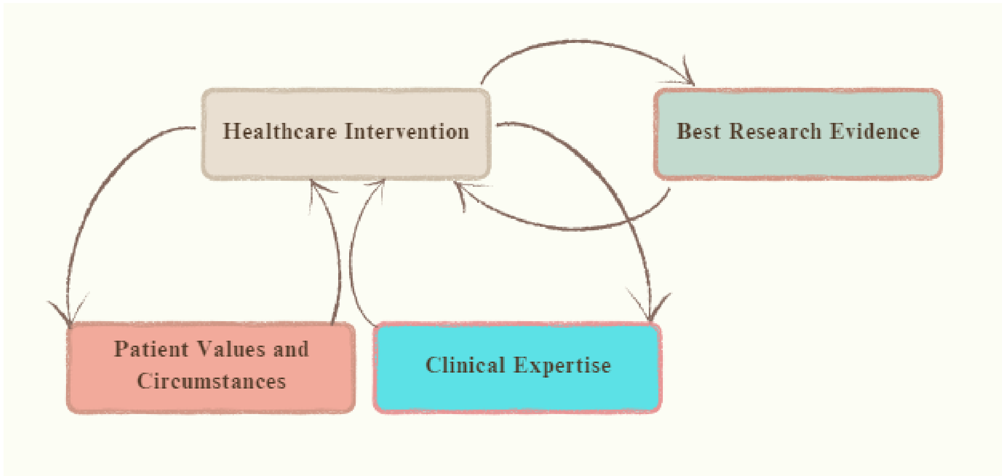
During the early 1950s, an American physician and mathematician, Dr. Alvan Feinstein, overseeing rheumatic fever patients in an acute care setting, made a notable observation. There were no established guidelines for physicians to distinguish between a benign and pathological murmur in pediatric patients (Feinstein & Di Massa, 1959). Through meticulous data collection and statistical analysis, this practitioner developed disease classification based on statistical analysis that significantly enhanced the hospital's patient healthcare outcomes (Feinstein, 1968; Feinstein & Di Massa, 1959). Dr. Feinstein then published critiques of the current healthcare interventions that lacked scientific evidence and instead relied heavily on the subjective opinions of the treating physician (Sur & Dahm, 2011). While Dr. Feinstein was not alone in recognizing the disparity between research and practice, his extensive publications earned him recognition for bridging the gap between epidemiology and medical research, laying the groundwork for the evidence-based approach to medical practices (Sur & Dahm, 2011).

Another pivotal figure, Dr. David Sackett, made significant contributions to healthcare diagnostics while leading the Department of Clinical Epidemiology and Biostatistics at McMaster University in 1967 (Sur & Dahm, 2011). Dr. Sackett advocated for integrating epidemiology and biometric methods into direct patient care, emphasizing the importance of a scientific foundation for accurate diagnosis and treatment in healthcare (Sackett, 1969). His collaborative efforts resulted in influential publications and the significance of biostatistics research in guiding healthcare interventions across medical conditions, prompting a paradigm shift within the medical community (Zimmerman et al., 2021). Though Dr. Sackett did not coin the term evidence-based medicine (EBM), he is known to be the father of EBM. Another prominent physician and advocate challenging medical trends characterized by non-scientifically based treatment approaches, Dr. Gordon Guyatt, coined the term EBM in a series of publications in the 1990s (Guyatt, 1992; Sur & Dahm, 2011).

EBM has since become the cornerstone of medical practices, wherein healthcare professionals rely on current, evidence-based research to inform decision-making processes regarding patient healthcare (Hong & Chen, 2019). EBM relies on evidence-based practice (EBP), which is the model that integrates current research evidence, patient values and circumstances, and clinical expertise through experiences to formulate healthcare interventions (Hong & Chen, 2019). Today, practitioners in various clinical settings in American healthcare use EBP to facilitate cost-effective treatments while prioritizing improved patient outcomes (Bhargava & Bhargava, 2007; Lehane et al., 2019). EBP has become the gold standard for establishing and implementing healthcare interventions, underscoring its vital role in contemporary medical practices (Dijkers et al., 2012). A scoping review of 636 peer-reviewed publications examining patient outcomes from treatment derived from EBP found overwhelmingly that patient outcomes improved with EBP interventions (Connor et al., 2023). The scoping review concluded that EBP models are constantly evolving (represented in figure 1.2) as the research guides intervention for improvement, and it is up to not only clinicians but also educators to continually aim to improve EBP and the interventions that are created from them (Connor et al., 2023).

Figure 2.1

Illustration of Evolving Healthcare Interventions with Evidence-Based Practice



The three concepts of evidence-based practice

EBP is a model built upon three fundamental research concepts: best research evidence, patient values and circumstances, and clinical expertise that formulates interventions for healthcare clinicians (Gopalakrishnan & Ganeshkumar, 2013; Lehane et al., 2019). All three concepts of EBP contribute to clinicians' approaches to treatment interventions for patient care (Paez, 2018). Clinicians must consider the best research evidence for treatment decisions and their patients' circumstances and experiences to formulate successful healthcare decisions (Frenk et al., 2010; Hoogeboom & Jette, 2021).

Best research evidence

The best research evidence validates or establishes a theory and follows the scientific method of 1) defining a question, 2) making a hypothesis, 3) collecting data, 4) analyzing data, and 5) drawing a conclusion (Lund et al., 2021). Using the best research evidence is a way to use reliable sources to inform healthcare decisions and deliver best practices for patient care (Gopalakrishnan & Ganeshkumar, 2013). The best research evidence comes from primary or secondary sources (Gopalakrishnan & Ganeshkumar, 2013). Primary research collects and analyzes data directly from patients or populations, while secondary research analyzes data already collected through primary research (Gopalakrishnan & Ganeshkumar, 2013). Systematic reviews and meta-analyses summarize multiple primary source articles and are examples of secondary research (Glasziou, 2004). These secondary sources allow clinicians to stay abreast of current literature from summaries and analysis of multiple credible primary sources, which allows for more apparent evidence-based answers to clinical intervention questions (Glasziou, 2004).

There is a common misunderstanding that EBP and experimental scientific method research (best research evidence) are synonymous. While both incorporate proper experimental research, there are fundamental distinctions between the two. EBP incorporates experimental research to translate the established understanding and then apply it to clinical practice (Lilienfeld & Basterfield, 2020). The hallmark of successful EBP and distinguishing it from experimental research is the incorporation of all three components: 1) best research evidence, 2) patient values and circumstances, and 3) clinical expertise (Lilienfeld & Basterfield, 2020).

Patient values and circumstances

Patient values and circumstances can be used in healthcare research as quantitative or qualitative data, providing insights into patients' perspectives, experiences, and contexts during their healthcare journey (Burki, 2021). Patient values and circumstances can be quantified through patient-reported outcome measures (PROMs), which undergo validity and reliability testing and measure how patients perceive their healthcare outcomes from medical interventions (Willik et al., 2021). Because PROMs give insight into the clinician-patient functional status and symptom burden, they are used as an objective measure to justify clinical decision-making and improve personalized care (Willik et al., 2021). PROMs also facilitate shared decision-making between patient and clinician, promoting patient compliance (D. Tai et al., 2020). PROMs are essential for research and have successfully built the trust of clinicians and patients (Weinman, 1990). Though the Weinmann study is over 30 years old, it was the first to examine patient reports of trust with clinicians. The study found that patients felt more trust toward their clinicians with PROM administration because the PROM facilitated communication and transparency with the provider (Weinman, 1990). Qualitative research aimed to explore various aspects of the patient experience, such as perceptions of illness, experience with healthcare providers and institutions, treatment decision-making, adherence to treatment plans, and challenges faced while trying to achieve desired outcomes also contributes to patient value and circumstance research (DiCicco-Bloom & Crabtree, 2006). Patient interview studies are another form of qualitative data analysis that systematically organizes and interprets data collected by individual patients to identify themes and patterns of their perspectives (Hunt et al., 2011). Whether through qualitative or quantitative means, the information gathered from patients' perspectives allows patients to be involved in their healthcare interventions, giving empowerment and ownership of the treatment plan and contributing to increased positive patient outcome measures (Wampold, 2015). In summary, gathering information and understanding patient values and circumstances is essential for developing patient-centered interventions and, ultimately, more effective in improving patient health outcomes (Burki, 2021).

Clinical expertise

Clinical expertise encompasses the clinicians' past clinical experience, science-based clinician knowledge, professional skills, and best clinical judgment (Paez, 2018). Quantitative and qualitative data analytics can measure clinical expertise (Farquhar et al., 2002). Though less prevalent in literature than other concepts in EBP, clinical expertise studies provide essential information on implementing medical treatments and protocols used for all healthcare interventions (Farquhar et al., 2002). Understanding and quantifying clinical expertise is vital for clinician decision-making regarding public health challenges as it collects options and practices from multiple clinicians to determine the challenges and successes of interventions and should not be discounted (Lulin et al., 2016).

Example of the importance of all three concepts of EBP for current healthcare interventions

By implementing all three concepts of EBP into examining and understanding the healthcare intervention of antibiotic drugs for bacterial infections, progress has occurred to curve the trend of overprescription and mismanagement of antibiotic drugs (Kadri, 2020). Antibiotics are the primary intervention for bacterial infections. However, the unforeseen consequence of excessive utilization of this drug has led to four decades of significant and rapid increase in the bacteria developing resistance to antibiotics, promoting urgent action to address this healthcare crisis (Ventola, 2015). Best research studies showed a direct link between over-prescription, overuse, and misuse of the drugs as significant contributors to antibiotic-resistant bacteria (Llor

& Bjerrum, 2014). The best research evidence studies lead to industry standard recommendations for physicians to refrain from prescribing antibiotics unless necessary (Al-Homaidan & Barrimah, 2018). This singular approach was unsuccessful, and the World Health Organization (WHO) determined that simply asking physicians to stop prescribing the drugs was unrealistic and ineffective over the past two decades, and more research was needed from the patient and clinician perspectives to fully understand the complications with the intervention (Al-Homaidan & Barrimah, 2018).

Therefore, additional studies were implemented following the EBP model and provided deeper insights (Kadri, 2020). Studies on patient value and circumstance revealed widespread confusion and frustration among patients regarding when they should and should not use antibiotics (Davis et al., 2017). Additionally, Patient survey studies showed that many patients perceive bacterial resistance diseases as a future concern rather than an immediate threat (Spicer et al., 2020). Qualitative studies on clinical experience demonstrated that patients often pressure physicians to prescribe antibiotics for symptom relief (Al-Homaidan & Barrimah, 2018). Clinicians comply with the patient's request even if the patient does not have a suspected bacterial infection (Al-Homaidan & Barrimah, 2018). Further overprescription comes from physicians wrongly believing that antibiotics alleviate burdensome symptoms in such situations (Teel et al., 2021). Simply asking physicians to refrain from prescribing antibiotics was not addressing the underlying issues driving the healthcare crisis (Kadri, 2020).

In response to this acknowledgment, the Centers for Disease Control (CDC) developed a comprehensive plan to combat antimicrobial resistance grounded on ongoing research across all facets of EBP (Kadri, 2020). The plan included funding and regulation for the development of new drugs (best research evidence), national efforts and continued research for patient education about habits contributing to drug misuse (patient values and circumstances), and clinician guidelines, reforms, and continued research to prevent overprescribing (clinical expertise) (Kadri, 2020). Although the problem persists, using the concepts of EBP has shown promising progress (Burstein et al., 2019). Educational initiatives targeting clinicians and the public have decreased antibiotic use and misuse (Burstein et al., 2019; Hayes, 2022). EBP, characterized by its continuous evolution, remains integral to addressing this healthcare intervention's byproduct crisis, with ongoing research spearheaded by the CDC from all three concepts of EBP (Hayes, 2022). This example illustrates that failure to incorporate EBP literature (with all three concepts comprehensively) may exacerbate healthcare challenges. This dissertation will scrutinize the lack of EBP literature on a fall intervention for older adults to illustrate how the lack of EBP research hampers the progression of the intervention and how it could potentially contribute to falls among older adults.

Evidence-based practice in professional healthcare curricula

Given the paramount importance of EBP in healthcare delivery, educational programs for healthcare professionals prioritize the integration of EBP principles into curricula (Dijkers et al., 2012; Farquhar et al., 2002; Gopalakrishnan & Ganeshkumar, 2013). EBP equips future healthcare clinicians with the necessary skills to retrieve research evidence for healthcare questions, critically appraise the evidence, validate it for importance, validity, and significance, and apply the knowledge from the evidence into clinical practice (Frenk et al., 2010; Lehane et al., 2019). Studies exploring the integration of EBP into educational curricula have demonstrated its positive impact on students' critical thinking skills (Abu-Baker et al., 2021; Guyatt, 1992; Johansson et al., 2016; Lehane et al., 2019). For instance, nursing students exposed to EBP courses exhibited higher cognitive and performance skill scores when compared to those in non-EBP elective courses, underscoring the efficacy of EBP in fostering enhanced clinical competencies (Cardoso et al., 2021).

The professional curriculum serves as a structured framework where students are introduced to the latest research evidence on managing and treating healthcare challenges (Lehane et al., 2019). This knowledge is applied practically during fieldwork or residency programs, providing students with invaluable hands-on experience working directly with patients under the guidance of experienced clinicians (Dijkers et al., 2012). In direct patient care education, students can integrate the three components of EBP to formulate interventions for their patients' ailments (Abu-Baker et al., 2021). Before EBM and the interjection of EBP into healthcare curricula, medical treatments were not guaranteed to be based on research science (Guyatt, 1992; Sackett, 1989). Today, the principles of EBP are ingrained within the healthcare professional curricula, meaning that healthcare interventions taught to students and then subsequently used in patient care are validated by the three concepts of EBP (Lulin et al., 2016). EBP ensures clinicians can avoid ineffective or suboptimal healthcare interventions, safeguarding patients from potentially harmful treatments (Guyatt, 1992; Sackett, 1989; Sackett et al., 1996).

While healthcare clinicians commonly use EBP and all three concepts to develop interventions, this dissertation concentrates on a subset of patients and professional clinicians: rehabilitative clinicians. Consequently, this dissertation's ensuing literature review, subsequent studies, and analysis will center on rehabilitative clinicians and their tailored treatment strategies for older adult patients with mobility challenges.

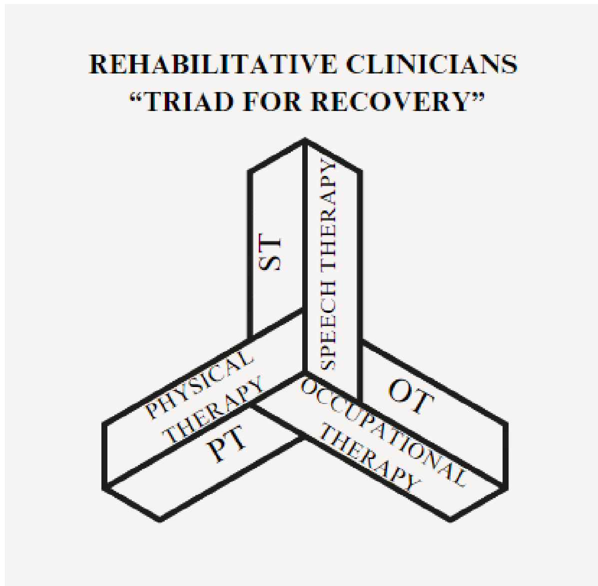
2.2 Overview of Rehabilitative Clinicians

Differentiating Rehabilitative Clinicians

The National Cancer Institute defines the term rehabilitative clinician as a healthcare professional specializing in aiding persons to regain function and strength after an illness or injury (*Definition of Rehabilitation Specialist - NCI Dictionary of Cancer Terms - (NCI*, 2011). Examples of rehabilitation specialists are physical therapists (PT), occupational therapists (OT), and speech and language pathologists (SLPs), also known as speech therapists (ST). These professions, collectively called the triad for recovery, often collaborate as integral members of healthcare teams focused on patient rehabilitation (Houtrow et al., 2019; Zomer et al., 2020)(Figure 2.1). To practice in The United States, each rehabilitation clinician must graduate from an accredited academic program, complete the mandated fieldwork or residency program, and pass their profession's national board exam (*2020 Certification Standards in Speech-Language Pathology*, n.d.; *APTA Guide to Physical Therapist Practice 4.0*, n.d.; *Schools – ACOTE*, 2023).

Figure 2.2

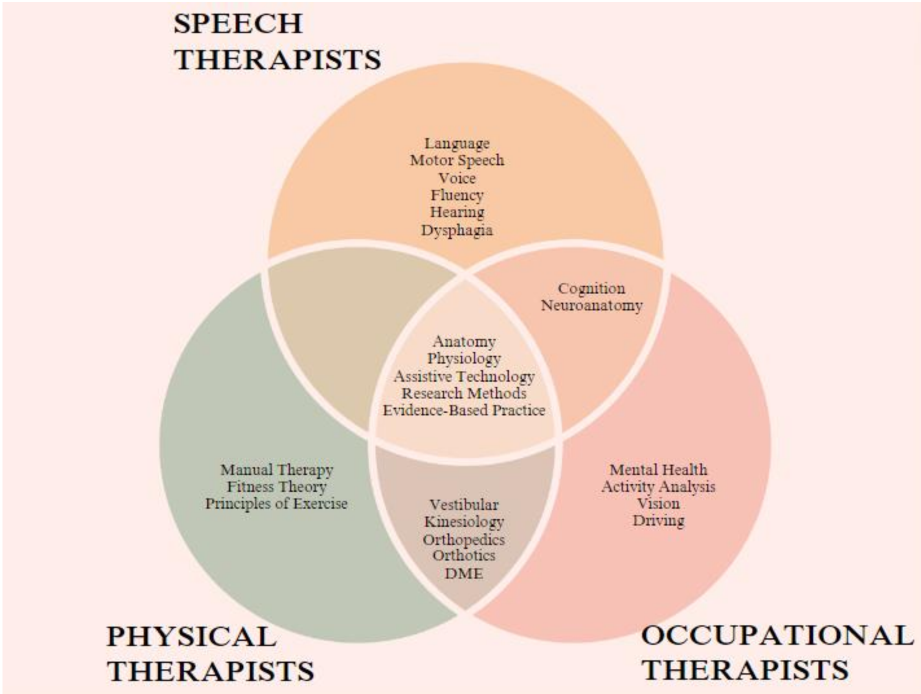
Illustration of Triad for Recovery



While each profession has distinct qualifications for rehabilitative care, the overarching goal of the recovery triad is to habilitate or rehabilitate patients to their highest functional level (Zomer et al., 2020). Their professional educational curriculum encompasses various rehabilitative theories and methodologies, enabling them to address the needs of patients across all age groups with diverse disabilities (*2020 Certification Standards in Speech-Language Pathology*, n.d.; *APTA Guide to Physical Therapist Practice 4.0*, n.d.; *Schools – ACOTE*, 2023). Figure 2.2 illustrates the general professional curriculum and highlights the skills shared among these professions in patient care.

Figure 2.3

Illustration of Recovery Triad Professional Curriculum Shared Skills of Knowledge.



This dissertation concentrates on older adults at risk for falls due to deficits in mobility. While the ST evaluates and treats older adults, evaluating and addressing mobility issues falls outside their scope of practice. Therefore, this dissertation study focuses solely on PTs and OTs. PTs and OTs work with various age groups and diagnoses; for this dissertation, PTs' and OTs' evaluation and treatments will be related to clinicians who evaluate and treat older adults at risk of falling. The author is aware and respects that both rehabilitative clinicians' fields of practice can go beyond this population of patients. However, this dissertation study focuses on older adults and falls and will reinforce the skills of PTs and OTs to address this specific niche. Lastly, despite the distinctions between PT and OT professions, including their therapeutic approaches, they often collaborate in treating the same patient population, working towards functional mobility outcomes guided by their respective scope of practice. This paper acknowledges and respects the significant differences between the PT and OT professions and their therapeutic modalities. However, given their shared involvement in evaluating and treating older adults with mobility disorders, both will be referred to as rehabilitative clinicians interchangeably within this dissertation.

PTs and OT's scope of practice for mobility

The American Physical Therapy Association (APTA) defines physical therapists (PTs) as licensed doctors collaborating with diverse patient groups affected by illness, injury, and mobility challenges. They aim to enhance the quality of life by preserving, rehabilitating, and enhancing patients' movement, functionality, and engagement in more dynamic lifestyles (*Becoming a Physical Therapist*, n.d.) As defined by the American Occupational Therapy Association, Occupational therapists (OTs) engage in the therapeutic application of daily activities to facilitate participation for individuals, groups, or communities. These services encompass habilitation, rehabilitation, and promoting health and well-being for clients with disability- and non-disability-related requirements. (*WHO ARE OCCUPATIONAL THERAPY PRACTITIONERS?*, n.d.). As healthcare professionals, PTs and OTs must operate within the boundaries of their professional scopes of practice, which define their specialized expertise in delivering patient care (American Occupational Therapy Association, 2022a; *Standards of Practice for Physical Therapy*, 2019). By following their distinct scopes of practice, which is an updated position statement produced by their respected professional bodies- PTs by the American Physical Therapy Association (APTA) and OTs by the American Occupational Therapy Association (AOTA), PTs and OTs safely, legally, and efficaciously treat patients (American Occupational Therapy Association, 2022a; *Becoming a Physical Therapist,* n.d.). The

APTA delineates their profession's scope of practice into three areas: professional, jurisdictional, and personal. The professional scope covers the school-based curriculum knowledge based on formulated and tested models and frameworks. The jurisdictional scope encompasses each state's specific mandates that ensure quality standards through licensure processes. The personal scope consists of tasks proficiently performed (*APTA Guide to Physical Therapist Practice 4.0*, n.d.). The AOTA defines the scope of practice for occupational therapists as a model to promote uniform standards and professional mobility across state occupational therapy statutes and regulations intended to serve as a resource for consumers, healthcare providers, educators, the community, funding agencies, payers, referral sources, and policymakers (American Occupational Therapy Association, 2022b).

Both therapies' scopes of practice encompass rehabilitation for mobility. Mobility refers to movement that encompasses basic ambulation, transferring between surfaces (such as from a bed to a chair), walking for leisure and daily tasks, participation in work and recreation activities, exercise, driving, and using all modes of public transportation (Satariano et al., 2012). Mobility is the most common activity of daily living (ADL), and walking is the most common form (Edemekong et al., 2022). For this dissertation study, the term “mobility” will be used interchangeably with “gait,” “ambulation,” and “walking.”

PTs and OTs employ therapeutic approaches to rehabilitate older adults with mobility impairments, enhancing their safety and functional abilities (Batterjee Medical College & Izzeddin Sarsak, 2019; Chen et al., 2022; Cumming et al., 2001; Morris et al., 2010). PTs leverage their in-depth understanding of movement disorders and gait biomechanics to evaluate their patients' impairments (Burtscher et al., 2024; Cheng et al., 2018; Morris et al., 2010). Based on these assessments, PTs devise comprehensive treatment plans integrating balance, strength, gait parameters, and adaptive strategies to enhance safety and functionality during mobility (Shubert, 2011). OTs also play a crucial role in addressing mobility issues for their clients as they conduct objective assessments of functional mobility to target specific ADL goals such as navigating the bathroom, grocery shopping, and managing household tasks (Cho et al., 2014; Cumming et al., 2001; Zipp & Winning, 2012). OTs evaluate clients' functional mobility and safety, examining factors such as balance, vision, coordination, and endurance to identify deficits and establish goals aimed at mitigating these deficits through improvements or modification (Foster et al., 2014; Möhwald et al., 2020; Radder et al., 2017). While OTs collaborate with patients to improve functional mobility, the detailed assessment of gait and specialized gait training primarily falls within the domain of the PT treatment approach (American Occupational Therapy Association, 2022a).

2.3 Overview of Mobility

Review of the gait cycle

To comprehend mobility disorders thoroughly, a foundational understanding of normal adult mobility is essential as the disorder deviates from average (Hsieh et al., 2019). Bipedal walking is the primary mode of propulsion, characterized by alternating movements of the lower limbs (Scafetta et al., 2009). Each lower limb assumes a distinct role in this process: one remains grounded for support while the other advances. This continuous interplay defines the gait cycle, a repetitive sequence inherent to walking (Alharthi et al., 2019). There are two distinct phases of the gait cycle: the stance and swing phases. The stance phase initiates with the heel strike of the support limb, where the foot makes initial contact with the ground and concludes with the toe-off, signifying the push-off from the support limb (Alharthi et al., 2019). Typically, the stance phase encompasses approximately 62% of the gait cycle duration (Alharthi et al., 2019). Conversely, the swing phase begins with a toe-off and concludes with the heel strike of the advancing limb, encompassing the remaining 38% of the gait cycle (Alharthi et al., 2019). Fundamentally, the stance entails the grounded leg providing support, while the swing phase involves the same leg propelling forward without ground contact.

Using gait analytics to assess the gait cycle

Analyzing the gait cycles is crucial for identifying pathologies affecting balance and energy expenditure and is essential for understanding and managing various medical conditions (Kuo & Donelan, 2010). The analytics of the gait cycle provide valuable insights into how diseases such as cancers, neuromuscular disorders, cerebral vascular accidents, and natural aging impact waking patterns (Brognara et al., 2019; Hausdorff et al., 2001; Hsieh et al., 2019; Jordan et al., 2007; Menz, 2003a; Mohan et al., 2021). Studying the gait cycle can assist with diagnosing and assessing the progression of treatment interventions (Alharthi et al., 2019; Scafetta et al., 2009). There are two familiar gait objective measures: spatiotemporal parameters (e.g., speed, step length, and cadence) and motion at the Center of Mass (CoM)(Aboutorabi et al., 2016; Alberts et al., 2015). Spatiotemporal parameters and CoM measurements evaluate balance, gait abnormalities, and fall risks (Ardestani et al., 2016). Ultimately, by objectively measuring gait, healthcare professionals can better evaluate and manage patients' conditions, improving outcomes (Fritz & Lusardi, 2009).

Humans have a preferred walking speed (PWS), categorized as walking at a comfortable speed as defined by the individual (Laufer, 2005; Samson et al., 2001). Studies have revealed that PWS minimizes energy consumption, allowing the body to use the passive mechanical advantages of the lower extremities and reducing the muscle force required (Cromwell & Newton, 2004; Espy et al., 2010a; Holt et al., 1991). Studying the average PWS has given researchers average healthy walking speeds for age ranges (Samson et al., 2001). Gait speed has been recommended as a vital sign for physical performance in older persons, with a ten centimeters (cm)/second (s) decrease in gait speed associated with higher fall risk in older persons (Ferrucci et al., 2000; *Verghese, J., Holtzer, R., Lipton, R. B., & Wang, C. (2009). Quantitative Gait Markers and Incident Fall Risk in Older Adults. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 64A(8), 896–901. Doi: 10.1093/Gerona/Glp033*, n.d.). Reduced gait speed indicates postural instability and is a fall predictor (Middleton et al., 2015). Gait speed is a valid and reliable objective measure of evaluating and monitoring overall health and wellness in various ages and populations (Middleton et al., 2015). In addition, gait speed is easy to measure and does not require complex tools or laboratory equipment. The equation for speed is not complex: s=d/t or speed equals the distance (e.g., meters) divided by time (e.g., seconds) and can be obtained from a stopwatch and a calculated distance.

Step length is the distance between the heels in the anteroposterior direction for consecutive heel strikes of opposite feet (Osoba et al., 2019). Step length is associated with gait speed. The shorter the step length, the slower the gait speed typically is (Latt et al., 2007). Step length generally decreases as individuals lose confidence in mobility or develop a fear of falling (Espy et al., 2010a). This adjustment occurs because the shorter step length allows for decreased time and distance of the swing phase of the gait cycle, allowing both limbs to remain close to the ground during the gait cycle (Herssens et al., 2018). Therefore, decreased step length and gait speed are often observed together (Latt et al., 2007). Step length requires sophisticated technology to be measured and calculated with equipment such as wearable sensors that record the oscillations of mobility and the heel strikes during the gait cycle (Muthukrishnan et al., 2020).

Cadence is a calculation of the ratio of the number of steps per minute (steps/time), and just as PWS is used to examine age-appropriate measures for gait, so is cadence (Nascimento et al., 2022). Healthy cadence rates represent diverse age groups (Tudor-Locke et al., 2020). For example, for moderate intensity for healthy participants, optimal cadence thresholds ranged from 123.8–127.5 for ages 21–30, 120.2–126.0 for ages 31–40, 117.7–122.7 for ages 41–50, and 113.3–116.1 steps/min for ages 51–60 (McAvoy et al., 2021). Step length and cadence are critical elements of gait speed (McAvoy et al., 2021). Two main strategies to slow down gait are 1) decreasing the step length or 2) decreasing cadence or steps per minute (Wu et al., 2019a). Investigating spatiotemporal parameters such as these as they relate to age allows insight into how gait changes with age and fall risks (Ambrose et al., 2013; Latt et al., 2007; Menz, 2003a; Wu et al., 2019b).

The center of mass (CoM) is critical when addressing balance because it objectively measures postural sway (Alberts et al., 2015; Lugade et al., 2011; Moe-Nilssen, 1998). CoM is a point equivalent to the center of the total body mass, which, for a human standing upright, is located between the third and fifth lumbar vertebrae (Howcroft et al., 2013; Nam et al., 2017). The act of falling results when the CoM is outside the base of support (BoS) (Nam et al., 2017). BoS is the surface area where the body (both feet, for example, when walking) contacts the ground (Lugade et al., 2011; Nam et al., 2017). Gait stability is possible because the successive and alternate relocations of the feet continuously re-establish the CoM and BoS in a rhythmic cyclic rotation of the lower limbs (MacKinnon & Winter, 1993; Tesio & Rota, 2019a). There are natural motions at the CoM that move in the anterior-posterior (AP), medial-lateral (ML) motion, and vertical (VT) axes and can be measured using accelerometers (Hulleck et al., 2022). The accelerometers measure the acceleration of the CoM and then convert it as the root mean square (RMS) of acceleration, a statistical measure of the magnitude of acceleration (Sekine et al., 2013). The CoM is a reliable way to detect discrepancies in gait that cannot always be seen objectively (Tesio & Rota, 2019a).

Numerous gait analysis systems are available, each with unique features, technologies, and applications (Hulleck et al., 2022). The systems vary in complexity from simple wearable devices (such as a pedometer) to sophisticated laboratory equipment with motion capture cameras and force plates (Hulleck et al., 2022). A well-known and widely used example of a gait analysis system that uses three-dimensional wireless sensors to capture motions and is then processed using a specialized software package is the Delsys Trigno™ (Prajapati et al., 2021). The motion-captured from movement activities such as walking or running by the Delsys triaxial sensors enables the extraction of gait parameters such as gait speed and step length with additional calculations cadence and CoM measurements can also be extracted (Bawa & Banitsas, 2022; Tao et al., 2012). Gait analytic systems such as Delsys offer a comprehensive toolset to understand and improve human movement because they provide valuable insight into individual gait patterns, facilitating assessments for abnormalities (Tao et al., 2012).

2.4 Overview of natural aging and factors that increase fall risk among older adults

Sensory and neuromuscular changes

Recent research has expanded our comprehension of the natural age-related changes in the body, mainly how aging affects the sensory system, encompassing all six senses: vision, auditory, taste, tactile, and smell. (Cavazzana et al., 2018). Research has shown that aging is associated with changes in the structure and function of the eye, leading to a decline in visual acuity (Dowiasch et al., 2015). Age-related hearing loss, known as presbycusis, is attributed to changes in the inner ear and neural pathways that affect hearing and balance (Paplou et al., 2021). Age is also correlated to the decreased number of taste buds and alterations in task perceptions, impacting the ability to detect and differentiate flavors (Jeon et al., 2021). Aging can alter the tactile senses, reducing sensitivity to touch and pressure due to changes in nerve function and degradation of the integumentary (skin) system (McIntyre et al., 2021). Declines in olfactory function (smell) due to changes in the olfactory epithelium and sensory processing are also expected in older adults (Olofsson et al., 2021). There is a direct correlation between the decreased sensory integration of participants and sustained falls, decreased independence with ADLs, and increased avoidance behaviors (Ho et al., 2021; Xing et al., 2023). This can be exceptionally dangerous for older adults because studies have shown that older individuals may not recognize their sensory deficits, hindering their ability to compensate effectively and further causing decreased safety (Cavazzana et al., 2018).

The sensory system impairments seen in older adults directly affect the somatosensory system, causing a collapse of the multi-sensory processing of the brain, causing delayed muscular reaction and balance disturbances (J. R. Mahoney et al., 2019; Shaffer & Harrison, 2007). In addition, the decreased motor response in older adults can cause the body's skeletal muscle to atrophy (Faulkner et al., 2007). At age 50, muscle atrophy begins and progressively continues, so, at 80, the average person will have lost 50% of fibers from limb muscles (Faulkner et al., 2007). In conjunction with muscle atrophy, adults above 65 show significantly decreased muscle strength and power compared to younger counterparts (Fielding et al., 2011). Lastly, the decreased motor response in older adults produces inconsistent and unpredictable motor strength during repetitive tasks (such as walking) (Vanden Noven et al., 2014). In summary, age-related changes to the sensory system directly impact the neuromuscular system, resulting in poor motor performance and detrimentally impacting physical function and safety (Fielding et al., 2011; Hunter et al., 2016).

The diminished motor performance in older adults has been objectively measured in gait parameter studies, as highlighted in a comprehensive systematic review of over 3000 peer-reviewed publications (Herssens et al., 2018). The results showed a significant decrease in gait parameter measurements (gait speed, step length, step width, and cadence) among older adults compared to younger counterparts (Herssens et al., 2018). Additionally, older adults exhibit increased gait variability, a marker associated with fall risk (Chien et al., 2015; Hausdorff et al., 2001; Herssens et al., 2018). This slower, more inconsistent gait pattern observed in older adults characterized by slower speed and shorter, narrower steps is often referred to as a "cautious gait pattern" (Espy et al., 2010a; Middleton et al., 2015; Pirker & Katzenschlager, 2017). Interestingly, this pattern mirrors the gait observed in healthy young walkers when navigating uneven terrain (Voloshina et al., 2013). This cautious gait pattern observed in older adults has been shown to reduce the motions at the CoM, potentially aiding in balance maintenance, as Menz et al. (2003) suggested. This decreased CoM motion is likely a compensatory strategy employed to cope with the reduced lower extremity muscle strength, mainly seen in older participants (Menz, 2003a; Menz et al., 2003). This adaptation reflects the intricate interplay between age-related biomechanical changes and individuals' dynamic strategies to maintain balance and mobility (Menz et al., 2003).

While the cautious gait pattern observed in older adults may serve as a strategy to stabilize their mobility and reduce the risk of falls, paradoxically, these very strategies can also contribute to falls within this population (Vaishya & Vaish, 2020). The slower, shorter, and more narrow steps decrease the stability margin, limiting the ability to adapt to unexpected environmental perturbations and increasing fall risks (Verghese et al., 2009). This is complied with reduced movement at the CoM, which impairs the ability to generate sufficient momentum to recover from balance disturbances, further predisposing older adults to falls (Menz et al., 2003; Pirker & Katzenschlager, 2017; Verghese et al., 2009).

The gait changes seen in the cautious gait pattern are often diagnosed generically as mobility disorders and are prevalent in older adult community dwellers (Freiberger et al., 2020). Since 1996, there has been a documented increase in the diagnosis of mobility disorders in older adults (Florence et al., 2018). A cross-sectional study examining 488 independent older adults aged 60-97 highlighted mobility disorders in 32.2% of their participants (Mahlknecht et al., 2013). The prevalence of mobility disorders increases with age, as evidenced by a 10% increase in the diagnosis in individuals aged 60-69 and a 35% increase in those aged 70 or older (Mahlknecht et al., 2013). Mobility disorders are the most common functional disability, which affects 1 out of every 8 American adults (Courtney-Long et al., 2015; Freiberger et al., 2020). This decrease in mobility increases the risk of falling and sustaining injuries (Andersen et al., 2007), as demonstrated in a longitudinal study of over 5000 older adults in Taiwan, which found mobility disorders were directly correlated to increased fall rates and repeated fall rates (Kuo &

Donelan, 2010). In summary, older adults have an increased prevalence of measurable deficits in the sensory and musculoskeletal system, deteriorating gait, and increasing fall risks (Herssens et al., 2018).

2.5 Overview of older adult falls

Prevalence and cost of older adult fall.

The World Health Organization (WHO) reports that today's average lifespan is 73.4 years old, an increase of 6.6 years from 2000 to 2019 (World Health Organization, n.d.). According to the WHO (World Health Organization, n.d.), expectations of continued longevity will continue. In America alone, 10,000 citizens turn 65 each day, and a quarter of these adults will live into their 90s (Arigoni,D, n.d.). Though humans live longer, this does not mean we are becoming immune from natural aging and ailments correlated to aging (G. C. Brown, 2015). Age longevity is possible due to increased healthcare, hygiene, lifestyle choices, and access to abundant food and medicine (Oeppen & Vaupel, 2002). However, the quantity of years does not equate to the quality of age (G. C. Brown, 2015). As noted previously, age leads to mobility disorders and costly falls (Anderson et al., 2004; Freiberger et al., 2020; Herssens et al., 2018; Kuo & Donelan, 2010).

Unfortunately, falls are the most common cause of severe injury among older adults (Vaishya & Vaish, 2020). In 2014, the CDC reported that falls were the prevalent cause of fatal and nonfatal injuries among Americans over 65 (Bergen et al., 2016). One out of every three older adults who fall or almost fall is at risk of moderate to severe injuries that require healthcare services (Ambrose et al., 2013). In 2016, the CDC also reported that 28.7% (29 million falls) of the older adult population reported falling in 2014, resulting in 7 million reported injuries (Bergen et al., 2016). With 30% and 40% of senior American adults aged 65 and above falling per year, this costs the country $50.0 billion annually (Ambrose et al., 2013; Bergen et al., 2016; Florence et al., 2018). Unfortunately, this cost is predicted to rise as older adults live longer and fall more (Ambrose et al., 2013; Houry et al., 2016). If the current trends continue (a 2 % increase in falls annually since 2001), then by the year 2030, the CDC is predicting 5.7 million non-fatal falls annually, which will cost trillions of dollars (Houry et al., 2016).

Falls' mental and emotional toll is unquantifiable, as it strips confidence and independence away from an already fragile human (Herman et al., 2005; Maki, 1997). Research has revealed that mobility is crucial for older adults' perceived health and well-being (Bourret et al., 2002). Subjective patient surveys indicate that maintaining or improving mobility is linked to an individual's independence and ability to complete ADLs, which influences their quality of life (QoL), making it a primary rehabilitation goal of older patients in the home and acute care settings (Allen et al., 2018; Guralnik et al., 2001; Kozica-Olenski et al., 2020).

On the other hand, there is an association that the loss of mobility is associated with self-reported depression, anxiety, limited social interactions, and reliance on caregivers (Rosso et al., 2013; Saajanaho et al., 2016). The conundrum comes because less walking does not lead to healthier lifestyles; on the contrary, sedentary, non-ambulating older adults are more likely to have increased chronic disease and hospitalization rates and decreased cognitive scores (Lee & Buchner, 2008). Essentially, the more mobile an individual feels, the more they sense independence and self-worth, as they can actively participate in their lives (Freiberger et al., 2020). Older adults desire independence, but due to their aging bodies, mobility becomes a health risk due to falling (Vaishya & Vaish, 2020). By following comprehensive approaches, healthcare providers can effectively diagnose and manage mobility disorders in older adults, helping them maintain or improve their mobility, independence, and quality of life (Freburger et al., 2018; Gillespie et al., 2012; Raymond et al., 2020).

Prescription for fall intervention

Primary care physicians (PCPs) and general hospitals are the principal medical practitioners who diagnose mobility impairments in older adults (Satariano et al., 2012). During the patient assessment, the evaluating physician will identify the mobility vulnerabilities of the patient, such as decreased strength, vision, balance, and gait (Phelan et al., 2015a). Because it is common for patients to not talk to their physician about personal fall risks, physicians initiate guideline conversation and assessment specifically for mobility and fall risks of patients over the age of 65 ("Guideline for the Prevention of Falls in Older Persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention," 2001). After identifying a heightened risk of falls in a patient, the physician refers the patient to a rehabilitative clinician for further evaluation and treatment for fall risks (Phelan et al., 2015a; Satariano et al., 2012). As noted in the systematic review examining 159 random control trials of older patients at risk for falls, if physicians identify the fall risk factors for that patient, schedule a follow-up assessment, and write a referral for a rehabilitative clinician, the chance of falls is reduced by 24% (Gillespie et al., 2012).

Physical and Occupational therapists: the fall risk specialists

PTs and OTs serve as rehabilitation clinicians in the frontline defense against older adult falls and related injuries (Jette et al., 2003; Lenze et al., 2004; Rappolt & Tassone, 2002). PTs and OTs have professional educational backgrounds that reinforce how to improve mobility safety, improve home safety, and reduce the fall risk of patients (Avin et al., 2015; Bleijlevens et al., 2010; Leland et al., 2012; Phelan et al., 2015a). PTs and OTs evaluate and address patients' mobility impairments and then design personalized treatment plans and implement treatment strategies to mitigate the deficits (Burtscher et al., 2024; Chen et al., 2022; Foster et al., 2014; Gillespie et al., 2012). The two primary interventions used by PTs and OTs for older adult fall prevention are 1) strengthening and balance exercises and 2) the incorporation of durable medical equipment (DME) such as walking adaptive devices (ADs) (Pirker & Katzenschlager, 2017; Van Hook et al., 2003). The two interventions are often used consecutively because rehabilitative therapists often include walking ADs as part of strengthening and balancing treatment programs and interventions (Phelan et al., 2015a).

Durable medical equipment

Assistive walking adaptive devices (ADs) are an example of durable medical equipment (DME). DME is defined as equipment considered medically necessary as prescribed by a physician, can withstand repeated use for medical reasons, must have an expected lifetime of at least three years, and must not be considered helpful to someone who is not sick or injured (Affairs (ASPA), 2013; *Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.). ADs are classified as DME, and ADs for mobility include manual and power wheelchairs, scooters, canes, walkers, crutches, commode chairs, hospital beds, and patient lifts (*What Are Some Types of Assistive Devices and How Are They Used?*, n.d.). Walking ADs are devices used to increase walking integrity and include canes, walkers, hemi-walkers, and crutches (*What Are Some Types of Assistive Devices and How Are They Used?*, n.d.). The most common forms of walking ADs for older adults are canes and walkers (Resnik et al., 2009a). The primary reason for using AD is to reduce the risk of falling while maintaining or increasing mobility for functional skills (Gell et al., 2015a). Walking ADs are theorized to help prevent falls among older adults by increasing the base of support (BoS), enhancing stability, and promoting safer participation in ADLs (O'Hare et al., 2013a; Smith et al., 2002).

Several avenues exist for older adults to acquire walking ADs. One approach involves having a medical physician (MD) prescribe the walking AD, akin to prescribing medication (Phelan et al., 2015a). However, instead of sending the prescription to a pharmacy, it is forwarded to a DME supply company, which fulfills the order after receiving authorization from the individual's healthcare insurance company (*Durable Medical Equipment Coverage*, n.d.). The cost of AD is contingent upon the individual's healthcare insurance policy, potentially imposing a financial burden on patients and influencing their inclination to obtain AD from MDs through healthcare channels (Osborne, 2014). The process of fulfilling DME requests can be labor intensive, burdensome, and costly due to the involvement of multiple parties, including the MD and staff, the patient and family, insurance companies, and DME companies (Teel et al., 2021).

Consequently, patients may purchase walking AD from sources that do not require MD prescriptions or insurance companies, such as privately paying for the equipment at a physical or online store (Health, 2018). Alternatively, patients may obtain their AD from secondhand sources, such as family or acquaintances, or purchase them at significantly reduced prices from thrift stores. However, obtaining walking ADs from secondhand sources carries the risk of needing more quality assurance protocols (Health, 2018).

2.6 Overview of EBP literature supporting balance and strengthening interventions to combat older adult falls

One of the two interventions for older adults with balance disorders is incorporating balance exercises into daily routines (Ng et al., 2019b). Because this population usually has multiple medical comorbidities, PTs, and OTs often establish and monitor the exercises and exercise programs to ensure safety and compliance (Pirker & Katzenschlager, 2017; Shubert, 2011). PTs and OTs focus on enhancing strength and endurance within their professional domains to increase older adult patient safety and functional independence (Phelan et al., 2015a; Rappolt & Tassone, 2002). EBP literature, including the best research evidence, patient value and circumstances, and clinical expertise, consistently supports the use of balance and exercise interventions as effective strategies for fall prevention among older adults (J. Moreland et al., 2003; Phelan et al., 2015a; Shubert, 2011).

The best research evidence for balance and strengthening interventions to combat older adult falls.

Overwhelming and non-controversial research evidence suggests, as noted in multiple meta-analyses and systematic reviews that decreased balance and strength contribute to older adults' falls. (Cheng et al., 2018; Hacıdursunoğlu Erbaş et al., 2021; Tinetti & Kumar, 2010). As a result, fall prevention programs that include strength and balance training have successfully prevented older adult falls ("Guideline for the Prevention of Falls in Older Persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention," 2001). When patients comply (patients participate in balance and strengthening programs and comply with the protocols), reduced fall rates appear to occur, as seen in an example from the United Kingdom where over 451 participants over the age of 65 decreased falls and decreased fall risk assessments after completing a balance and exercise program called *Staying Steady Healthworks* (James et al., 2022). A balance and strengthening program called *Lifestyle integrated Functional Exercise* (LiFE), which focuses on functional balance and strengthening, was used in a randomized control trial (RCT) comparing the LiFE program to standard gentle exercises and found those who participated in the LiFE program had a significant decrease in fall rates, increased measurement in ankle stability, increased measurements with static standing, and functional assessment scores compared to the previous year (Clemson et al., 2012). Another RCT that included 344 older adults who received balance and exercise programs at two locations, a clinic and at home, compared to age-matched cohorts who received no intervention, showed those who received intervention regardless of the site location showed a significant reduction in reported falls (Liu-Ambrose et al., 2019). A meta-analysis of 16 qualified RCT studies analyzing exercise and balance programs on fall rates of patients aged 65 or older found improvements in dynamic balance and static balance, decreased reports of fear of falling, increased balance confidence scores, increased quality of life scores, increased scores in physical performance, and an overall decrease in fall rate (Papalia et al., 2020b). Another meta-analysis comprised ten randomized control trials on older adults who participated in balance and exercise programs versus those who did not on fall rates, which showed that the intervention of balance and strengthening significantly reduced the number of reported falls (Sun et al., 2021).

Patient values and circumstance for balance and strengthening interventions for older adult falls.

Patient value and circumstance qualitative and quantitative studies can uncover factors that negate the intentions of the positive impact of interventions that patients face in accessing and adhering to healthcare interventions such as balance and exercise programs for fall prevention. Factors such as patient non-compliance rates for balance and exercise programs established by PTs and OTs could be as high as 50 % (Argent et al., 2018). A systematic review of older adults' compliance with balance and exercise programs found that patient circumstances of depression, isolation, and poor social support are common circumstances that negatively impact exercise compliance. However, with additional attention to interventions, these obstacles can be negated (Jack et al., 2010). An additional factor affecting the success of fall prevention was found from a cohort study of 10 older adults with documented fall occurrences at an assisted living facility who identified that the absence of a formal fall prevention program or exercises to prevent falls contributed to their fall history (Collins et al., 2022, p. 20). Understanding these factors to participate in fall prevention programs from a patient perspective is invaluable for healthcare providers to develop interventions that address these circumstances effectively to improve patient outcomes.

Patient perspective investigations unveil the profound influence of individual perceptions of fall risks on engagement with fall prevention programs (Dabkowski et al., 2022; Kiyoshi-Teo et al., 2020), which is highlighted in a study by Dabkowski et. al (2022) where participants and clinicians completed fall risk assessments, offering subjective evaluations, while clinicians employed objective measures from standardized tests (Dabkowski et al., 2022). The findings revealed that participants deemed elevated risk of falls based on objective clinician evaluations did not perceive themselves as such, leading to a disregard or non-attendance of programs aimed at enhancing balance, strength, and fall education, consequently exacerbating the occurrence of falls (Dabkowski et al., 2022). A similar study with 30 participants aged 65 and above, designed to gauge patient perspectives on fall prevention strategies, showed how individuals perceive their susceptibility to falls impacts their engagement with fall prevention interventions such as balance and exercise programs (Kiyoshi-Teo et al., 2020). Notably, participants who viewed their fall risk as temporary were more agreeable to adopting preventive measures such as balance and exercise programs. Those who perceived their fall risk as permanent were less willing to engage (Kiyoshi-Teo et al., 2020). The conclusion of both studies highlighted the need for heightened patient education to facilitate the recognition of fall risk factors and to foster an understanding that falls can be prevented with participation in balance and exercise initiatives for fall prevention (Dabkowski et al., 2022; Kiyoshi-Teo et al., 2020).

Studies of patient values and circumstances have also shown the success of programs. A survey of 451 participants over 65 who completed the balance and exercise program called *Staying Steady Healthworks* reported an improved ability to complete ADLs, improved confidence, and a reduced fear of falling (James et al., 2022). Patient perspective studies have also measured the success of increased compliance. For example, a study of 134 participants in a community exercise program focused on strengthening and balance found that when patients were in a group versus an individual, they reported increased compliance (Barmentloo et al., 2020). Another study with 122 older participants who completed a balance and exercise program called *ProAct 65+*. The results found that participants were more compliant with a flexible group program than a rigid schedule program with little flexibility (Lafond et al., 2019). Lastly, a study of 39 older adult participants who participated in a qualitative interview study after completing an RCT of balance and exercise fall prevention called the *StayBalanced* program revealed that the participants felt that the program's structure (exercise and education) led to safety and self-awareness during mobility, which they perceived as increased compliance (Halén et al., 2022).

In summary, studies of patient values and circumstances studies are vital to understanding how patients perceive education programs, which has enabled clinicians to develop new interventions, including patient teach-back skills, support systems to encourage compliance, and ways to incorporate the interventions into daily routines to increase compliance (Black, 2013; Willik et al., 2021). Patient value and circumstances studies have demonstrated how patient perspectives can influence the effectiveness of balance and strengthening programs for fall interventions in older adults. Using the EBP model interventions, such as those examined here, allows for refinement, adaptation, and insights gained from patient perspectives and compliance to tailor interventions to meet patient needs and enhance program effectiveness.

Clinician expertise for balance and strengthening interventions for older adult falls.

Various scholarly studies have examined clinical perspectives to identify obstacles that impede the effectiveness of exercise and balance programs in preventing older patients from falling. An example is from a particular investigation of 24 rehabilitative clinicians who reported obstacles within exercise programs aimed at fall prevention. The results revealed that the clinicians underscored the shortcomings of off-the-shelf exercise regimens, attributing their lack of success to the absence of personalized tailoring to individual patients (Haas et al., 2012). The clinicians reported significant improvements in patient outcomes when treatments accommodate the unique physiological profiles of each patient, thereby addressing their day-to-day requirements (Haas et al., 2012). A meta-analysis by Van Rhyn and Barwick (2019) explored barriers associated with exercise-based fall prevention programs, encompassing perspectives from clinicians on both patient and clinician barriers (Van Rhyn & Barwick, 2019). The study identified clinician barriers encompassing interpersonal conflicts with patients, inadequately established patient rapport, and limited clinician access to research findings supporting interventions (Van Rhyn & Barwick, 2019). The barriers to patient retention highlighted the lack of retention of learned skills, the denial of age-related balance issues, and the insufficient intervention duration (Van Rhyn & Barwick, 2019). An additional study from the clinicians' vantage point revealed deficient interprofessional communication, a lack of interventions to empower patients, and limited access to modes of patient education, which all impeded balance and strengthening fall interventions (Heng et al., 2022).

While most of the literature reviewed underscored the barriers predominantly from the clinicians' standpoint of exercise fall prevention programs, a single study demonstrated the efficacy of one program called the *Otago Exercise Programme* (OEP) (Cederbom et al., 2022). Insights from 17 physical therapists reported that the OEP significantly enhanced patient capacity for independence in ADLs, bolstered patient confidence, and elevated self-efficacy scores, facilitating patients to live independently in their home environments (Cederbom et al., 2022). Through this literature review of clinician perspectives on balance and exercise programs for older adult fall prevention, both obstacles and achievements studies can help refine existing interventions and enhance patient outcomes, reducing falls among older adults.

Summary of EBP for balance and strengthening programs for balance and strengthening interventions for older adult falls.

All three concepts of EBP are applied and have been investigated to endorse and evolve balance and exercise regimens aimed at fall prevention among older adults. The findings from this EBP literature review have highlighted certain areas necessitating additional focus, notably patient adherence. Using EBP has facilitated the progressive refinement of their intervention to better address the needs of patients, mitigating fall risks. While this intervention is not flawless, its use of EBP underscores a commitment to continual education and enhancement by examining the perspectives of patients and clinicians.

2.7 Overview of EBP literature for walking ADs as an Intervention to combat Older Adult Falls

The secondary strategy for fall prevention among older adults involves recommending and training walking ADs, such as canes and walkers (Bateni et al., 2004; Bateni & Maki, 2005b). Unlike the comprehensive investigations into the efficacy of balance and strength interventions for older adults within an EBP model, the use of ADs to prevent falls lacks support in the literature. Despite being widely accepted as a treatment intervention, the use of walking ADs has yet to undergo rigorous scrutiny akin to other interventions aimed at preventing falls in older adults.

Best research evidence for walking AD interventions for older adult falls.

The personal benefits of using AD, such as canes or walkers, are to enhance confidence, increase autonomy, and increase independence and safety to allow older community dwellers to remain independent while reducing fall risks (Teel et al., 2021). The walking AD's design will enable walkers to hold onto a handle or handle it with one or both hands and bear weight through the arm(s) to compensate for lower extremity weakness or poor motor control (J. Edelstein, 2019). Canes are generally prescribed for people with moderate impairment, while walkers are prescribed for those with general liability, debilitating conditions, and poor balance (J. Edelstein, 2019; J. E. Edelstein, 2007). Purportedly, ADs such as canes and walkers benefit the users by expanding the base of support (BoS), enabling a broader range of motion for the CoM, maintaining stability without compromising balance, reducing attentional demands, and promoting balance by reducing lower limb load (Bateni & Maki, 2005b; J. E. Edelstein, 2007; Miyasike-daSilva et al., 2013). Canes are recommended to accommodate mild sensory or coordination problems in visual, auditory, vestibular, peripheral proprioceptive, or central cerebellar disease (Lam, 2007). The cane stabilizes a patient's gait by providing an additional contact point with the ground, increasing the BoS (J. Edelstein, 2019; Lam, 2007). Ideally, the elbows should be flexed at 20° to 30° and 15 cm from the toes' lateral border, allowing elbow movement when holding a cane (Lam, 2007). The cane height should be about the distance from the ground to the wrist crease when the patient's arm is hanging by their side (Lam, 2007). Walkers are recommended for conditions such as poor balance, generalized weakness, restricted lower-limb weight bearing (e.g., post-hip surgery), and debilitating conditions (J. Edelstein, 2019; Stevens et al., 2009a). Proper fitting of the walker requires the patient to comfortably stand in the walker and the walker with the handles to the level of the wrist crease and the elbow angle at ~ 20–30 degrees (Stevens et al., 2009a).

Some studies report the benefits of walking ADs. The use of AD in the older adult population has led to increased independence with ADLs in long-term care facilities, improved QoL and social participation with a reduction of reliance upon personal care aids (Bateni & Maki, 2005b; Dicianno et al., 2019; Freedman et al., 2016; Meng et al., 2019). Gait analysis measures the benefits of AD in older patients. These studies look at parameters such as gait speed, step length, and cadence to determine whether gait improves with walking ADs. Long-term care resident participants showed increased stride time and length and stride length when ambulating with a cane compared to walking with no AD (Härdi et al., 2014). Cane use improved distance tolerance and gait speed for individuals with hemiplegia (Allet et al., 2009). Participants who suffered from spinal cord injuries also benefited from AD with reported increased community mobility and distance tolerance using a cane (Brotherton et al., 2012). Studies have shown that AD increases gait stability in older adults when the balance is challenged with obstacle terrain (Miyasike-daSilva et al., 2013).

There are also contradictory studies that show concerns for walking ADs. Lui et al. (2009) found conflicting results from Härdi et al. (2014) when residents who lived in an assisted living facility were grouped into two groups: 1) those who used AD and 2) those who were potential users (H. H. Liu et al., 2009). The study found that residents who walked with AD had significantly slower gait speed and step length when compared to potential AD users, indicating walking patterns may decrease when residents rely on AD for mobility (H. H. Liu et al., 2009). Studies also found that AD promoted decreased compensatory stepping and impeded lateral movements of the feet, which are movements to regain equilibrium when loss of balance occurs, and grasping mechanisms during balance recovery, concluding that AD could cause gait interferences, which can lead to falls (Bateni et al., 2004). ADs increase the attentional demand of the user, as seen by a study completed in 1992 but has not been reproduced which had five participants educated on how to use AD and five who were not (Wright & Kemp, 1992). Both groups completed a combination of walking, dual, and reaction time tasks with a standard and rolling walker (Wright & Kemp, 1992). The study found that regardless of the type of AD or the educational level of the participant, all participants increased their attentional demands when using ADs, concluding that the additional attention demand could increase fall risks (Wright & Kemp, 1992). Lastly, the long-term use of walking AD may correlate with falling risks, as seen in a longitudinal study that assessed older adult participants' limits of stability (LoS) measurements (from gait spatiotemporal parameters) (H. (Howe) Liu et al., 2017). The results indicated that over a five-month timeframe, participants who used a walker significantly decreased their LoS scores, indicative of fall risks (H. (Howe) Liu et al., 2017).

Patient values and circumstances for walking AD interventions for older adult falls.

Subjective patient studies are integral to EBP research because the results capture patient perspectives and experiences of healthcare interventions (Grocott & McSherry, 2018). Unfortunately, the literature review for AD as an intervention for older adult falls produced published research that needs to be updated and often did not focus on walking AD but on DME entirely. Because there is no overwhelming current and specific literature on patient perspectives on walking AD for older adult fall prevention, all articles, regardless of date and broad topics, are included in this dissertation's literature review.

Proper fitting of walking AD to individual patients and adequate training on how to use walking AD is crucial for ensuring the safety of older adults using walking ADs (Bateni et al., 2004; Joyce & Kirby, 1991). Ensuring optimal usage and technique of the equipment is critical to reducing the risk of falls, enhancing mobility, and promoting the independence of ADLs (Luz et al., 2015; Thies et al., 2020). Some studies demonstrate that AD may be dangerous to patients not only because of the biomechanics of gait but also because of how the patients use (or misuse) AD (Kraskowsky & Finlayson, 2001). Misuse of AD, which has been directly correlated to falls and fall risks, was noted in the systematic review completed by Lovarine et al. in 2013 (Lovarini et al., 2013). Misuse can occur because of an inappropriate selection of AD, which can result in abnormal gait patterns that are not beneficial to the walker, increase energy expenditure, and increase the risk of falls in patients (Bateni & Maki, 2005b; Joyce & Kirby, 1991). The appropriate fit and adjustment of walking ADs are essential to effectively addressing balance and mobility concerns, as improper fitting of ADs leads to walking with decreased stability and increased fall risk (Thies et al., 2020). Training patients to use AD correctly and ensuring the AD appropriately fits is also vital to prevent falls (Luz et al., 2015). Patient perspective studies also capture this insight, as seen in a study by Mann et al. (1995) that interviewed 105 community-dwelling older adults who use canes for mobility (Mann et al., 1995). The participants blamed lack of training and fitting as reasons for tripping with their cane (Mann et al., 1995). In addition, 262 participants with a fall history who reside in an assisted living facility and rely on different walking ADs for mobility reported never receiving training on using their AD in their home environment (68%), with only 50% reporting receiving training on proper device use (Luz et al., 2015). The study concluded that better fitting and education could prevent falls in this population (Luz et al., 2015). Best research evidence and patient value and circumstance studies both point to the lack of training and proper fitting as reasons for AD misuse and abandonment (Dicianno et al., 2019; Kraskowsky & Finlayson, 2001; Larsson Ranada & Lidström, 2019).

The abandonment (stopping use) of walking AD by older adults can pose significant dangers, including increased risk of falls, loss of mobility independence, and potential exacerbation of underlying health conditions (Bateni & Maki, 2005b; O'Hare et al., 2013a; Thies et al., 2020). Patient perspective studies give insight into why older adults abandon their walking ADs. In 1993, Phillips and Zhao completed a survey of 127 older adults with various disabilities to understand further how DME was selected and used (Phillips & Zhao, 1993a). Though walking ADs was not the study's primary focus, a dedicated survey section addressed this subtopic. The study found that compared to all other types of DME, walking ADs were most frequently abandoned (Phillips & Zhao, 1993a). The risk of abandonment was most significant in the first five years of use, and the primary reason listed for abandonment was a lack of patient insight during the selection process. The study's conclusion reiterated the importance of collecting patients' opinions when recommending or training with DME (Phillips & Zhao, 1993a). A correlation between abandonment and the lack of patients' insight when the AD was distributed to them was found in another patient perspective study (Resnik et al., 2009a). Additionally, a literature review of fourteen patient perspective studies identified primary reasons for walking AD nonuse (or permanent abandonment). The results revealed that when the AD was not fit for the patient, the environment was not conducive to the use of AD, or the equipment was in poor condition, patients stopped using their devices (Kraskowsky & Finlayson, 2001). In another study, participants who sustained falls because of abandoning their AD stated the top reasons for their AD abandonment were: 1) believing the device was not needed, 2) forgetting to use the device, and 3) reporting the AD was not used because it gave the impression they were old (Luz et al., 2015).

Clinical experience for walking AD interventions for older adult falls.

To the author's knowledge, there are no peer-reviewed publications specifically addressing clinical expertise related to walking ADs for older adults' mobility impairments. While an internet search yields numerous advertisements advocating ADs for various conditions based on PT and OT recommendations, no peer-reviewed literature focusing on clinical perspectives of walking ADs was identified.

Summary of EBP for ADs

Balance and strengthening interventions for fall prevention in older adults are heavily endorsed by EBP literature. However, despite the widespread use of walking ADs in healthcare interventions for older adult falls, the intervention needs more substantial support from EBP literature. It is noteworthy and perplexing that rehabilitative clinicians and healthcare professionals for older adults readily use these two commonly employed fall interventions. However, only one is backed by evidence to justify its efficacy.

No contradictory studies were found to challenge the validity of balance and strengthening program interventions (Liu-Ambrose et al., 2019; Papalia et al., 2020b; Sun et al., 2021). However, the same cannot be said for walking ADs, which have numerous conflicting studies (Allet et al., 2009; Andersen et al., 2007; Bateni et al., 2004; Gell et al., 2015a; Härdi et al., 2014; Miyasike-daSilva et al., 2013; O'Hare et al., 2013a; Thies et al., 2020). Even a systematic review assessing the cost and benefits of waling ADs for fall prevention failed to conclusively determine their effectiveness due to overwhelming conflicting research (O'Hare et al., 2013a). Patient circumstance and value studies on balance and strengthening programs for older adults provided invaluable subjective information influencing the intervention success, which can inform the development of more robust programs (Allen et al., 2018; Barmentloo et al., 2020; Halén et al., 2022; James et al., 2022; Kiyoshi-Teo et al., 2020; Lafond et al., 2019; B.-W. B. Tai et al., 2016). For walking ADs, subjective patient circumstance and values studies are outdated and not specific to walking AD but more about assistive technology in general (Bateni et al., 2004; Kraskowsky & Finlayson, 2001; Phillips & Zhao, 1993a). Additionally, while data from both best research evidence and patient circumstance and values studies have been used to enhance the intervention for balance and strengthening programs, the same proactive approach is lacking for walking ADs (O'Hare et al., 2013a; Resnik et al., 2009b; Roman de Mettelinge & Cambier, 2015; Sun et al., 2021; B.-W. B. Tai et al., 2016). Despite research linking walking ADs to fall risk factors, no changes have been made to this intervention from an EBP literature standpoint (Gell et al., 2015b; O'Hare et al., 2013a; Thies et al., 2020). Furthermore, documented clinical expertise studies for balance and strengthening interventions have provided valuable insight from clinicians on treatment approaches and barriers to success, contributing to the intervention progression (Cederbom et al., 2022; Haas et al., 2012; Van Rhyn & Barwick, 2019). In contrast, there is a notable absence of literature on clinical expertise studies regarding walking AD interventions for older adult falls.

To improve patient outcomes, all three aspects of EBP literature (best research evidence, patient circumstances and values, and clinical expertise) must support the intervention (Bhargava

& Bhargava, 2007; Burki, 2021; Farquhar et al., 2002; Lehane et al., 2019). The lack of EBP literature may explain why older adults continue to experience falls despite using walking ADs.

2.8 Niche in current EBP research for walking ADs as a fall intervention for older adults

EBP is the foundational model for creating and implementing healthcare interventions (Bhargava & Bhargava, 2007; Farquhar et al., 2002; Lulin et al., 2016). However, the use of walking ADs for older adults with mobility disorders lacks the literature to support the EBP model, which may inadvertently increase the risk of falls. Notably, the lack of acknowledgment regarding the absence of EBP backing for this intervention could exacerbate the issue. To the author's knowledge, no research has explored the deficiency of EBP support for walking ADs as a potential contributor to falls among older adults. Consequently, this niche is the foundation for this dissertation.

Chapter 3 will address the niche from the many contradictory best research evidence studies using gait analysis and walking AD. Regarding spatiotemporal parameters, some studies indicate that the gait parameters increased, representing a healthy gait. However, others reported a decrease, indicating a less stable and more concerning gait with ADs. Bateni and Maki (2005) completed a systematic review on the subject. They found that although walking ADs can improve balance and mobility, as shown through gait parameter measurements, they can also disrupt balance and require extensive metabolic demands (Bateni & Maki, 2005a). One concern about the research found for this literature review is that most of the studies examine older adults with no mention or consideration of medical or functional deficits. As previously mentioned, older adults have age-related deficits even with no additional diagnosis. The general health of the study participants could be more apparent as many occur in assisted living or long-term care facilities. In addition, none of the literature review studies used CoM measurements to assess gait; they relied only on spatiotemporal parameters. The CoM is a reliable way to detect discrepancies in gait that cannot always be in other objective measures (Tesio & Rota, 2019b). So, although EBP's best research evidence studies exist, there are inconsistent previous findings. A niche in the literature is that no known study has analyzed gait with spatiotemporal parameters and with CoM motion measurements of healthy participants to understand AD's impact on non-obstructed gait. The first study of this dissertation (chapter 3) will examine this question to contribute to the best research practice of EBP for walking ADs as an intervention for older adults with mobility disorders.

Both best research evidence and patient value and circumstance studies have identified factors such as proper fitting, training, education, and personal input as essential for the successful use of AD. The niche in current patient value and circumstance literature is a contemporary investigation of these factors. The second study of this dissertation (Chapter 4) will investigate these factors from a patient perspective to identify areas for quality improvement for AD and fall prevention in older populations.

To date, no studies have qualitatively or quantitatively addressed the clinical experience of PTs and OTs for older adults using walking ADs as an intervention for mobility disorders. Therefore, no studies have established a baseline of clinicians' demographics and standard practices for evaluating and treating older adults who use walking ADs. Chapter 5 of this dissertation will serve as the final investigation, examining the baseline characteristics of PTs and OTs who use walking ADs as an intervention for older adult falls.

CHAPTER 3

EXPERIMENT ONE: WALKING ADAPTIVE DEVICES CONTRAIN ACCELERATION OF THE CENTER OF MASS AND REDUCES GAIT SPEED IN HEALTHY ADULTS

3. 1 Introduction

Over the past two decades in the United States, falls among older adults have increased, becoming the leading cause of death in that population and a health crisis with an annual cost of $54 million (Haddad et al., 2019; B. Moreland, 2020). Most falls experienced by older adults occur while walking (Li et al., 2006). Falls happen when an individual's center of mass (CoM) extends beyond their base of support (BoS). The BoS refers to the area of contact with the ground surface that supports the body (Nam et al., 2017). A wider BoS enhances stability, offering better balance (Yoo et al., 2012). The CoM is a point where the mean of the mass distribution occurs and helps consider how the total body mass acts. For a human standing upright in the neutral position, the CoM is located approximately at the third-fifth lumbar vertebrae (Howcroft et al., 2013). During walking, as the individual pushes off the ground with one foot, their CoM shifts toward the contralateral side (medial-lateral axis, ML), forward (anterior-posterior axis, AP), and upwards (vertical axis, VT) (Lugade et al., 2011). Consequently, this results in the CoM moving outside the BoS. However, dynamic stability is maintained by placing the other foot on the ground and extending the BoS to encompass the CoM to prevent loss of balance (Tesio & Rota, 2019a). Measuring the motion of the CoM along these axes provides a means for assessing stability, where smaller displacements/ accelerations of the CoM indicate more excellent stability (Alberts et al., 2015; Tesio & Rota, 2019b). Older adults produce reduced CoM motion in all three axes (ML, AP, and VT) compared to younger healthy walkers, which is likely a strategy for enhancing stability (Menz, 2003b).

Spatiotemporal parameters, such as gait speed, step length, and cadence, have been more commonly measured than CoM motion in investigations of normal and pathological gait (Aboutorabi et al., 2016). Standard spatiotemporal gait parameter changes seen with age are labeled “cautious gait,” defined as a slower gait speed with shorter step length and minimal changes in cadence (Paul et al., 2009; Voloshina et al., 2013). These gait changes are associated with weakness in the musculoskeletal system, deterioration of the central and peripheral nervous system, or even fear of falling (Härdi et al., 2014; Herssens et al., 2018; Maki, 1997). Given that these individuals can walk faster when prompted, and the slower, shorter strides would convey reduced motion and acceleration of the CoM in ML, AP, and VT axes, this cautious gait is likely an effort to increase stability for those with balance deficits (Orendurff et al., 2004). Even though older adults adopt this more cautious, stable gait, the considerable number of falls in this population indicates that this strategy is not remarkably successful at fall prevention (Barak et al., 2006; Latt et al., 2007; Menz, 2003a).

To combat fall risks in older adults, adaptive devices (ADs) such as canes and walkers are prescribed (Gell et al., 2015a). ADs increase the BoS of the user, which in turn hypothetically normalizes walking spatiotemporal parameters (Luz et al., 2015). Millions (13.8%) of older adult Americans use ADs while walking (Anderson et al., 2004; Clark, 2015). This percentage is projected to increase as the population ages (Gell et al., 2015a). The benefit of ADs in older adults is correlated to increases in independence with activities of daily living (ADL), an increase in quality of life, and a reduction of reliance upon personal care aides (Bateni & Maki, 2005b; Dicianno et al., 2019; Freedman et al., 2016; Meng et al., 2019). Using walking ADs has significantly increased their gait velocity, swing time, and stride time among older adult long-term care residents (Schülein et al., 2017). Long-term care residents also increased stride time and length when walking with a cane compared to walking without AD (Härdi et al., 2014). Canes improve distance tolerance and gait speed for individuals with hemiplegia (Allet et al., 2009). With all the benefits of ADs, the fall rates of older adults would be expected to decrease as the number of mobility ADs is distributed. Unfortunately, this is not the case; the number of falls among older adults continues to increase, with 36 million falls and 32,000 deaths annually (Bergen et al., 2016).

Contrary to previously mentioned studies that demonstrated AD benefits, studies have also shown that ADs can have adverse effects on gait. Assisted living facility residents decreased speed, step length, and cadence when given an AD for walking. In addition, the study compared residents who were “potential users” to those who were “current users” of ADs and found that those who were current users had significantly slower gait speed and step length (H. (Howe) Liu et al., 2017). Walkers and canes have even been found to interfere with balance recovery in healthy young adults by impeding the lateral movement of the feet during compensatory stepping (Bateni et al., 2004). Hence, ADs may even contribute to some falls. Indeed, annual estimates of 47,312 older adult fall injuries in the United States were associated with older adults who rely on walking ADs (Stevens, 2005).

The preceding highlights the conflicting findings regarding the effects of ADs on gait. A systematic review of ADs concluded that insufficient evidence exists to determine whether ADs increase or decrease fall risk in older adults (O’Hare et al., 2013b). A potential reason for the variation in previous findings is comorbidities in the participants and their heterogeneity within and between studies. The participants in most AD studies are older adults who live in nonindependent environments and have pre-existing health conditions, indicating confounding variables that were not accounted for during gait analysis. While it is essential to investigate the effects of ADs on individuals with gait and balance disorders, we can understand the impact of ADs on gait by examining healthy walkers, which will provide a baseline for studying the effects of ADs on individuals with different deficits. Previous research on ADs has focused on quantifying spatiotemporal parameters of gait, with little concern for CoM motion changes. Maintenance of balance is achieved by keeping the CoM dynamically within the BoS. ADs extend the BoS, but whether this promotes more significant CoM motion is unknown. Therefore, the primary goal of this study is to determine the impact of ADs on spatiotemporal gait parameters and CoM motion of healthy adults. This study examines the most common types of ADs: single point cane (SC), double canes (DC), and a front wheeled walker (FWW) (Van Hook et al., 2003).

3.2 Methods

Study design

This study used a within-subjects design, in which all participants walked without AD and with three types of ADs (SC, DC, and an FWW).

Participants

Twenty-five healthy adults (10 male/15 female) with a mean age of 42.2 ± 16.1 years volunteered to participate in the study. All participants were screened before the study as healthy, with no previously diagnosed comorbidities affecting musculoskeletal or neurological problems. All participants reported independence with ADLs and walking 1.5 miles without requiring AD and rest breaks.

Protocol

Before data collection, an explanation of all procedures and written informed consent, which the University's Institutional Review Board approved, was provided, and signed by all participants. Anthropometric measurements were taken with height, and weight was measured via a mechanical beam physician's scale with height. A triaxial accelerometer (Trigno Avanti, Delsys Inc, Natick, MA) was placed on the cleaned bare skin of each participant at the fourth lumbar vertebrae, approximating the CoM in the ML, AP, and VT axes during walking (Orendurff et al., 2004; Tesio & Rota, 2019b). The researchers provided verbal and written explanations and demonstrated how to use each AD properly. The equipment was adjusted for each participant to accommodate individual heights (Lam, 2007). The participants practiced with each AD for as long as needed. Once they reported being comfortable with the AD, the following four conditions were performed: 1) walking without AD (No AD), 2) walking with an SC, 3) walking with DCs, and 4) walking with an FWW. For each condition, the participants walked along a walkway (flat 28 m indoor hallway) for seven trials. At the beginning and end of the walkway, timing gates (Brower Timing System, Draper, UT) were placed to capture the time for each trial accurately. The participants walked approximately 1 m before the timing gates were engaged. The order of study conditions was counterbalanced before the participant's arrival.

Data Analysis

Triaxial accelerations were collected throughout each trial at a rate of 148 Hz. Acceleration data were processed using custom-designed code created in MATLAB software (MathWorks, Natick, MA). The data were filtered via a fourth-order, low-pass Butterworth filter with a cut-off frequency of 30 Hz. A correction factor was implemented based on trigonometric methods to obtain accelerations in approximately ML, AP, and VT axes (Moe-Nilssen, 1998). Six dependent variables were calculated: Walking speed (m/s) was calculated by dividing the walkway distance (28 m) by the time recorded from the timing gates. Step length (m) was calculated by dividing the distance (28 m) by the number of steps taken. Cadence (steps/min) was calculated by identifying the period between each vertical acceleration peak for each heel strike and dividing 60 by the average step time. Root mean square (RMS) was calculated for acceleration in the ML, AP, and VT axes. RMS measures the dispersion of the acceleration data relative to zero, quantifying the average magnitude of acceleration changes.

Statistical Analysis

All statistical analyses are performed via SPSS Statistics for Windows, version 27.0 (SPSS Inc., Chicago, Ill., USA). One-way repeated measures analyses of variance (ANOVA) were used to assess the effect of walking with and without ADs on the gait parameters and RMS of CoM. Significant main effects were followed up via Bonferroni post hoc comparisons. The significance level was 0.05 for all analyses, and the effect size was computed. Values are interpreted via Cohen's *d* as ≥0.2 as a small effect size, ≥0.5 as a medium effect size, and ≥0.8 as a large effect size.

3.3 Results

Spatiotemporal parameters of gait

Walking with ADs resulted in a significantly slower walking speed ($F_{(3,72)}$=10.54, p=.001) (Table 3.2). Post-hoc analyses found all ADs produced significantly slower gait speeds when compared to walking with no AD (*p's* < .05), but no significant difference between the types of

AD (*p's*> .05) was seen. Walking with DC had a medium effect on walking speed compared to walking without AD. Walking with an SC or FWW resulted in large effect sizes for speed compared with no AD. Walking with AD significantly decreased cadence ($F_{(3,72)}$= 16.82, p=.001. Post-hoc analyses found all AD produced significantly slower cadence compared to walking with no AD (*p's* < .05) but no significant difference between the different types of ADs (*p's*> .05). All ADs had a significant effect size on cadence relative to the no AD condition. In contrast to walking speed and cadence, AD had no significant effect on step length ($F_{(3,72)}$=.60, p=.62.

RMS CoM in the ML, AP, and VT axes

Figure 3.1 shows the acceleration of the CoM in the ML, AP, and VT axes during walking with no AD and with FWW. Walking with any AD resulted in more remarkable acceleration changes (RMS) at the CoM than walking without AD in all three axes. In the ML axis, RMS CoM was significantly reduced with a medium effect size for all ADs compared with no AD ($F_{(3,72)}$=8.41, p=.001). In the AP axis, walking with ADs also resulted in significant decreases in RMS CoM ($F_{(3,72)}$= 5.62, p=.002), with a medium effect size, compared with no AD. Finally, in the VT axis, CoM RMS was significantly reduced when participants used AD compared to walking with no AD ($F_{(3,72)}$=8.21, p=.0001), with a medium effect size. Post-hoc analyses of CoM RMS for all axes (ML, AP, and VT) found no significant differences (*p's*> .05) between any of the different types of AD.

3.4 Discussion

This study aimed to determine the effect of ADs on the gait of healthy adults. ADs are prescribed to enhance stability in those at risk of falling, but the effects on gait have been inconsistent in the literature. A limitation of previous studies is the variability in the comorbidities of participants. When participants have comorbidities that increase fall risk, it is difficult to isolate how ADs impact gait versus how ADs interact with comorbidities. While previous research has focused on spatiotemporal parameters of gait, the current study also measured acceleration of the lower trunk to understand how ADs impact the CoM during walking. Healthy adults were found to reduce gait speed and accelerations at the CoM when using three standard ADs, and no significant differences were observed between different AD types.

In principle, ADs allow more significant motion of the CoM during walking. ADs increase the BoS by extending contact with the ground outside the feet. A larger BoS increases stability by allowing the CoM to move further before passing outside of the BoS, leading to a fall unless the BoS is changed. With an AD, individuals could push off the ground with greater force, increasing acceleration of the CoM of the body upward and forward while using the AD outside of the feet to maintain the CoM dynamically within the BoS. This could increase gait speed. Instead, the use of ADs in the current study resulted in reduced acceleration of the CoM along all three axes (ML, AP, and VT) and a slower gait speed. The magnitude of CoM accelerations during walking has previously been shown to scale positively with speed. (Espy et al., 2010a; Latt et al., 2008; Menz, 2003b). Hence, the use of AD made the gait of healthy individuals resemble the slower, cautious gait of older adult individuals. While ADs have a deleterious effect on individuals without gait disorders, ADs may promote more significant CoM motion and faster gait speed for individuals with balance deficits or fear of falling who walk with reduced CoM motion without AD. A factor in prescribing an AD could be whether it leads to increased or decreased CoM motion and walking speed.

While ADs led to reduced walking speeds, the way this was achieved differed from that observed with aging. In the current study, participants slowed their gait speed by decreasing their cadence while maintaining their step length. In contrast, older adults' cautious gait is defined by a decrease in gait speed via a reduced step length but with minor changes in cadence (Maslivec et al., 2017; Paul et al., 2009; Toots et al., 2013). Espy et al. (2010) further examined gait speed and step length to understand older adults' cautious gait patterns. Decreased step length increases stabilization and reduces fall risk (Espy et al., 2010a). In theory, decreasing cadence could also enhance stability by slowing the motion of the CoM, making it easier to control from one step to the next, but this does not appear to be the mechanism adopted by older adults to enhance stability. ADs improve stability by increasing the BoS, and healthy adults adopt the same step length as they used without AD but slow down their step time. Given that they did not have balance concerns, this reduced cadence and CoM accelerations suggest that ADs disrupted their natural gait pattern.

The impact of ADs on CoM motion and spatiotemporal parameters of healthy adult walking highlights some disadvantages of ADs. According to the six determinants of gait theory, a significant contributor to the energetics of walking is the energy required to move the CoM. Therefore, VT and horizontal displacement of the CoM should be minimized (Saunders et al., 1953). This theory has since been refuted, with studies finding that reducing the VT displacement of the CoM increases the energetic cost of walking (Wurdeman et al., 2017). To reduce VT displacement, humans move their hips, knees, and ankles through a greater range of motion that requires increased muscle activity (Ortega & Farley, 2005; Wurdeman et al., 2017). Instead, by capitalizing on the stance leg acting as an inverted pendulum, mechanical energy can be better conserved as the CoM raises during the stance phase, reducing the overall energetic cost of walking (Kuo & Donelan, 2010). The reduced magnitude of CoM acceleration in the current study suggests that holding a cane or walker disrupts the inverted pendular movements of the stance leg, likely making gait with an AD less efficient.

The efficiency of gait is further affected by the reduced cadence observed when walking with an AD. Healthy adults prefer to walk at a cadence and step length that minimizes the energetic cost for a given walking speed (Holt et al., 1991; Waters et al., 1988). The preferred cadence has been successfully modeled as the resonant frequency of a hybrid spring-pendulum, which requires additional force to oscillate at faster or slower frequencies (Hatsopoulos & Warren, 1996). Observing that ADs resulted in a slower cadence without a significant change in step length indicates that individuals adopted spatiotemporal gait parameters found to increase the energetic cost of transport (i.e., to walk a given distance) (Elftman, 1966). Prior research has demonstrated that walking with ADs, such as standard and four-wheeled walkers, is energetically more expensive than an unassisted gait (Priebe & Kram, 2011). Changes to the spatiotemporal parameters and motion of the CoM will likely significantly contribute to the increased energetic cost of walking with AD. This increase in energetic cost may discourage the use of ADs, and alterations to the typical gait pattern and reliance on the extended BoS could negatively transfer gait stability when individuals with ADs elect to walk without them, potentially increasing their fall risk.

3.5 Conclusion

ADs aim to increase gait stability by extending the BoS, allowing the CoM to move safely through a larger area. Nevertheless, for healthy adults, SC, DC, and FWW all led to a slower gait speed, decreased cadence, and smaller accelerations of the CoM in all three dimensions. No significant differences were observed between ADs. These changes disrupt the pendular properties of gait, which likely contributes to the increased energetic cost of walking with AD. Increased energetic cost of walking likely discourages the use of ADs, and alterations in gait may have a negative transfer effect when individuals with ADs elect to walk without them, putting them at more risk of falls.

3.6 Limitations

The metabolic costs of walking were not measured in this study but were inferred by associating the findings with previous literature. Because the study focused on acute adaptations to ADs, it is unknown whether the gait changes would remain over the extended practice with ADs. Studying healthy adults provided a base for understanding the effects of ADs, but further research is needed to examine the impact on different patient populations.

Table 3.1

Anthropometric Measurements of Participants

Anthropometric measurements	*Mean (± Standard Deviation)*
Age (years)	42.2 (±16.10)
Height (cm)	168.42 (±9.90)
Weight (kg)	74.25 (±10.58)

Note: N=25

Table 3.2

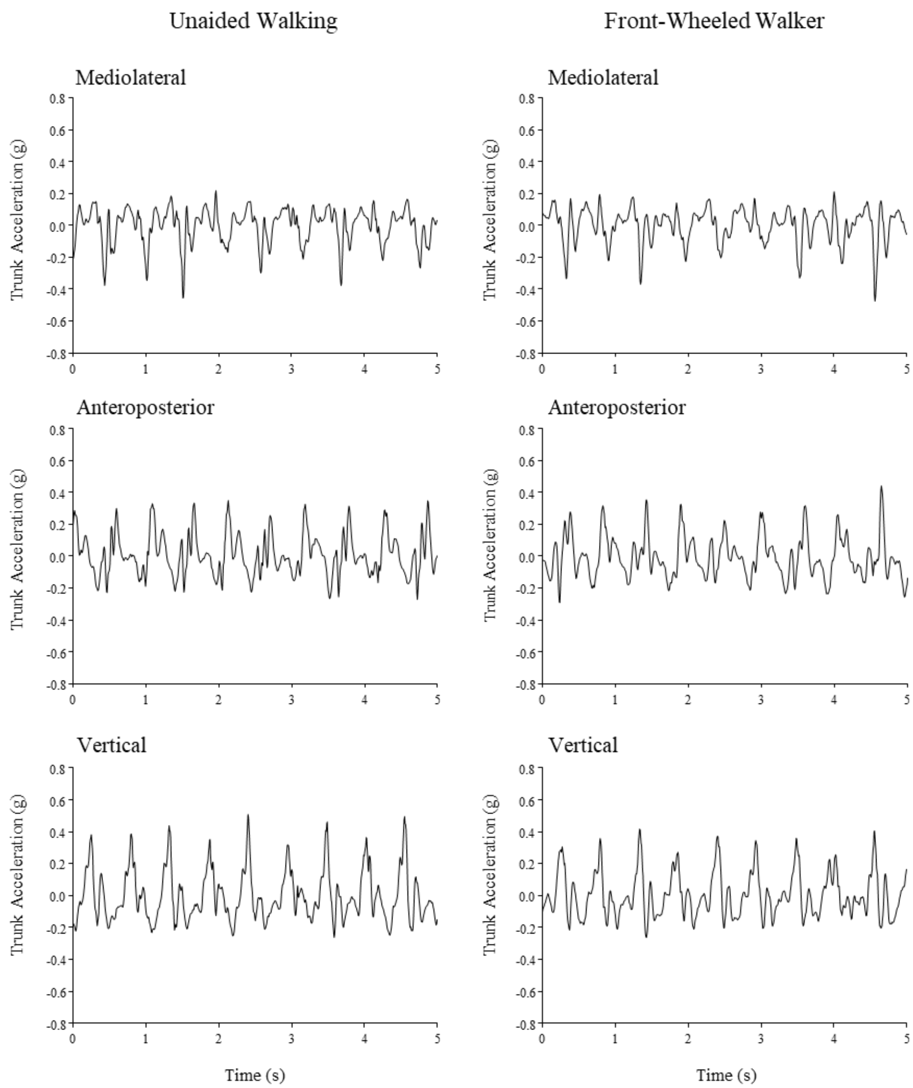
Spatiotemporal Parameters and CoM RMS in the AP, ML, and VT Axes for all Four Walking Conditions

	Conditions				
Dependent Variable	No AD	SC	DC	FWW	P value
Gait Speed (m/s)	1.69(0.163)	1.52(.198)* *d* = 1.04	1.52(.228)* *d*= 1.04	1.58(.228)* *d*= .67	<.001
Step Length (m)	0.87(.07)	.85(.07) *d*= .29	.86(.07) *d*= .14	.85(.07) *d*= .29	.620
Cadence (steps/ minute)	116.67(6.45)	106.63(9.79)* *d*= 1.56	106.11(12.16)* *d*= 1.50	110.78(10.05)* *d*= .91	<.001
Trunk ML (RMS)	0.12(.022)	.11(.025)* *d*= .45	.11(.026)* *d*= .45	.11(.025)* *d*= .45	.010
Trunk AP (RMS)	0.15(.030)	.14(.026)* *d*= .33	.14(.027) *d*= .33	.13(.031)* *d*= .67	.002
Trunk VT (RMS)	0.18(.05)	.16(.04)* *d*= .40	.16(.04)* *d*= .40	.15(.04)* *d*= .60	<.001

Note. N=25. Abbreviations: CoM= center of mass; AD= adaptive devices; SC= single cane; DC= double canes; FWW= front wheeled walker; m= meter; s= seconds; RMS= root mean squared; ML= mediolateral; AP= anterior-posterior; VT= vertical. Mean (standard deviation) denoted asterisk (*) = Significantly different compared to walking with no adaptive device ($p < 0.05$), *d*= the effect size of Cohen’s *d* compared to walking with no adaptive device.

Figure 3.1

Acceleration of the Center of Mass in the Mediolateral, Anterior-Posterior, and Vertical axes during Walking with no Adaptive Devices and with a Front Wheeled Walker



CHAPTER 4

EXPERIMENT TWO: PATIENT PERSPECTIVES ON WALKING ADAPTIVE DEVICES AND THE RELEVANCE TO FALLS

4.1 Introduction:

Falls among older Americans represent a significant public health challenge, with millions occurring annually and imposing substantial economic burdens (Ambrose et al., 2013; Bergen et al., 2016; Florence et al., 2018). One strategy to combat falls relies on integrating walking adaptive devices (ADs) such as canes and walkers into the mobility practices of older adults (Van Hook et al., 2003). There are three main avenues through which consumers can acquire walking ADs: through medical doctors (MD), by privately purchasing the AD (PP), or by obtaining AD from second-hand sources (SH) (*Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.; Teel et al., 2021).

Since the implementation of the Affordable Care Act in 2010, for a consumer to have their healthcare insurance cover either a portion or the entire cost of their AD equipment initiation by an MD is required (Affairs (ASPA), 2013; *Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.). Following an in-person assessment by an MD, if the AD is deemed suitable to enhance mobility skills, the MD will issue a prescription for the walking AD (Affairs (ASPA), 2013; Phelan et al., 2015a). Subsequently, the prescription is forwarded to a durable medical equipment (DME) company for fulfillment, and the cost is invoiced according to the amount of the consumer's healthcare insurance coverage (*Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.). The responsibility of DME extends beyond billing and supplying AD; it also encompasses the initial education of the user on proper fitting and usage techniques for safe mobility (Affairs (ASPA), 2013; Teel et al., 2021).

Obtaining AD from MD offers benefits such as mandated clinical assessment to determine suitability, proper fitting, and education on usage (Phelan et al., 2015a; Satariano et al., 2012; Teel et al., 2021). Additionally, MDs commonly refer patients who require AD for mobility to physical therapy (PT) and occupational therapy (OT) (Phelan et al., 2015b; Satariano et al., 2012). This referral allows a comprehensive evaluation and treatment from clinicians specializing in mobility disorders (E. R. Burns et al., 2016; Phelan et al., 2015b). Hypothetically, this referral process allows healthcare professionals to provide additional fitting, training, and education and solicit patient input regarding AD (Dumurgier et al., 2009; Karinkanta et al., 2010). Acquiring AD from MD includes safety measures designed to reduce the rate of falls associated with using AD during mobility (Teel et al., 2021).

However, barriers exist for consumers who obtain their AD from MD, including poor collaboration and communication between the multiple parties involved (MD and staff, the patient and family, the insurance company, and the DME company) (Teel et al., 2021). Obtaining AD from an MD can be time-consuming and burdensome for the consumer, negatively affecting the willingness to obtain ADs from medical channels (Osborne, 2014; Teel et al., 2021). In addition, not all healthcare insurance companies cover the entire cost of walking AD and rehabilitation therapy interventions, so there can be associated insurance co-pays, which is not an option for all who require these devices (Affairs (ASPA), 2013; Teel et al., 2021).

These barriers can lead patients to obtain AD from alternative sources such as privately purchased (PP) from brick-and-mortar stores, online retailers, or second-hand (SH) sources. PP ADs typically have printed instructions for self-education on fitting and safety practices (*What*

Medicare Covers | Medicare, n.d.). This option allows consumers to explore assorted brands, styles, and prices of AD, but acquiring new AD can be costly, making it unfeasible for some individuals (Phelan et al., 2015b; Satariano et al., 2012; Teel et al., 2021). Some consumers opt for SH sources to obtain their walking AD for cost-effectiveness and convenience. AD can be borrowed or given to individuals from friends, family, and neighbors. Consumers can also purchase AD from SH thrift stores at a drastically reduced price. SH sources offer cost mitigation but lack personalized fitting, training, or educational materials.

The use of walking ADs has been associated with increased independence in activities of daily living (ADLs) in long-term care facilities, improved quality of life and social participation, and reduced reliance on family and personal care aids (Bateni & Maki, 2005a; Freedman et al., 2016; Meng et al., 2019). However, despite their potential benefits, fall rates persist among users (Houry et al., 2016). Previous research highlights AD misuse as a contributing factor for older adult falls (Andersen et al., 2007; Bateni et al., 2004; Bateni & Maki, 2005a; Bradley & Hernandez, 2011; Gell et al., 2015a; Härdi et al., 2014; H. (Howe) Liu et al., 2017; J. E. Mahoney et al., 1999; Schülein et al., 2017; Thies et al., 2020).

Misuse of AD, characterized by improper posture, improper grasps, and abandonment (refraining from using the AD for essential activities either temporarily or permanently), has been linked to reported falls in numerous studies (Kraskowsky & Finlayson, 2001; Luz et al., 2015; Stevens et al., 2009b). To comprehend why older adults are misusing their AD and sustaining falls while using their AD, research was conducted explicitly focusing on AD from the users' perspective (Kaye et al., 2000; Phillips & Zhao, 1993a; Resnik et al., 2009a). The research unveiled various themes that shed light on the factors of misuse and fall among older adults. The identified factors include improper fitting, lack of training, inferior quality of training, inadequate education, and neglect to consider the consumers' opinion during the AD selection process (Alexander, 1996; Joyce & Kirby, 1991; Kaye et al., 2000; Kraskowsky & Finlayson, 2001; Phillips & Zhao, 1993b; Resnik et al., 2009a). However, the existing literature on these factors from a user’s perspective is outdated, limiting our understanding of current methods of obtaining ADs and their potential impact on both perspectives and falls. Although differences in fitting, training, and education between the MD, PP, and SH avenues for obtaining ADs have been recognized, it remains unclear how these differences influence perspectives on factors contributing to AD misuse and whether they are associated with self-reported falls.

This study aims to assess the influence of acquisition avenues (MD, PP, SH) on consumer perceptions of misuse factors and examine their association with self-reported falls. The hypothesis is that those who obtained their walking AD from an MD compared to those who obtained AD from PP and SH groups will perceive that their AD was fit for them, that training was completed with high scores for training satisfaction, that educational materials were provided to them, and that their input was considered while obtaining the AD. The PP group will report that fitting, training, satisfaction, education, and solicited opinions were received but with less frequency when compared to the MD group (but with higher frequency when compared to the SH group). Compared to the PP and MD groups, the SH group will report minimal fitting, training, satisfaction, education, and solicited opinions. Because we hypothesized that both the MD and PP groups would perceive they received fitting, training, higher satisfaction, and more reports of solicited opinions of AD, we also hypothesized that the MD and PP groups (with no significant difference between the MD and PP groups) would report significantly fewer falls for the six months preceding the study when compared to the SH group. Lastly, we hypothesized that there would be a significant difference in ages between the groups, with the PP group being significantly younger than the MD and SH groups (with no significant difference between the MD and SH groups).

4.2 Methods:

This study used a cross-sectional, paper-based survey to achieve the established aims. The study was approved by a university IRB before data collection.

Instrumentation development

Due to the lack of patient-reported outcome measure (PROM) surveys assessing the patient's perspective on obtaining walking ADs, one was created for this study. A pair of researchers, one with over 15 years of clinical rehabilitation therapy experience and one with a decade of survey-based healthcare research experience, created a subjective survey to address the study's aims. To validate the survey, four professional and licensed rehabilitation therapists (2 PTs and 2 OTs) completed a Content Validity Index (CVI) (Polit et al., 2007; Polit & Beck, 2006). The therapists used a structured grading system ranging from 1-4 to evaluate the survey, with a score of 4 indicating that the question was clear and relevant to the research aims and a score of 1 indicating a lack of alignment with the research aims. If the question received a score of 1 or 2, the therapists were prompted to provide suggestions for improvement to align it to the research better aims. These recommendations were then integrated into the survey and subjected to subsequent content validity testing by the same four professional therapists. The final version of the study survey achieved a Content Validity Index for Averages (CVI-A) score of >0.90, indicating excellent content validity (Polit et al., 2007; Polit & Beck, 2006).

Instrumentation

The final survey instrument consisted of nine questions. Questions 1 and 2 of the survey were demographic and asked about participants' age and gender, respectively. Question 3 asked participants how they obtained their walking AD (medical doctor (MD), private pay (PP), or second-hand (SH)). Questions 4-7 were PROMs on patient perceptions of acquiring ADs. Question 8 asked participants to rank their satisfaction (0-7, with zero being no training and seven equating to excellent) with the AD training they received. Question 9 asked the participants the number of falls they had sustained in the last six months. The final survey is available in Appendix A.

Participants

We employed convenience sampling to recruit geographically local patient participants who were 55 years old or older, independent with activities of daily living, presently using walking ADs, or had used walking ADs in the past. Patients were recruited in person at outpatient rehabilitation clinics, community-dwelling business areas such as grocery stores, senior living apartment buildings, and religious institutions around the Hampton Roads area of Virginia. Once inclusion status was established and consent to participate was obtained, the participants were given a paper survey. A research team member was present to answer questions and collect the surveys upon completion.

Data Analysis

Descriptive statistics (frequency, mean, standard deviation (SD)) were used to characterize our participant population with information from questions 1 and 2. Question 3 categorized participants (MD, PP, or SH) and was used as the independent variable with three levels. In addition to descriptive statistics, a one-way between-subjects analysis of variance (ANOVA) with a Bonferroni post-hoc analysis was used to determine if the participants' ages differed significantly between groups. The effect size was computed for both ANOVAs and the values were interpreted via Cohen's *d* as ≥0.2 as a small effect size, ≥0.5 as a medium effect size, and ≥0.8 as a large effect size.

The data from questions 4-7 was categorical with "Yes, Maybe, or No" responses; therefore, 3x3 Pearson's Chi-Squares with Bonferroni corrections were performed to identify relationships between how patients obtained their AD and their answers to the PROMs. Question 8 was analyzed using a Kruskal-Wallis, non-parametric test for interval data, which had patients report satisfaction scores for AD training. If significant, the Kruskal-Wallis was followed with a Mann-Whitney, non-parametric assessment. The significance level for the non-parametric analyses was adjusted to $p > 0.017$ ($0.05 \div 3$). Question 9 asked the participants the number of self-reported falls in the last six months, and this was analyzed using a one-way between-subjects ANOVA with a Bonferroni post hoc analysis. The significance level for all ANOVA analyses was set a-priori at $p > 0.05$.

4.3 Results:

Demographics survey questions

There were 226 participants in the study, consisting of 92 who identified as male and 134 who identified as female (Table 4.1). Most respondents (62.8%) reported acquiring their AD from a medical professional (MD). The lowest number of respondents (15.93%) reported obtaining their AD (new) from PP sources, such as online or from a store. The other respondents (21.24%) received their AD (used) from SH sources. Combined participants' age ranges were 55-96 years old (mean age of 68.96 ± 16). The results of the ANOVA examining age revealed significant differences between groups, $F_{(2,223)} = 6.91$, $p < 0.001$ (Figure 4.1). Bonferroni post hoc analysis revealed that MD group participants were significantly older than the PP group (p=.001) with a calculated effect size via Cohens $d = 0.58$, showing a median effect.

Survey Questions with the options of "Yes, Maybe, No" responses

Table 4.2 displays all the PROM responses for all the questions with "yes, maybe, or no" responses. Participants were asked if their AD was correctly fit when it was obtained. There was an association found between how an AD was received and if the patient perceived the AD was correctly fit for their use ($X^2(4)= 30.27$, $p <.001$), with patients who received their AD through PP being more likely to indicate that their AD was appropriately fit for them when compared to the MD and the SH groups. The SH group was more likely to suggest that their AD was not appropriately fit for them. The percentages of participants whose AD was and was not adequately fit relative to how they obtained their AD are available in Table 4.2.

We asked participants if they received training on their AD when the device was received; a statistically significant association was found between how an AD was obtained and if the patient believed they received adequate training when they received their AD ($X^2(4) = 94.64$, $p < .001$) with participants who received their AD from SH significantly less likely to report training when compared to the MD and PP groups. The MD group was significantly less likely to report no training than the PP and SH groups. The PP group was significantly less likely to report no training than the SH group but more likely to report no training than the MD group.

Participants were asked if they received instructional handouts or additional educational material when obtaining their AD. There was a positive association found between how an AD was obtained and if the patient received instructional handouts or additional educational materials when they received the AD ($X^2(4)> = 56.14$, $p < .001$), with participants in the PP group more likely to indicate receiving instructional handouts compared to those who obtained AD from both the SH and MD groups. The SH group was most likely to report not receiving additional educational materials compared to both the MD and PP groups. The MD group was less likely to report not receiving additional educational materials compared to the SH group but more likely to report not receiving additional educational materials compared to the PP group. The PP group was significantly less likely to report not receiving additional educational materials compared to both the MD and SH groups.

We asked participants if their input or opinion was solicited during device fittings. There was an association found between how an AD was obtained and if the patient's opinion was asked during the fitting ($X^2(4)> = 66.29$, $p < .001$), with participants who received their AD from PP most likely to report having their opinion being asked when obtaining their AD compared to the MD and SH groups. The SH group was more likely to report having their opinion asked when obtaining their AD than the MD group but less likely to report having their opinion asked when obtaining their AD than the PP group. The MD group was the least likely to report having their opinion asked when obtaining their AD compared to the PP and SH groups. The MD group was more likely to report having their opinion asked (“Maybe” response) when obtaining their AD compared to the PP and SH groups. Finally, the SH group was more likely to report not having their opinion asked when obtaining their AD compared to the MD and PP groups.

Survey Questions of Satisfaction Rates of AD Training

We asked on a scale of 1-7, with one equating to “extremely dissatisfied” and seven equating to “extremely satisfied” (and 0=no training), how participants would rate their satisfaction with the training, and a Kruskal-Wallis's nonparametric test revealed no statistically significant differences between groups, ($H(2) = 5.76$, $p =.056$).

Survey Questions of self-reported falls in the past six months

Lastly, we asked our participants to quantify the number of falls they had experienced in the last six months (Figure 4.2). The MD group averaged 1.06 ± 1.14 falls, the PP group averaged 0.39 ± 0.77 falls, and the SH group averaged 1.48 ± 1.2 falls. The results revealed a significant effect of how participants obtained their AD on self-reported falls in the past six months ($F_{(2,223)} = 10.06$, $p < 0.001$). Bonferroni's post hoc analysis revealed a significantly lower number of reported falls for those participants who obtained their AD from PP compared to MD ($p=.004$) and SH ($p <.001$) groups which was followed by a Cohens *d* calculated for effect size which was 0.83 for both indicating a large effect for both groups.

4.4 Discussion:

Fitting and opinions

Adequate fitting of the device is crucial for its effectiveness, with proper adjustments based on the patient's height being imperative (Bradley & Hernandez, 2011). The results of our study revealed that participants in the PP group reported having AD fit appropriately for them. This group also reported sustaining significantly fewer falls than the other groups. On the other hand, the SH group noted that most participants felt their AD was not fitted correctly for them. This group reported the highest incidence of falls. The findings reiterate that poor AD fitting does not appear advantageous as it is negatively associated with falls. The association between poor AD fitting and the incidence of falls in older adults has also been highlighted in previous studies (Dollard et al., 2012; Hill et al., 2011; Luz et al., 2015). This correlation may stem from incorrect AD height promoting poor posture, incorrect usage of the device, incorrect gait patterns, or holding the device on the wrong side (Kaye et al., 2000).

The PP group perceived that their opinion was considered when obtaining ADs. The MD and SH groups perceived that their opinion was not solicited when obtaining AD. Again, the PP group reported sustaining the least falls, followed by the MD group, and the SH group reported sustaining the most. In general, lack of patient involvement in healthcare has been documented to correlate to poor health outcomes (Lenze et al., 2004). There are two studies in the literature that address patient opinions about AD (not specifically about walking AD but AD in general), and both found that a lack of patient input was correlated to misuse of ADs (Kuan et al., 1999;

Phillips & Zhao, 1993b). Again, misuse of walking AD has been correlated to falls, which was seen in our groups, who felt their opinion was not solicited.

Training, training satisfaction, and educational materials

Given the crucial role of training in ensuring safety during ambulation, this study was imperative to assess patient perceptions of the adequacy of their training in device usage (Sheehan & Millicheap, 2008). Most participants in both the MD and PP groups reported having received training on the proper use of ADs. The SH group overwhelmingly reported not being trained to use their AD. Patient subjective studies specifically pointed to a lack of training as a reason for the misuse and abandonment of ADs (Dicianno et al., 2019; Kraskowsky & Finlayson, 2001; Larsson Ranada & Lidström, 2019). This may be why the SH group had significantly more falls than the PP group. However, the MD group did report training but did not have significantly different fall rates compared to the SH group. This study also found no differences between groups and satisfaction with training.

Hence, training effectiveness extends beyond satisfaction, suggesting a need for supplementary educational materials to enhance the training process. Educational materials, such as handouts and videos, as patient reference sources allow for the carryover of skills and prolonged learning (Abramsky et al., 2018). The MD group, with 87%, and the SH group, with 100% of the participants, reported receiving no additional educational materials. Lack of patient educational materials has also been correlated with AD misuse (Larsson et al., 2019). This reiterates the importance of not only initial training but also carryover skills of patients by providing information to allow for continued education. Patients only sometimes comply with initial education; one study stated that only 50% adhere to education provided during medical interventions (Argent et al., 2018). A systematic review found around twenty common barriers to patient compliance, the most common being reported low self-efficacy, poor social support or activity, and increased pain levels (Jack et al., 2010). Strategies such as follow-up handouts, education in videos, caregiver education, and teaching back skills to patients can mitigate these barriers (Jack et al., 2010). Among our participants, the PP group reported that higher levels of educational materials were provided. This may be because when participants from the PP group purchased the new ADs, they arrived disassembled, requiring the consumer to consult with the provided product materials and instructions to assemble the device for proper usage. The provided product materials and instructions for the PP group may be perceived as comprehensive, encompassing fitting, training, and supplementary education materials. For the MD group, DME providers or subsequent PT and OT involvement should create treatment plans around patient education, including handouts (Abramsky et al., 2018). Although training was provided to the MD group, the absence of supplementary education materials such as handouts or additional recourses for post-initial training may have led to the information being overlooked or forgotten during the learning process. Supplementary education post-initial training can effectively reinforce training and enhance patient information retention (Jack et al., 2010).

The study must recognize age as a potential factor contributing to falls. Participants in the PP group were significantly younger than those in the MD group. Considering that older age is associated with higher incidences of falls, it is plausible that the PP group experienced fewer falls due to their younger age (Guralnik et al., 2001). However, it is noteworthy that no significant difference in age was found between the PP and SH groups. Nevertheless, there was a significant difference in the fall occurrences, with the SH group falling significantly more. Therefore, since age was not a contributing factor between the PP and SH groups, the other aspects of perceptions of fitting, training, additional educational materials, and solicited opinions played a significant role in the reported differences in fall incidences between the two groups.

Clinician recommendations from the findings of the study

When asked about satisfaction with the AD training, overwhelmingly, the participants responded with "neither agree nor disagree," inferring ambivalence to this vital step for the safety of AD use. The response highlights the need to improve clinicians' training approaches and merchandising strategies. Engaging patients more on a personal level and fostering interactions during AD training could potentially enhance therapeutic interpersonal relationships and subsequently improve satisfaction scores. For merchandising, having interactive training materials, such as interactive demonstration videos, could also increase the consumer's training engagement and satisfaction scores. For the MD group, a straightforward strategy to enhance the AD acquisition process is actively soliciting patient feedback regarding the fitting process, training received, and supplemental educational materials related to their AD. Patients need to feel involved in their medical care, and there is an apparent lack of this in obtaining ADs through medical channels. A solution to addressing solicited patient opinions for their AD is to implement standardized tests of satisfaction scores. Patient satisfaction is widely recognized as a patient outcome indicator of healthcare and can be applied to the acquisition and usage of ADs (Yellen et al., 2002). Standardized tests are an efficient and convenient method to quantify patients' experiences, which can influence compliance and satisfaction even with AD (Abramsky et al., 2018). Clinicians must also educate patients on their AD or schedule annual follow-up visits for maintenance education and fittings for AD checks.

Though it would not be a part of the acquisition stages of AD training, patients' AD maintenance can be incorporated into annual PCP assessments. This would include all groups, regardless of where patients obtain their AD. Simple questions such as the ones created for this survey could be asked during annual exams by PCPs or rehabilitation therapy assessments, which could help identify patients needing AD intervention. PCPs can also provide yearly AD education, which could be included in fall prevention. If the PCP cannot or does not want to complete assessment and education on ADs, they can offer annual referrals to PT and OT for AD checks. ADs can be viewed in the same manner as prescription medication. Insurance reimbursement for medication requires annual physician assessments, and the same policies could be incorporated for ADs. No rules or guidelines exist for re-evaluating AD after it is acquired. This becomes a problem for those who use AD for extended periods. Patients' health, posture, endurance, and function can change over time, but if no one checks on the AD use, the AD may not fit correctly or meet the patient's current needs. The SH group missed proper fitting, training, and education opportunities during acquisition. Having AD checks during annual PCP visits would allow for the correct fitting of the device for the patient, educating them on how to use it and providing additional education, such as handouts. Falls across all groups emphasize the need for extra support and intervention from clinicians (medical doctors and rehabilitation clinicians) irrespective of how the individual obtains AD. This highlights the importance of ongoing monitoring, education, and evaluations from healthcare providers to address patients' mobility needs and challenges to increase safety and decrease falls.

4.5 Conclusion:

Patient surveys are a critical piece of information to ensure clinical interventions are helping patients and can be used to decide on interventions to improve patient care (Burki, 2021; Mercieca-Bebber et al., 2018). They were used in this study to examine the participants' perspectives on obtaining walking AD to understand falls better in this population. The study revealed differences between the groups regarding fitting, training, educational materials, and solicited opinions. The study also revealed differences in groups and six-month fall rates. The group (PP) that perceived AD was fit for them, that training was received, that additional education was provided, and that their opinion was solicited had significantly lower fall rates when compared to the MD and SH groups. Subsequently, the reverse was true. The SH group perceived AD was not fit for them, training needed to be received, handouts were not provided, and their opinion was not asked of them, sustaining the most falls. Clinicians should provide patients with additional educational materials to supplement the education and training for walking ADs to improve long-term patient outcomes.

4.6 Limitations:

Subjective survey research data devoid of objective measures relies entirely on participant responses, which various limitations can influence. Examples of participant limitations in this study include response bias, poor memory recall, recall bias, and misunderstanding of the questions. Additionally, research limitations, including sampling bias due to the convivence sampling used in this study, potential failure to capture the perspective of all older adults using ADs, and inadequate accountability for all relative variables that could influence the outcomes, could have skewed the data. Lastly, the age of the participants can be a limiting factor as our participants were all over the age of 55, and physical limitations, cognitive decline, and generational differences between the groups cannot be discounted. The age limitation could influence the quality and reliability of data collected in this survey. Overall, all these limitations can undermine the validity of the study findings, affecting the conclusions drawn from the data.

4.7 Future research:

Longitudinal studies following patients beginning from acquiring AD could provide valuable insights into factors that influence the use of ADs and factors that contribute to falls. Comparative studies can compare different formats and delivery methods of AD fitting and training to determine which approaches are most effective for fall prevention and increasing patient satisfaction scores. Lastly, additional qualitative patient interview studies can be completed to delve deeper into patient experiences with AD to understand better patient perspectives for creating and implementing more individualized educational approaches for AD use.

Table 4.1

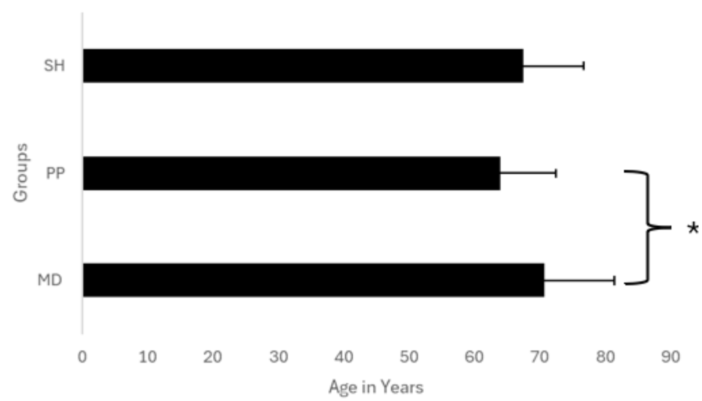
Participant Demographics of Gender

	Groups					
	MD		*PP*		*SH*	
	n	*%*	*n*	*%*	*n*	*%*
Gender						
Male	56	39.4%	14	38.9%	22	45.8%
Female	86	60.6%	22	61.1%	26	54.2%
Total	142	100.0%	36	100.0%	48	100.0%

Note. N = 226. Abbreviations: Medical Doctor = MD; Private Pay = PP; Second-hand = SH.

Figure 4.1

Illustration of the Age Characteristics of Participants between Groups



Note. Abbreviations: Medical Doctor = MD; Private Pay = PP; Second-hand = SH. Significant age differences are denoted with an asterisk (*).

Table 4.2

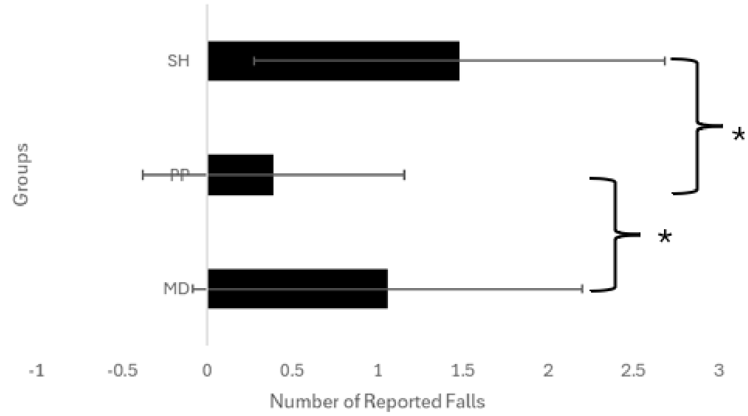
Survey Questions Regarding Fitting, Training, Personal Input, and Educational Materials.

		Groups					
		MD		PP		SH	
		n	%	n	%	n	%
Survey Questions	Responses						
When you received the device, was it fit for you?	Yes	63a	44.4%	25b	69.4%	13a	27.1%
	Maybe	36a	25.4%	3b	8.3%	4b	8.3%
	No	43a	30.3%	8a	22.2%	31b	64.6%
	Total	142	100.0%	36	100.0%	48	100.0%
Did you receive training when you received the device?	Yes	119a	83.8%	24a	66.7%	4b	8.3%
	Maybe	6a	4.2%	0a	0.0%	4a	8.3%
	No	17a	12.0%	12b	33.3%	40c	83.3%
	Total	142	100.0%	36	100.0%	48	100.0%
Were handouts of educational materials provided for you when you received the device?	Yes	7a	4.9%	15b	41.7%	0a	0.0%
	Maybe	11a	7.7%	3a	8.3%	0a	0.0%
	No	124a	87.3%	18b	50.0%	48c	100.0%
	Total	142	100.0%	36	100.0%	48	100.0%
Was your opinion asked of you when you received the device?	Yes	24a	16.9%	26b	72.2%	17c	35.4%
	Maybe	72a	50.7%	3b	8.3%	4b	8.3%
	No	46a	32.4%	7a	19.4%	27b	56.3%
	Total	142	100.0%	36	100.0%	48	100.0%

Note. N = 226. Note. Abbreviations: Medical Doctor= MD; Private Pay= PP; Second-hand= SH. Differing subscripts within rows (a, b, c) are significantly different at $p < .05$ based on Bonferroni’s post hoc paired comparisons.

Figure 4.2

Illustration of the Number of Self-Reported Falls in the Past Six Months of Participants.



Note. Abbreviations: Medical Doctor = MD; Private Pay = PP; Second-hand = SH. Significant differences in the number of falls are denoted with an asterisk (*).

CHAPTER 5

EXPERIMENT THREE: CLINICIAN EXPERTISE IN WALKING ADAPTIVE DEVICES FOR OLDER ADULTS

5.1 Introduction:

Older individuals experience changes in their balance and stability as they age, impacting their walking abilities and increasing the risk of falls (Menz, 2003a; Menz et al., 2003; Osoba et al., 2019). Falls pose a significant healthcare challenge for older Americans, affecting their functional independence and quality of life (Arigoni,D, n.d.; Houry et al., 2016). To address this issue, a group of skilled professionals known as rehabilitative clinicians including physical therapists (PTs) and their assistants [Physical therapy assistants (PTAs)] and occupational therapists (OTs) and their assistants [certified occupational therapy assistants (COTAs)] use therapeutic interventions specialized for decreasing falls and enhancing functional mobility and safety in older adults (Avin et al., 2015; Bleijlevens et al., 2010; Leland et al., 2012; Phelan et al., 2015a). Their interventions often involve the use of walking adaptive devices (AD) (such as canes and walkers) for older adults to increase independence and decrease fall risks during activities of daily living (ADLs) (Pirker & Katzenschlager, 2017; Van Hook et al., 2003).

Unfortunately, as the rates of AD distribution and use in older adults have excelled, so too have the incidents of falls among this demographic (Gell et al., 2015b; H. (Howe) Liu et al., 2017; Stevens et al., 2009b). Instead of eradicating falls, this intervention has raised concerns about potential contributions to fall occurrences, prompting scrutiny of this intervention (Gell et al., 2015b; Stevens et al., 2009b; Thies et al., 2020). One critical aspect requiring closer examination is the process by which the intervention was developed and whether its efficacy is being evaluated by evidence-based practice (EBP). Ideally, all treatment interventions to address older adult fall prevention should be found and supported by evidence from EBP literature (B. Moreland, 2020; Ng et al., 2019a; Papalia et al., 2020a). However, there is a notable gap with no clinical expertise studies in the literature on this subject, potentially compromising the effectiveness of these interventions (Makhene, 2022; Van Hook et al., 2003; Van Rhyn & Barwick, 2019). Without clinical expertise research, especially foundational studies identifying demographics, educational backgrounds, and standard assessment methods, crucial insights into intervention implementation can be missed, negatively impacting the intervention itself (Farquhar et al., 2002; Hallingberg et al., 2018).

Rehabilitative clinicians receive education in AD intervention as a part of their professional curriculum with mandated instruction and integration of training programs (*APTA Guide to Physical Therapist Practice 4.0*, n.d.; *Schools – ACOTE*, 2023). However, there are variations between the programs based on educational levels (*Accreditation Handbook*, n.d.; *Schools – ACOTE*, 2023; Mathur, 2011). For instance, while PT programs mandate a post-graduate doctorate level, OT programs must offer post-graduate master's level programs (doctorate-level programs are accredited at many institutions) (*APTA Guide to Physical Therapist Practice 4.0*, n.d.; *Schools – ACOTE*, 2023). Previously, both PT and OT programs were accredited with four-year undergraduate degrees. However, with changes in educational requirements mandating PT to be doctoral level by 2020 and OT mandated to be master level by 2007, the clinicians who graduated with lesser degrees were grandfathered into legal practice (T. Brown et al., 2015; Mathur, 2011). Consequently, many seasoned PTs and OTs with undergraduate degrees and PTs with post-graduate master's level degrees continue to practice legally. Accredited PTA and COTA programs are typically two-year associate degree programs

(*APTA Guide to Physical Therapist Practice 4.0*, n.d.; *Schools – ACOTE*, 2023). All rehabilitative clinicians can advance their education by pursuing a Doctor of Philosophy (Ph.D.) degree. Students with a Ph.D. or doctoral degree and those with a master's degree typically spend more time in formal education than those enrolled in undergraduate and associate degrees. Additionally, students with an undergraduate degree typically spend more time in formal education than those with an associate degree. As a result, the depth and extent of education on walking ADs may differ based on the level of education attained.

Education for AD interventions for rehabilitative clinicians extends beyond professional curricula. Despite differences in degrees, all rehabilitative clinicians have access to additional education on AD as a fall intervention through continued education (CE). CE is available through formal courses and workshops, informal self-education, mentorships, and on-the-job training (Burgess et al., 2018; Forsetlund et al., 2009; Gracía-Pérez & Gil-Lacruz, 2018; Hall et al., 2016). All forms of CE are vitally important for healthcare workers to be competent and effective in-patient care (Gallagher, 2007). While clinicians must acquire several hours (set by state mandates) of professional continued education credits (CECs), the topic of the CEC is at the discretion of the clinician (Hall et al., 2016). No state or federal laws require clinicians working with ADs to complete CE or CECs, specifically on ADs. The extent of rehabilitative clinicians' involvement with CE on AD and the impact of educational levels on CE remains unclear.

The literature review has identified gaps in AD EBP literature. Firstly, there is a lack of foundational studies that explore the clinical expertise of rehabilitation clinicians working with this demographic of patients. Secondly, there is a gap in the literature regarding the effectiveness of professional curricula and CE in adequately preparing rehabilitative clinicians to evaluate and treat older adults using walking ADs and if educational levels impact the perceptions of preparedness. Understanding these aspects is essential for improving the quality of care provided by rehabilitation clinicians in addressing older adult falls with walking ADs. Therefore, this study will be the first clinical expertise study to contribute to EBP on walking AD as a fall intervention through three sub-aims: 1) identifying clinician demographics, including walking AD educational backgrounds; 2) examining clinician preparedness ranking of walking AD education experiences and educational levels; and 3) identifying standard methods of assessment used by clinicians to determine walking ADs for older adults. Sub-aims 1 and 3 are exploratory, so only sub-aim 2 has a hypothesis. The hypothesis for sub-aim 2 is that preparedness ranking scores for both professional curricula and CE will be significantly higher for higher education than for lower education levels.

5.2 Methods:

This study measured the aims using a cross-sectional survey administered online and on paper. Before data collection, a university IRB approved the study.

Sample

The survey was designed and administered through the Qualtrics platform (Qualtrics, Provo, UT, USA) but was also provided in paper form if requested. We employed convenience and snowball sampling to recruit local clinical rehabilitative clinicians who met the following inclusion criteria: 1) earned a degree from an accredited PT or OT educational institution, 2) licensed and registered to be employed, and 3) have worked with patients over 55 who use walking ADs. Sampling was completed in two ways: 1) through channels of employment or 2) through personal contacts of research team members. The research team members asked multiple rehabilitative therapy offices throughout the Hampton Roads area of Virginia if their employees could be contacted to complete the survey. If the management team approved, an email containing a link to the survey was sent to all rehabilitative clinicians through their work emails. Paper copy surveys were also provided to facilities if requested. This was successful at two acute care hospitals (which included an inpatient rehabilitation unit), two skilled nursing facilities, two outpatient facilities, and three home health companies. The research team consisted of physical and occupational therapists who also sent emails and texts to co-workers and acquaintances known as clinical rehabilitative therapists. The emails and text messages contained a direct link to the survey. Regardless of how the surveys were distributed, all the participants could share the survey with other potential participants.

Instrumentation development

Due to the lack of clinician expertise surveys assessing the clinician’s comfort and preparedness with older adults walking ADs, one was created for this study. A pair of researchers, one with over 15 years of clinical rehabilitation therapy experience and one with a decade of survey-based healthcare research experience, created a clinician experience survey to address the study's aims. Four professional and licensed rehabilitation therapists (2 PTs and 2 OTs) completed a Content Validity Index (CVI) to validate the survey. The therapists evaluated the questionnaire using a structured grading system from 1 to 4. A rating of four denoted that the question was pertinent to the research objectives, whereas a score of one suggested a lack of alignment with research aims. When a question received a rating of one or two, the evaluator was prompted to offer suggestions for enhancing the quality of the questions. Recommendations were incorporated, and the survey was updated to reflect the reviewers' feedback. Once completed, the survey again went through content validity by the same four professional and licensed rehabilitation therapists (two occupational and two physical therapists). The survey achieved a final CVI-A score of >0.90, demonstrating excellent content validity (Polit et al., 2007; Polit & Beck, 2006).

Instrumentation

The final survey instrument consisted of ten questions. There were three sections of questions, each addressing a different foundational clinician expertise category: participants' demographics, education on AD, which includes preparedness Likert scale, and methods of practice for assessment. Several questions allowed for multiple responses. The questions were designed to pertain to the present moment. The final survey is available in Appendix B.

Demographics

Six questions were used to characterize our participant population with information from questions. We collected participants' age, gender, zip code, professional degrees, highest education level (independent variable used for Likert ranking questions), years of clinical practice, and current employment setting.

Education

Three questions focused on participant education regarding older adult walking ADs. Likert scale ratings (strongly disagree – strongly agree with five possible responses) were used to assess replies regarding whether participants' school curriculum sufficiently prepared them to recommend, assess, and train older adult patients to use walking adaptive devices. We asked participants to identify what type, if any, CE focused on older adult walking. Lastly, another

Likert scale rating (none, strongly disagree – strongly agree) assessed if the participants' post-curriculum CE sufficiently prepared them to recommend, assess, and train older adult patients to use walking adaptive devices.

Methods of practice

The last question asked participants to identify standard methods to assess, treat, and recommend walking adaptive devices for older adult patients. Clinicians could either pick from the options provided or write their methods in a fill-in-the-blank. If clinicians chose "standardized tests," they were asked to fill in the blank to identify the standardized test(s) or method used.

.

Data Analysis

Descriptive statistics were employed to analyze demographic data and the methods used for assessing, treating, and recommending adaptive devices. The educational background provided was also used to categorize our participants into groups based on their level of professional education (Associate, Undergraduate, Master, Doctorate/Ph.D.).

Likert scale data were analyzed using descriptive statistics and the Kruskal-Wallis non-parametric test for interval data. Scores were assigned to each Likert Scale rating with a range of '1' to '5'. "Strongly disagree" was scored as '1', and "strongly agree" was scored as '5'. A significant Kruskal-Wallis was followed up with Mann-Whitney assessments. The significance level for all Kruskal-Wallis non-parametric analyses was set *a-priori* at $p < 0.013$ ($0.05 \div 4$). The significance level for all Mann-Whitney non-parametric analyses with a Bonferroni adjusted *a-*

priori at $p < .013$ (0.05 ÷ 4). Question 8 identified rehabilitative clinicians' CE experiences (post-curriculum) related to walking ADs. Descriptive statistics were completed on Question 8.

5.3 Results:

Sample

The sample size (N=108) was the same for all analyses for all questions, with one exception. One write-in response to question 10 was only available to those who chose STs as an option for assessment: therefore, for this analysis only, N=39. The survey allowed participants to provide multiple responses to several questions. Consequently, the number of responses (n) accommodated the cumulative responses from all participants across multiple questions.

Demographics

All basic demographics formulated from descriptive statistics, including gender, clinician identification, years of practice, and practice setting, are presented in Table 1. The study included 108 registered or licensed rehabilitative clinicians who graduated from accredited PT or OT programs and identified as working with older adults who use or need walking AD for mobility (23 men, 85 women, mean age = 41.71 ± 11.58).

Education

The educational levels of the participants were categorized as follows: N=108; Associate (31.5%), Undergraduate (10.2%), Masters (17.6%), and Doctorate/ Ph.D. (29.6%) (Table 1)**.** Participants then indicated whether they had completed post-curriculum CE and, if so, identified the source(s) (n=160 as participants could choose multiple options). Fifty percent of the CE sources were from on-the-job training, followed by 24.4% from self-education. Nine-point four percent reported “No CE,” 8.8% from a vendor, and 0.06% reported “Other” but did not use the fill-in-the-blank option to provide details. The results of CE identification are presented in Table 5.2.

For perceived preparedness from school curriculum to “sufficiently recommend, assess, and train patients to use walking adaptive devices” (Figure 5.1), there was a significant difference between the rank totals: 62.35 (Associate), 45.41 (Undergraduate), 37 (Masters), and 66.23 (Doctorate/ Ph.D.), H (3, n = 108) = 18.54, p = <.001. Post hoc comparisons were conducted using Mann-Whitney Tests with a Bonferroni-adjusted alpha level of .013 (0.05 ÷ 4). The Associate group ranked preparedness scores statistically significantly higher when compared to the Masters group (U ($N_{\text{Associate}}$ = 34, N_{Masters} = 31) = 65, z = 266.5, p = <.001). The Associate group somewhat agreed (41.2%) and strongly agreed (35.3%) with the statement. The Master's group somewhat agreed (25.8%) and strongly agreed (9.7%) with the statement. The Doctorate/Ph.D. group ranked preparedness scores statistically significantly higher when compared to the Master's group (U ($N_{\text{Doctorate/Ph.D.}}$ = 32, N_{Masters} = 31) = 63, z = 256, p = <.001). The Doctorate/ Ph.D. group somewhat agreed (15.6%) and strongly agreed (56.3%) with the statement. This is compared to the Master's group, which somewhat agreed (25.8%) and strongly agreed (9.7%) with the statement. None of the other comparisons were significant after the Bonferroni adjustment (p > .013). Table 5.3 depicts all the percentages and numbers from each group for each response to the question.

The perception of preparedness from CE to “sufficiently recommend, assess, and train patients to use walking adaptive devices” (Figure 5.2) also showed differences between the rank totals of 58.72 (Associate), 34.86 (Undergraduate), 46.82 (Masters), and 64.2 (Doctorate/ PhD).

Therefore, a significant difference between groups was seen, H (3, n = 108) = 11.00, p = .012. Post hoc comparisons were conducted using Mann-Whitney Tests with a Bonferroni-adjusted alpha level of .013 (0.05 ÷ 4). The Doctorate/PhD group ranked preparedness scores statistically significantly higher when compared to the Undergraduate group (U ($N_{\text{Undergraduate}}$= 11, $N_{\text{Doctorate/PhD}}$ = 32) = 43, z = 86.5, p = .011). The Undergraduate group strongly disagreed (18.2%) and somewhat disagreed (9.1 %) with the statement. The Doctorate/Ph.D. group strongly disagreed (3.1%) and somewhat disagreed (0%) with the statement. None of the other comparisons were significant after the Bonferroni adjustment (p > .013). The only group that did not choose “no CE” as an answer option was the Undergraduate group, meaning that all other groups had some participants who had not completed any AD CE post-school curriculum. Table 5.3 describes the percentages and numbers from each group for each response to the question.

Methods of practice

Basic descriptives of the methods of practice for AD for older patients were completed and presented in Table 5.4. Most participants (44.8%) reported using clinical judgment to assess walking ADs. This was followed by team meetings (20.8%), independent research (11.5%), standardized tests (STs) (9.9%), vendor recommendations (6.3%), none (4.7%), and reference guides from employers (2.1%). If participants used STs, we asked them to write in what test(s) they were most likely to use. Table 5.5 presents the reported STs used by the participants.

5.4 Discussion:

Demographics

The demographic results produced findings indicative of a diverse clinician cohort. Primarily, the participation of both PTs and OTs allowed representation of both fields of practice as both play significant roles in older adults and AD therapeutic approaches. Additionally, there was a notable diversity in the clinicians' employment setting. Patients present very differently in varied rehabilitation settings (i.e., acute care versus outpatient therapy). Therefore, the therapeutic interventions involving ADs can vary significantly depending on the setting. The diversity in employment settings reflected the varied clinician experiences of the study participants. Furthermore, participants reported various educational backgrounds and years of experience. Thus, the demographics of our participant population represent a spectrum of clinicians involved in treating and managing older adults who use AD.

Identification of CE clinicians who participated

The study identified the sources of CE for clinicians. A majority (50%) of the participants reported on-the-job training. Despite the efforts to have clinicians translate EBP into actual clinical practices, studies have shown that clinicians rely on colleagues versus EBP to formulate their treatment plans (Bennett et al., 2003; Jette et al., 2003, p. 200; Rappolt & Tassone, 2002). While research has demonstrated the benefits of work-based training for both clinicians and patient outcomes, it may pose a challenge if clinicians rely solely on each other rather than EBP (Attenborough et al., 2019; Liljedahl et al., 2023; Mahboob & Sajjad, 2015). In such cases, interventions such as walking AD and fall prevention could potentially remain unchecked. Self-education (24.4%) was the participants' second-highest form of AD CE. One study by Unertl et al. (2018) found that lack of time, compensation, and access to current journals were all barriers to clinicians completing comprehensive self-education on patient treatment options (Unertl et al., 2018). This suggests that although self-education occurs, the standards and quality of the CE are unknown. The results indicate that 74.4% of the participants are completing CE on non-regulated or reviewed AD. The study found that 9.4% of participants had no CE on walking ADs. This means that there are clinicians who rely solely on the education foundation from professional curriculums, and again, over 30% of clinicians stated that the school curriculum did not sufficiently prepare them to treat this population. Clinicians are mandated by their state to acquire professional development through formal courses and workshops (Forsetlund et al., 2009), which earn CEC to maintain their licensure (Hall et al., 2016). When a CEC is accredited and approved by an organization, the educational material has been reviewed, the resources have been checked, and the education provided is from peer-reviewed sources (Friedman, 2023). CECs allow for lifelong learning for an EBP model. Though not specifically on walking AD and not including OTs, a study by Shubert (2011) identified 209,000 registered PTs in the United States in 2019 and found only 1.2% of them completed CECs to be certified as geriatric specialists, even though over ½ of them worked with the geriatric population (Shubert, 2011). The same seems true for participants in our study, who reported that only 6.9% of participants received formal CE on ADs. Therapists treat the population daily with walking ADs but do not seek certification or CECs. Because walking AD is a primary intervention for falls in the elderly, it seems unbalanced for so few clinicians to have formal accredited training on the subject. One significant finding of this foundational study is that clinicians are not participating in formal post-curricular education on AD. The only required AD education for PTs and OTs is through professional curriculums.

Understanding the results from preparedness ranking data

In both rankings (professional curriculum and CE), the Doctorate/ Ph.D. group ranked the highest preparedness scores but not significantly higher than all other groups, as the hypothesis suggested. The Master's, Undergraduate, and Associate groups did not follow the hypothesized ranking trajectory based on educational levels. The Associate group ranked preparedness scores the second highest in both rankings (although it was only significantly higher in the professional curricula question). Requirements for PT, including PTA curricula regarding AD, stipulate that graduates of PT programs must be able to "select and competently administer tests and measures appropriate to the patient's age, diagnosis, and health status, including, but not limited to, those that assess assistive technology" (*Accreditation Handbook*, n.d.). Requirements for OT and COTAs curriculum regarding AD states the clinicians need to "assess the need for and demonstrate the ability to design, fabricate, apply, fit, and train in assistive technologies and devices (e.g., electronic aids to daily living, seating, and positioning systems) used to enhance occupational performance and foster participation and well-being" (*Schools – ACOTE*, 2023). It may be that the Doctorate/Ph.D. group spends more time on the AD subject because the curriculum has more time to foster the topic. Assistants (the Associate group) for PTs and OTs follow treatment plans and carry out interventions from their evaluating therapists (American Occupational Therapy Association, 2022b; *Standards of Practice for Physical Therapy*, 2019). Because their curriculum focuses more on treatment interventions (not evaluations), they may spend more time and practice on AD because it is a significant treatment intervention. Both groups may be ranking AD preparedness higher simply because they have more time and practice in their curriculums. The rankings scores may be an example of knowledge of translation.

Knowledge translation

The Canadian Institute of Health Research defines knowledge translation (KT) as "a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health, provide more effective health services and products and strengthen the healthcare system" (+Government of Canada, 2005 https://cihr-irsc.gc.ca/e/29418.html). Many well-documented KT barriers exist in academic settings, including lack of time, skills, and institutional support (Kalbarczyk et al., 2021). Walking AD training and education is included in a broader class of assistive technology in PT and OT programs, covering all technology, not only for mobility (*Accreditation Handbook*, n.d.; *Schools – ACOTE*, 2023). Programs have minimal time to spend on walking AD interventions due to the lack of explicit requirements set by their governing accreditation bodies and the barrier of curricular time. The known barriers to KT, including lack of time, skills, and institutional support, are present in AD professional education for rehabilitative clinicians. Students who spend less time and practice on topics such as ADs are less likely to translate that knowledge into their careers (Dal Mas et al., 2020; Straus et al., 2011). A KT study completed by 873 students from Taiwan showed that regardless of additional education provided, the prior baseline knowledge of a subject impacted the students' absorptive capacity and learning outcomes scores (Peng et al., 2021). For rehabilitative clinicians, the basis of knowledge about walking ADs comes from professional curriculums regardless of completion of additional CEs. The Doctorate

Ph.D. and Associate groups may have more time and practice with walking ADs and, therefore, perceive they are more prepared by both professional curriculum and CEs. Rehabilitative professions education program administrators should consider the importance of exposure in professional education to KT when considering which aspects of clinical practices, such as ADs, should receive additional curricular emphasis regardless of their requisite inclusion by specialty accreditors.

Identified assessment methods for ADs

Clinical judgment was the most identified method (44.8%) clinicians use to assess, treat, and recommend walking ADs for older adult patients. Clinical judgment is a generic term clinicians use to describe daily decisions for complex patient care involving conflicting or multiple solution pathways (Tsang et al., 2017). Clinical judgment relies on experience, practice, and baseline knowledge of the patient and the subject (Kienle & Kiene, 2011). Team meetings were the second highest AD assessment method (20.8%). Team meetings allow interdisciplinary approaches that contribute to greater job satisfaction, mutual respect for other healthcare disciplines (Ansa et al., 2020), and increased patient functional outcome measures (Moyers & Metzler, 2014). The third most identified method (11.5%) was independent research, followed by (9.9%) for standardized tests (STs). The American Psychological Association defines STs as "an assessment instrument whose validity and reliability have been established by thorough empirical investigation and analysis" (Himelfarb, 2019, p. 153). Mobility STs allow PTs and OTs to measure an individual's baseline, determine if the individual's mobility has changed compared to age-related norms, identify early signs of decline, allow therapeutic intervention, goal setting for plans of care, and discharge planning (Macri et al., 2012; Soubra et al., 2019;

Sullivan et al., 2011). A systematic review revealed twenty-nine commonly used objective STs that PTs and OTs use to assess the functional mobility of older adults (Soubra et al., 2019). Of the 29 mobility standardized tests mentioned, none specifically assess mobility with ADs but can be used to determine mobility before and after the implementation of walking AD. STs are included in PT and OT curriculum requirements (*Accreditation Handbook*, n.d.; *Schools – ACOTE*, 2023). The decreased use of ST in AD intervention may also be due to KT. The results from this foundational study show that clinicians use no consistent tool to assess, treat, and recommend walking ADs for older adult patients. There is certainly not a standardized method.

Recommendations for improvement

Regardless of when a clinician graduates, CECs must ensure clinicians stay abreast of current literature. CE allows an opportunity for education post-school curriculum to address therapeutic interventions such as walking ADs. One solution to increase clinician AD preparedness is to push for more CE on the specific topic. This only partially solves the problem. Using the KT theory, the foundation of knowledge and what is perceived as necessary is already established when clinicians graduate from their programs, have finished their clinicals, and are employed. Therefore, those who received more time and practice will theoretically seek out and participate in more CE on walking ADs and vice versa. One direct way to change this outcome is to have the governing bodies of both rehabilitative clinicians place more importance on walking ADs. O’Hare et al. (2013) completed a systematic review of walking ADs. They found that clinicians' lack of mandated guidelines contributed to falls in older adults (O’Hare et al., 2013b). If the accreditation standards were to be increased for walking ADs, mandated guidelines could be established and enforced, decreasing fall rates in older adults who rely on ADs for independence.

5.5 Conclusion:

This is the first foundational study of clinician perspectives of walking ADs for older adults. This study identified clinicians' demographics, CE, and methods for walking AD use and assessed preparedness rankings. The overall findings show a need for more precise evaluation methods and a lack of consistency in how clinicians assess, treat, and recommend ADs to older adults. Educational levels did not relate to the preparedness scores of clinicians. The clinicians obtain most of their post-curricular learning of AD from on-the-job training and not from accredited CEC.

5.6 Limitations:

Limitations of this study include the geographic cluster of participants, which may not represent all geographic regions where OT and PT are conducted. Additionally, the validity of the survey research relies on participants providing honest and precise responses. It is plausible that the clinicians participating in the survey may withhold truths or exhibit recall bias, potentially skewing their perceptions and, consequently, the research outcomes.

5.7 Future Research:

Given the foundational nature of this study, numerous opportunities exist to enhance EBP for AD and older adults. One direction involves further investigation of the impact of AD on gait, which would improve the fundamental components of educational curricula tailored for rehabilitative clinicians. The goal for both professional organizations should be to formulate and mandate guidelines for their clinicians to ensure that this treatment intervention increases patient safety and independence. Additional research assessing professional curriculums could accomplish this goal. Future research can investigate AD KT to ascertain the optimal duration and implementation of PT and OT programs dedicated to walking AD. This would allow understanding of the correlation between a heightened emphasis on walking AD within the educational curricula, increased engagement in AD CECs, elevated preparedness scores, expanded use of standardized tests, and reduced occurrence of patient falls. Finally, it is worth noting that currently, no STs are exclusively designed to assess the impact of AD gait and ADL independence in older adults. Future research endeavors could develop one.

Table 5.1

Sociodemographic Characteristics of Clinicians

	Groups									
	Associate		Undergraduate		Master		Doctorate/ Ph.D.		Full sample	
Baseline Characteristics	n	%	n	%	n	%	n	%	n	%
Gender										
Women	25	73.5	9	81.8	27	87.1	24	75	85	78.7
Men	9	26.5	2	18.2	4	12.9	8	25	23	21.3
Rehabilitative Clinician										
PT	22	64.7	1	9.1	13	41.9	23	71.9	59	54.6
OT	12	35.3	10	90.9	18	58.1	9	28.1	49	45.4
Years of practice										
>1	0	0	1	9.1	2	6.5	2	6.3	5	4.6
1-5	7	20.6	0	0	5	16.1	5	15.6	17	15.7
6-10	11	32.4	0	0	4	12.9	8	25	23	21.3
11-15	9	26.5	0	0	6	19.4	10	31.3	25	23.1
16-20	3	8.8	2	18.2	4	12.9	2	6.3	11	10.2
Over 20	4	11.8	8	72.7	10	32.3	5	15.6	27	25
Practice setting										
Acute	3	8.3	3	17.6	6	14.3	4	10	16	11.9
Inpatient	4	11.2	3	17.6	6	14.2	4	10	17	12.5
Outpatient	5	13.9	7	41.2	14	33.3	18	45	44	32.6
SNF	4	11.1	2	11.8	4	9.5	1	2.5	11	8.1
LTC	0	0	0	0	1	2.4	1	2.5	2	1.5
Home Health	18	50	2	11.8	8	19	6	15	34	25.2
Instructor	2	5.6	0	0	3	7.1	6	15	11	8.1
Other	0	0	0	0	0	0	0	0	0	0
Total	34	100	11	100	31	100	32	100	108	100

Table 5.1 (continued)

Note. N = 108; n = 135 for the practice setting due to multiple responses per participant for gender and years of practice. Abbreviations: Physical therapy = PT, Occupational therapy = OT, skilled nursing facility = SNF, and Long-Term Care = LTC. Participants were, on average, 41.71 (SD ± 11.58) years old, and participant age did not differ by condition.

Table 5.2

Continued Education Experiences of Clinicians

	Groups									
	Associate		Undergraduate		Masters		Ph.D. or Doctorate		Full sample	
	n	%	n	%	n	%	n	%	n	%
Continued Education										
CE credits	4	7.8	2	11.8	2	4.3	3	6.7	11	6.9
Vendor	3	5.9	0	0	4	8.5	7	15.6	14	8.8
On-the-job	28	54.9	10	58.8	23	48.9	19	42.2	80	50
Self-Ed	13	25.5	5	29.4	15	31.9	6	13.3	39	24.4
None	3	5.9	0	0	2	4.3	10	22.2	15	9.4
Total	51	100	17	100	47	100	45	100	160	100

Note. N = 108; n=160 total responses due to multiple response options for this question.

Abbreviations: AD adaptive devices; CE continued education; Self-Ed = self-education.

Table 5.3

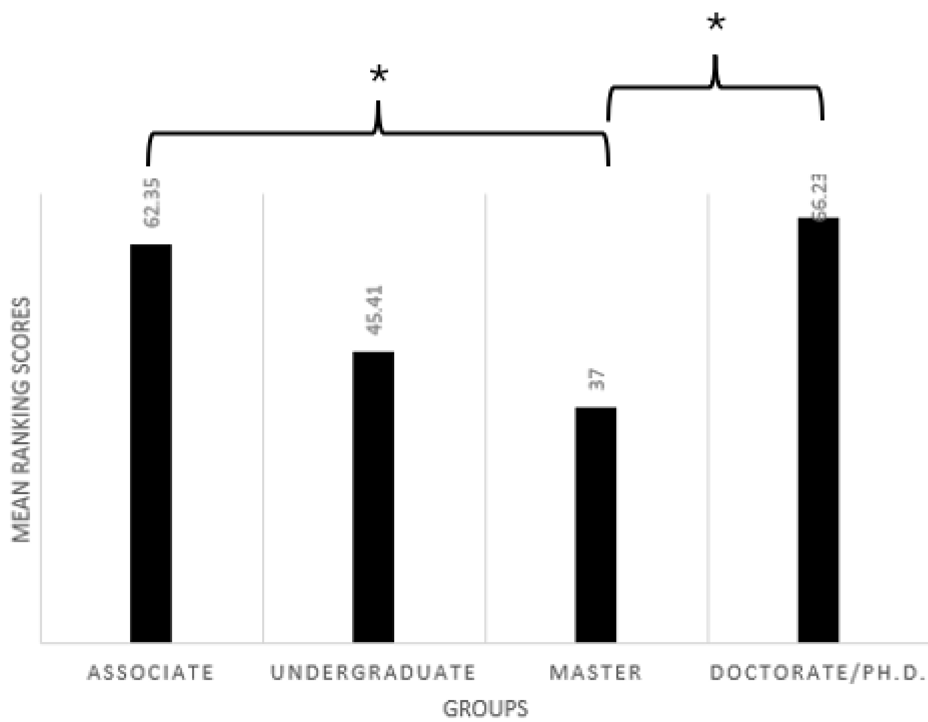
Percentage (%) of Preparedness of Clinicians to Recommend, Assess, and Train Older Adult Patients to Use Walking Adaptive Devices from School Curriculum and Continued Education.

	Groups									
	Associate		Undergraduate		Masters		Ph.D. or Doctorate		Full sample	
	n	%	n	%	n	%	N	%	n	%
The curriculum sufficiently prepared participants to recommend, assess, and train older adult patients to use walking adaptive devices.										
Responses										
Strongly disagree	1	2.9	1	9.1	6	19.4	3	9.4	11	10.2
Somewhat disagree	5	14.7	2	18.2	11	35.5	5	15.6	23	21.3
Neither	2	5.9	1	9.1	3	9.7	1	3.1	7	6.5
Somewhat agree	14	41.2	7	63.6	8	25.8	5	15.6	34	31.5
Strongly agree	12	35.3	0	0	3	9.7	18	56.3	33	30.6
Total	34	100	11	100	31	100	32	100	10	100
CE sufficiently prepared participants to recommend, assess, and train older adult patients to use walking adaptive devices.										
Strongly disagree	1	2.9	2	18.2	0	0	1	3.1	4	3.7
Somewhat disagree	1	2.9	1	9.1	3	9.7	0	0	5	4.5
Neither	0	0	1	9.1	1	3.2	2	6.3	4	3.7
Somewhat agree	13	38.2	4	36.4	16	51.6	9	28.1	42	38.9
Strongly agree	14	41.2	3	27.3	9	29	11	34.4	37	34.3
No CE	5	14.7	0	0	2	6.5	9	28.1	16	14.8
Total	34	100	11	100	31	100	32	100	10	100

Note. N = 108 clinician participants. Abbreviations: continued education = CE.

Figure 5.1

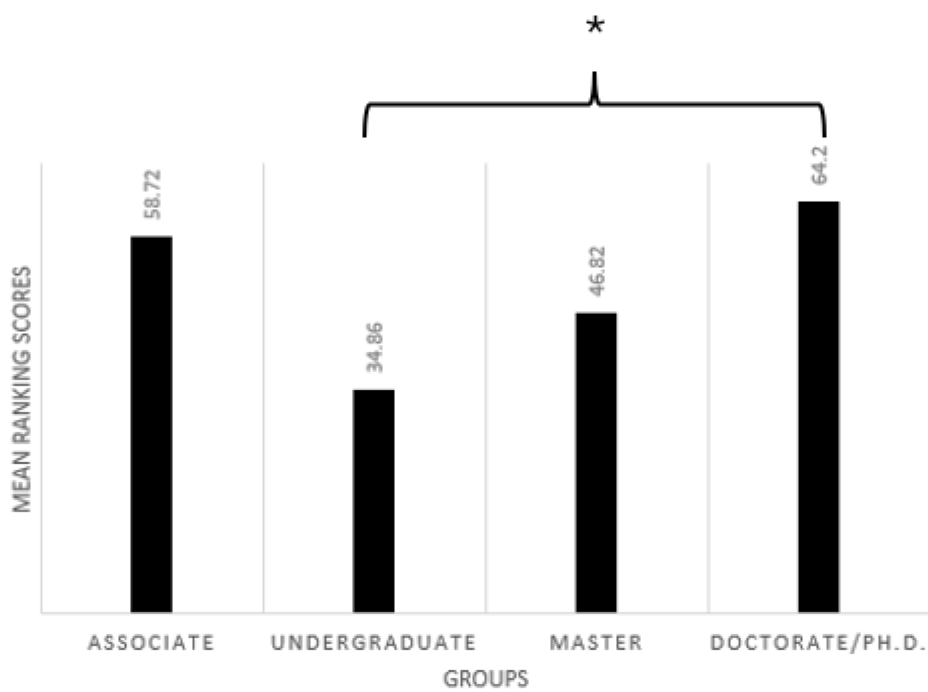
Illustration of Ranking Scores of Preparedness of Clinicians to Recommend, Assess, and Train Older Adult Patients to Use Walking Adaptive Devices from School Curriculum.



Note. Significant differences in professional curricula ranking are denoted with an asterisk (*).

Figure 5.2

Illustration of Ranking Scores of Preparedness of Clinicians to Recommend, Assess, and Train Older Adult Patients to Use Walking Adaptive Devices from Continued Education.



Note. Significant differences in professional curricula ranking are denoted with an asterisk (*).

Table 5.4

Methods of Adaptive Device Assessment

	Groups									
	Associate		Undergraduate		Master		Ph.D. or Doctorate		Full sample	
	n	%	n	%	n	%	n	%	n	%
Methods of assessment										
Standardized test(s)	4	6.5	2	11.1	4	6.9	9	16.7	19	9.9
Reference guide	4	6.5	0	0	0	0	0	0	4	2.1
Team meetings	14	22.6	4	22.2	16	27.6	6	11.1	40	20.8
Independent research	10	16.1	1	5.6	6	103	5	9.3	22	11.5
Vendor	4	6.5	0	0	3	5.2	5	9.3	12	6.3
Clinical judgement	24	38.7	9	50	28	48.3	25	46.3	86	44.8
None	22	3.2	2	11.1	1	1.7	4	7.4	9	4.7
Total	62	100	18	100	58	100	54	100	192	100

Note. N = 108; n=192 total responses due to multiple response options for this question

Table 5.5

Standardized Tests Used to Assess Walking Adaptive Devices in Older Patients.

	Groups									
	Associate		Undergraduate		Masters		Ph.D. or Doctorate		Full sample	
	n	%	n	%	n	%	n	%	n	%
Standardized tests (STs)										
BERG	3	30	2	40	3	12	3	9.4	11	15.3
TUG	3	30	2	40	7	28	13	40.6	25	34.7
Barthel	0	0	0	0	2	8	0	0	2	2.8
Tinetti	4	40	1	20	1	4	6	18.8	12	16.7
GS	0	0	0	0	1	4	2	6.3	3	4.2
PASS	0	0	0	0	1	4	0	0	1	1.4
STS	0	0	0	0	1	4	1	3.1	2	2.8
FGA	0	0	0	0	2	8	3	9.4	5	6.9
MWT	0	0	0	0	5	20	3	9.4	8	11.1
DGI	0	0	0	0	1	4	0	0	1	1.4
AMP	0	0	0	0	1	4	0	0	1	1.4
Total	10	100	5	100	25	100	32	100	72	100

Note. N = 39; n=72 responses due to multiple response options for this question**.** Abbreviations: Berg Balance Scale = BERG, Timed up and go test TUG, Barthel Index Score= Barthel, Tinetti Balance and Gait Assessment= Tinetti, Gait Speed= GS, Postural Assessment Scale for Stroke= PASS, Sit to Stand= STS, Functional Gait Assessment= FGA, Minute Walk Test= MWT, **Table**

Table 5.5 (continued)

Dynamic Gait Index= DGI, Amputee Mobility Predictor= AMP, Modified Clinical Test of Sensory Interaction on Balance= MSCIT.

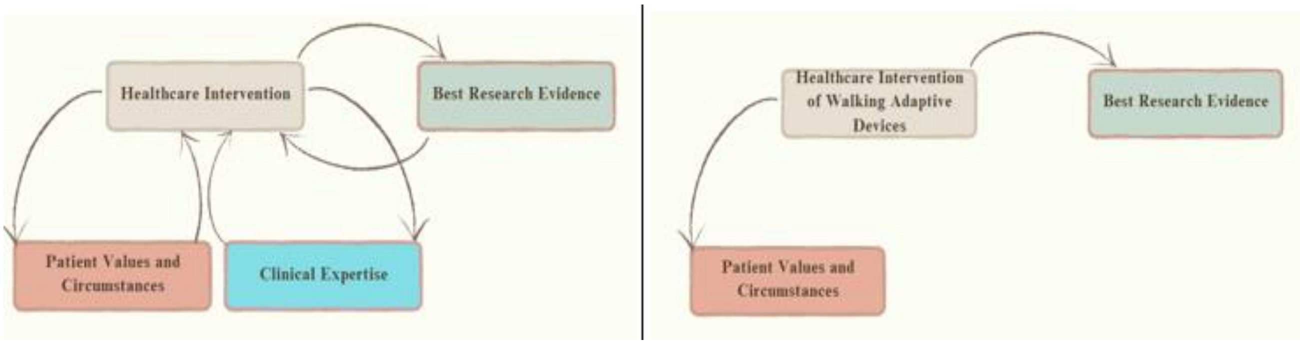
CHAPTER 6

CONCLUSION

The dissertation examined the intervention of walking ADs through the three concepts (best research evidence, patient value and circumstances, and clinical expertise) of evidence-based practice (EBP). This research aimed to understand further why older adult falls have increased to near-epidemic levels in unison with this intervention (Gell et al., 2015b; Kaye et al., 2000; Stevens et al., 2009b). The dissertation approach was to create and implement three research studies, each representing a concept of EBP. This dissertation's overarching aim was to enhance the understanding of walking AD as an intervention for older adults by scrutinizing the EBP literature on the subject. The findings of the dissertation point to the lack of EBP as a contributor to falls in older adults who use walking ADs. Clinicians and their accrediting educational institutions supporting them have not adequately questioned or researched this intervention, contributing to the cycle where outdated or insufficient research data perpetuates ineffective practices. The dissertation showed that without continuous integration of new research findings into the EBP model, akin to the evolution of artificial intelligence (AI), interventions such as those involving ADs will fail to adapt and improve, remaining stagnant or even worsening over time (Figure 7.1). Therefore, to prevent falls among older adults who use AD, rehabilitation healthcare clinicians and their accrediting institutions must prioritize ongoing research, education, and critical evaluation of all three concepts of EBP to enhance the effectiveness of this intervention; the alternative is continued falls among older adults who rely on AD for mobility.

Figure 6.1

Illustration of Evolving Healthcare Interventions with Evidence-Based Practice Versus Illustration of Stagnate Walking Adaptive Device Intervention Lacking Evidence-Based Practice



Walking Adaptive Devices Constrain Acceleration of the Center of Mass and Reduce Gait Speed in Healthy Adults

The first study, representing the best research evidence study, aimed to investigate the impact of walking ADs on healthy gait. The necessity for this study arose from inconclusive findings in the literature review regarding whether ADs prevent or contribute to falls among older adults (O'Hare et al., 2013a). The research evaluated gait using six objective measures (three spatiotemporal parameters and motions of the CoM in three axes). The spatiotemporal parameter measures of gait speed, step length, and cadence are standard objective measures used in present-day research studies (Espy et al., 2010b; Fritz & Lusardi, 2009; Middleton et al., 2015; Pirker & Katzenschlager, 2017). The motions of the CoM objective measurements, while less common, offer invaluable insight into postural sways that impact balance (Lugade et al., 2011; Tesio & Rota, 2019b; Wurdeman et al., 2017). The second objective measure is from motions of the center of mass (CoM) in all three axes

The primary aim of the study was to determine if healthy gait, as measured by spatiotemporal parameters and motions in all three axes of the CoM, differs when using three common types of walking ADs (cane, double canes, and front wheeled walker) compared to walking without AD. The data supported the hypotheses that all three types of walking ADs resulted in alterations to both spatiotemporal parameters and motions of the CoM in healthy participants compared to walking without ADs. These findings suggest that ADs induce biomechanical changes in gait patterns among individuals without underlying muscular or neurological impairments. Rather than improving gait, the AD produced results of unnatural walking patterns that were also seen in prior research (Cromwell & Newton, 2004; Espy et al., 2010b; Lugade et al., 2011; Nam et al., 2017; Pirker & Katzenschlager, 2017).

Additionally, the study had four six sub-aims focusing specifically on the three measurements from spatiotemporal parameters (gait speed, step length, and cadence) and three measurements from each axis of CoM (mediolateral, anterior-posterior, and vertical). The hypothesis for all six sub-aims was that walking ADs would significantly decrease the objective measurements compared to walking without ADs. The findings supported the hypotheses related to gait speed, cadence, and all three axes of CoM. Participants in the study did reduce gait speed, cadence, and motions of the CoM in all three axes when using all three types of ADs. However, the evidence did not support the hypothesis regarding step length, as participants did not reduce their step length.

The study represents the best research concept of EBP contributing to AD literature as it revealed that the 25 healthy participants exhibited slower gait speed, slower cadence, and constricted motions at the CoM, all while maintaining step length. This study emphasizes for this dissertation that walking ADs do not conclusively enhance the safety of older adults, but instead have Even though this study contributes to the literature, additional investigations into the safety of walking ADs for older adults need to occur as the alterations of gait seen in this study could potentially escalate the risk of falls among older adults.

Patient Perspectives on Walking Adaptive Devices and the Relevance to Falls

The second study within this dissertation explored the patient values and circumstances concept of EBP literature. Previous subjective studies identified vital factors contributing to consumer misuse of ADs, including fitting AD, training with AD, satisfaction with training, provision of educational materials, and soliciting subjective opinions during the acquisition process. Unfortunately, there is a direct link between increased falls and each of these contributing factors of AD misuse (Anderson et al., 2004; Bateni et al., 2004; Bateni & Maki, 2005b; Bradley & Hernandez, 2011; Gell et al., 2015b; Kraskowsky & Finlayson, 2001; Luz et al., 2015; Stevens, 2005; Thies et al., 2020). Moreover, since the publication of the reviewed studies, changes in rules and regulations regarding the acquisition of AD have occurred. Consumers now have three options to obtain walking AD: from a medical doctor (MD), privately purchasing (PP), or from second-hand sources (SH) (*Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.; Teel et al., 2021). Since the Affordable Care Act in 2010, education, training, and fitting have been mandated when obtaining ADs from MD sources (Affairs (ASPA), 2013; *Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS*, n.d.). In addition, opportunities to obtain AD from PP and SH sources have increased (Teel et al., 2021). To the author's knowledge, no study has investigated the method of AD acquisition on consumer opinions regarding factors contributing to misuse or whether AD acquisition contributes to self-reported falls in a six-month period.

By creating a consumer survey and having 226 local independent community-dwelling older adults participate, this study's primary aim was to examine how walking ADs are obtained (MD, PP, SH) and their effects on patient perceptions and six-month period fall rates. There were seven sub-aims of the study. Five sub-aims were for the patient perspectives of factors contributing to misuse: fitting AD, training with AD, satisfaction with training, provision of educational materials, and soliciting subjective opinions during the acquisition process. The hypotheses for all five of these sub-aims was that those who obtained their AD from MD sources would have significantly greater ranking scores (responses of “yes” and more positive ranking for perceived satisfaction) for patient perspectives of factors contributing to misuse: fitting of AD, training with AD, satisfaction with training, provision of educational materials, and the solicitation of personal opinions during the acquisition process compared to those who obtained their AD from PP and SH sources. The additional hypothesis was that those who obtained their AD from PP sources would have significantly greater ranking scores (responses of “yes” and more positive ranking for perceived satisfaction) for patient perspectives of factors contributing to misuse than those who received their AD SH sources. The findings did not support the hypotheses. The PP group was the group that most often reported “yes” to questions regarding fitting, training, and educational materials and solicited opinions. The hypothesis regarding training satisfaction rankings was also not supported, as no significant differences existed between groups.

The sixth sub-aim assessed the number of self-reported falls the participants had in the six months leading up to their participation in the study. The hypothesis was that those who obtained their AD from MD sources would have significantly fewer falls when compared to both the PP and SH groups. The additional hypothesis was that those who obtained their AD from PP sources would have significantly fewer falls when compared to the SH group. The results did not support the hypotheses. The results indicated that the PP group reported significantly fewer falls six months before study participation than the MD and SH groups.

The final seventh sub-aim of the study was to compare the ages between the groups. The hypothesis was that the PP group would be significantly younger than both the MD and SH groups and that there would be no significant differences in age between the MD and SH groups. The hypothesis was not supported, as the PP and SH groups had no significant difference in age.

The study findings indicate that patients who feel they need to be adequately supported by medical clinicians regarding their walking ADs, despite mandated requirements, tend to report more falls within six months. Additionally, many patients reported needing more training and education from medical professionals regarding their ADs, highlighting potential gaps in support provisions that could contribute to falls.

Patient value and circumstance studies such as this reveal insights from the patient's perspective on the factors influencing the proper usage and safety of walking ADs. Collecting and interpreting patient subjective information is essential for crafting patient-centered care interventions and improving patient outcomes (Burki, 2021). Patient perspective information facilitates the evolution of interventions by providing insights into treatment plan adherence and challenges faced while attempting to achieve desired outcomes (DiCicco-Bloom & Crabtree, 2006). Considering patient value and circumstances, EBP healthcare interventions can progress (Gopalakrishnan & Ganeshkumar, 2013; Lehane et al., 2019). The absence of literature on patient values and circumstances for walking ADs may contribute to the stagnation of this intervention for older adults. This lack of progress could heighten the risk of falls among older adults who use walking ADs.

Clinician expertise in walking Adaptive devices for older adults

The final study represents the clinical experience concept of EBP for walking ADs for older adults at risk of falls. Unfortunately, no literature was found on this topic. Understanding and quantifying clinical expertise is critical for guiding decision-making concerning public health challenges (Lulin et al., 2016). Falls among older adults who use walking ADs are a public health challenge (E. R. Burns et al., 2016), yet there is a void in the literature supporting its use. This final study was the first to examine the clinical experience of rehabilitative clinicians using walking ADs as an intervention for older adult falls.

Due to the lack of subjective surveys on walking ADs, a clinician survey was created and validated via content validity testing. The study aimed to be the first foundational study of its kind. The study has five study aims. The first was identifying the 108 rehabilitation clinician participants' basic demographics, educational backgrounds, and current employment settings. This aim had no hypothesis as it is descriptive. The descriptive information obtained grouped the participants based on their educational level. There were four groups: Associate, Undergraduate, Masters, and Doctorate/ PhD.

The second and third aims examine rehabilitative clinicians' opinions on their preparedness to "recommend, evaluate and train older adult patients to use walking ADs" based on their educational curriculum (Associate, Undergraduate, Master, and Doctorate/Ph.D.). The hypothesis for these aims was that clinicians with higher levels of education (post-undergraduate:

Masters and Doctorate/ Ph.D.) would report significantly greater preparedness scores for "recommending, evaluating and treating older adult patients to use walking ADs" when compared to 1) clinicians with educational levels at undergraduate degrees and 2) with associate degrees (with no significant differences seen between the Masters and Doctorate/ Ph.D. groups). The data did not support the hypothesis. The clinicians who reported the highest-ranked preparedness scores were those from the Doctorate/ Ph.D. and the Associate degree groups.

The third aim is to identify rehabilitative clinicians' continued educational experiences (post-curriculum) related to walking ADs. This study has no hypothesis as it is descriptive. The data identified post-curriculum continued education experiences, with 50 % reporting on-the-job training and 24.4% for self-education.

The fourth specific aim of the study involves examining rehabilitative clinicians (categorized into groups based on education: Associate, Undergraduate, Master, and Doctorate/Ph.D.) to determine their preparedness to "recommend, evaluate and train older adult patients to use walking ADs" after undertaking post-curriculum education on walking ADs (with no significant differences seen between the Masters and Doctorate/ Ph.D. groups). The hypothesis proposed that clinicians with higher levels of education (post-undergraduate: Masters and Doctorate/ Ph.D. groups) will report significantly greater preparedness scores for "recommending, evaluating and treating older adult patients to use walking ADs" when compared to 1) clinicians with educational levels at undergraduate degrees and 2) with associate degrees after undertaking post curriculum education on walking ADs. However, the data did not support this finding. Again, clinicians with a Doctorate/ Ph.D. and an Associate degree perceived themselves as the most prepared, while those with undergraduate and masters reported lower preparedness ranking scores.

The study's fifth and final aim was to identify evaluation tools the participating clinicians used to assess older adult walkers using walking ADs. This study's aim was descriptive and did not propose a hypothesis. The data revealed that 44.8% of the participants used clinical judgment, followed by 20.8% who used team meetings and methods of practice to assess patients who used walking ADs.

Data from this clinical expertise EBP study served as a foundational study exploring clinician demographics, educational experiences, preparedness, and viewpoints regarding walking ADs for older adults. The study was able to identify the demographics of the participants. The study revealed that preparedness ranking scores did not align with educational levels. The study uncovered inconsistencies in clinicians' evaluation methods and approaches to assess, treat, and recommend walking ADs for older adults. This study achieved the goal of being the first foundational study for clinical expertise for rehabilitative clinicians who use walking ADs as an intervention for older adult falls. This study collected insights and practices from diverse clinicians to evaluate and identify obstacles to this relatively common but poorly understood fall intervention.

Summary for all three EBP research studies

Overall, the evidence from the dissertation study underscores the need for comprehensive EBP research, including quantitative and qualitative analyses, to develop guidelines and interventions for using walking ADs in older adults with mobility disorders. Lastly, integrating patient values and circumstances and clinical expertise data is essential for comprehensively understanding additional factors contributing to falls among older adults. These factors may not have been fully captured by relying solely on the best research evidence.

Furthermore, there is a lack of transfer of best research evidence into clinical practice for this subject. The literature uncovered numerous studies dating back to the 1990s, cautioning the fall risk factors associated with walking ADs (Bateni et al., 2004; Joyce & Kirby, 1991; Kraskowsky & Finlayson, 2001; Mann et al., 1995; Phillips & Zhao, 1993b). Despite the publication of these studies, minimal effort has been made to modify the intervention or investigate the factors further (as evident by the literature review) to mitigate the potential harm of this intervention. In addition, despite the studies published over the past three decades, no guidelines have been established for rehabilitative clinicians, nor have theories been formulated regarding which patients may be adversely affected using walking ADs. In summary, it is not only the minimal EBP literature on this topic that is contributing to older adult falls but also the failure to use the existing literature to adapt this intervention to safeguard patients.

Research Implications

This dissertation study is critical to rehabilitative clinicians as they are the primary rehabilitative clinicians for the treatment of older adults with mobility disorders (Cumming et al., 2001; Papalia et al., 2020a; Pirker & Katzenschlager, 2017). This dissertation stresses that because of the lack of EBP research in all three concepts, the deficits for AD have not been fully identified and addressed. This dissertation is not trying to indicate or categorize AD as only harmful for all older patients. As the literature review revealed, some studies concluded that AD is beneficial in both the best research evidence and studies of patients' perspectives. The dissertation found that the lack of established evidence-based practice for walking ADs may contribute to the persistence of falls and fall-related injuries in older adult populations. So, it is not necessarily the AD itself that is harmful to patients but the lack of understanding and neglect of current research incorporation into intervention strategies that are harmful to patients.

Recommendations for EBP research

From the literature review, it became evident that there are few outdated studies addressing patient values and circumstances of older adults and walking ADs. The literature review also found no peer-reviewed publications regarding the studies representing the clinical expertise concepts of EBP for older adults and walking ADs. The influence of the research ranking system could be to blame for this. In the last two decades, there has been a substantial increase in the reliance on healthcare decisions based on the best available research evidence, which is ranked (Lilienfeld & Basterfield, 2020; Lulin et al., 2016). This ranking of the best evidence was initially reported by the Canadian Periodic Health Examination in 1979. It became widely accepted in the healthcare community ("The Periodic Health Examination. Canadian Task Force on the Periodic Health Examination," 1979). Dr. David Sacket, a researcher and epidemiologist, further expanded the levels of evidence in 1989 (Sackett, 1989). With the guidance of Dr. Sackett in 1995, the University of Oxford established the Center for Evidence-Based Medicine (CEBM), which is still regarded as a world-renowned center for research (P. B. Burns et al., 2011; Sur & Dahm, 2011) and organized research into four categories: treatment, prognosis, diagnosis, and economic/decision analysis (P. B. Burns et al., 2011). The CEBM established its research ranking model involving medical treatments, which was updated in 2009 and expanded in 2011 (*The Centre for Evidence-Based Medicine*, n.d.). The Oxford CEBM ranking system identifies systematic reviews as the highest source of adequate and appropriate contributions to generate healthcare decisions. RCTs follow systematic reviews, both representing a level 1. CEBM ranks cohort and outcome studies (non-randomized), which would be patient experience and survey studies, as level 3. CEMB ranks studies with expert (clinician) opinions as level 5.

Many journals and conferences require authors to assign a level to the research they submit. This allows the reader to know the level of evidence of the study. The problem is that the levels have become interpreted to equal quality of research, with level one often perceived as the best while lower levels are considered weaker (Shaneyfelt, 2016). Many investigators question this and worry that many studies' findings are discarded due to their lower ranking from hierarchies' models (Shaneyfelt, 2016). Research studies addressing evidence relating to patient perspectives and clinician experience and opinions in descriptive study designs are defined as lower levels of research (Hoogeboom & Jette, 2021). The hierarchical research model should be used as a guide, not a definitive grading tool, as the hierarchical model may diminish the value of sound evidence that could be used to determine the most successful patient interventions (Shaneyfelt, 2016). Many researchers are concerned that the hierarchical models repress publications of valued and needed studies that contribute to EBP, such as studies involving patient and clinician perspectives (Lulin et al., 2016).

In theory, the three concepts of EBP contribute to healthcare interventions. Still, the hierarchical research model needs to consider patient or clinician experience as a high-quality contributor to the literature. This narrowed view of what qualifies as evidence may contribute to interventions lacking productivity. The healthcare industry must understand EBP interventions and the importance of published research beyond best research evidence studies. EBP must remember the importance of patient and clinician perspectives in justifying and progressing interventions. Patient and clinician perspective studies can be quantified and qualified to provide valuable information regarding how interventions work within patient populations. Updating the research ranking system or creating an offshoot ranking system to categorize these survey-style research designs could elevate this research style's importance. The elevation of importance may allow clinicians to absorb the information and encourage more publications on the subject.

Recommendations for the healthcare insurance industry:

Walking AD is considered DME and can be covered by insurance companies. There are limits to this; a patient can only receive a new walking AD every five years, regardless of the patient's changing condition (*Durable Medical Equipment, Prosthetics/Orthotics & Supplies Fee Schedule | CMS,* n.d.). Insurance companies and the healthcare industry may want to consider walking AD exchanges to allow for AD that meets the patients' current needs, not the needs of the past. Insurance companies may want to consider paying for having patients complete annual AD checks with rehabilitative clinicians to evaluate current ADs and, if needed, recommend updated equipment, all to prevent falls.

Recommendations for referring clinicians such as primary care physicians (PCP)

PCPs see patients at least once a year for an annual assessment (Rose et al., 2019). This is an opportunity for PCPs to deliver high-value, proactive, quality care and address current and future healthcare problems (Rose et al., 2019). PCPs can refer patients to specialists such as PTs and OTs for ailments such as mobility disorders and the ability to prescribe walking ADs (Freburger et al., 2018; Kaye et al., 2000; Michael et al., 2020; Raymond et al., 2020; Rose et al., 2019). There are no current guidelines for PCPs on follow-up walking ADs, meaning that the equipment does not have to be checked at any given time after the prescription is ordered. Walking AD prescriptions are not viewed as the same as medication prescriptions, but they should be. Regular follow-up visits and maintenance checks for ADs should be essential to ensure proper fit and function over time. Incorporating AD assessments into annual primary care visits can help identify any issues or changes in patient needs and provide opportunities for additional education and adjustments, as necessary.

Recommendations for rehabilitative clinicians such as PTs and OTs

The understanding that ADs can cause harm to the patients if training, fitting, and education are not completed needs to be taught and reinforced throughout a rehabilitative clinician's career. Clinicians may not be fully aware of the discrepancies between the best research evidence that highlights the costs and benefits of AD use among older adults. There appears to be a gap in knowledge of the potential risks and benefits of recommending and training patients to use AD for everyday use. Clinicians must seek accredited continued education to stay abreast of the EBP literature regarding walking ADs. Education on the limitations or adverse effects of walking ADs can lead to modified or alternative treatments and interventions that can prevent falls and increase patient independence. Clinicians should prioritize patient-centered care and actively involve patients in decision-making regarding AD acquisition and use. This includes soliciting patient feedback, providing comprehensive training and educational materials, and integrating AD maintenance into routine healthcare assessments. Patient opinions need to be considered and directly obtained during the AD recommendation process, and documentation of this should be required. Standardized tests should be used to explore the cost and benefit of walking ADs on patients to determine if the intervention is successful or needs alterations. Adequate training is vital for the safe and effective use of ADs. Educational materials like handouts and videos can complement training and promote continued learning. Clinicians should ensure that patients receive comprehensive training and have access to academic resources to support ongoing use and reduce the risk of falls.

Recommendations for the governing accreditation bodies of rehabilitative clinicians

Millions of patients will use this intervention under the direction of rehabilitation clinicians, who, in turn, need to be experts in the healthcare industry on the subject. The way to achieve this is to start with a professional curriculum. Recommendations focus on enhancing educational curricula, increasing education on the importance of CE opportunities, and advocating for professional standards and guidelines. These efforts could improve patient outcomes and reduce fall rates among older adults.

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APPENDICES

Appendix A

EXPERIMENT 2: PATIENT PERSPECTIVES ON WALKING ADAPTIVE DEVICES AND THE RELEVANCE TO FALLS

Survey questions:

1. What is your age in years?
2. Gender: How do you identify (male, female, non-binary, prefer not to say, other __________________________)?
3. How did you obtain your walking AD? (Medical doctor, private pay, second hand, I do not know, or other __________________________________)
4. When you received the device, was it fit you? Categorical data (Yes= 1/ Maybe=2/ No= 0)
5. Did you receive training when you received the device? Categorical data (Yes= 1/ Maybe=2/ No= 0)
6. Were handouts of educational materials provided for you when you received the device? Categorical data (Yes= 1/ Maybe=2/ No= 0)
7. Was your opinion asked of you when you received the device? Categorical data (Yes= 1/ Maybe=2/ No= 0)
8. On a scale of 1-7, with one equating to extremely dissatisfied and seven equating to delighted (and 0=no training), how would you rate your satisfaction with the training? Interval data 0-7.

9. How many falls have you had in the last six months? (fill in the blank numerical response)

   numerical data.

Appendix B

EXPERIMENT 3: CLINICIAN EXPERTISE IN WALKING ADAPTIVE DEVICES FOR OLDER ADULTS

Survey questions:

1. What is your age in years?

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2. How do you identify?

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary/third gender (3)
- ○ Prefer not to say (4)

3. Please provide your zip code.

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4. Please indicate all your professional degrees. Please check all that apply.

- ☐ BA/BS, OT (1)
- ☐ MA/MS, OT (2)
- ☐ OTD or other clinical doctorate specifically for occupational therapy (3)
- ☐ BS, PT (4)
- ☐ MS, PT (5)
- ☐ DPT or other clinical doctorate specifically for physical therapy (6)
- ☐ PhD or other research doctorate for occupational or physical therapy (7)
- ☐ Occupational therapy assistant (8)
- ☐ Physical therapy assistant (9)
- ☐ Other (Fill in the blank) (10)

____

5. How many years have you been a practicing clinical rehabilitative therapist?

- ○ Less than one year (1)
- ○ 1-5 years (2)
- ○ 6-10 years (3)
- ○ 11-15 years (4)

○ 16- 20 years (5)

○ Over 20 years (6)

6. What clinical setting(s) are you currently employed? Please check all that apply.

☐ Acute Hospital (1)

☐ Subacute Rehabilitation (2)

☐ Inpatient Rehabilitation Facility (3)

☐ Outpatient Rehabilitation (4)

☐ Skilled Nursing Facility (5)

☐ Long-Term Care Hospitals (6)

☐ Home Health (7)

☐ Adult Daycare (8)

☐ Instructor/ professor in two or four-year program(s) including research (9)

☐ Other: ______________________ (10)

7. The following questions are regarding walking adaptive devices (four-wheeled walkers, hemi walkers, canes, etc.) Would your school curriculum sufficiently prepare you to recommend, assess, and train older adult patients to use walking adaptive devices?

○ Strongly disagree (1)

○ Somewhat disagree (2)

○ Neither agree nor disagree (3)

○ Somewhat agree (4)

○ Strongly agree (5)

8. Since graduating with your professional degree, have you been involved in continued education focused on walking adaptive devices? If so, what kind of education? (please check all that apply)

▢ Yes, I earned continued educational credits for participating in an in-person, online, or journal article with a quiz course approved by my national program (i.e., American Occupational Therapy Association (AOTA)). (1)

▢ Yes, I participated in a course or educational class that did not earn continuing education credits but was based on walking devices. This, for example, could be a course offered by your employer or a vendor. (2)

▢ I have received on-the-job training from colleagues such as co-workers or managers. (3)

▢ I have completed self-education from textbooks and online education. (4)

▢ I have not completed any education regarding walking adaptive devices since graduating. (5)

▢ Other (6) ____

9. Would you say your continued education post-school curriculum sufficiently prepares you to recommend, assess, and treat patients to use walking adaptive devices?

   ○ NA, I did not have additional education (0)

   ○ Strongly disagree (1)

   ○ Somewhat disagree (2)

   ○ Neither agree nor disagree (3)

   ○ Somewhat agree (4)

   ○ Strongly agree (5)

10. Please check any methods you standardly use to assess, treat, and recommend walking adaptive devices for older adult patients.

   ▢ Standardized test(s) (1) (if checked, please provide the name of the test(s) used)

   ____

   ▢ Reference guide from employer (2)

   ▢ Team meetings or team member communication (3)

   ▢ Independent search (i.e., from past educational materials, internet search, and journal articles) (4)

   ▢ Vendor recommendations (5)

☐ Clinical judgment (6)

☐ None, I do not recommend walking adaptive devices for older adult patients (7)

☐ Other (8) (please provide additional information)

____

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Abstract

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Grants

Firoved, A. Gait discrepancies across the healthy adult lifespan with and without the use of walking aids. Old Dominion University Graduate Summer Award Program. May 2020. $3000.