Client Perspectives on Perturbation-Based Balance Assessment and Training: A Survey-Based Study

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THESIS

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
PwS	People with Stroke
PwPD	People with Parkinson's Disease
PwMS	People with Multiple Sclerosis
PBBA	Perturbation-Based Balance Assessment
PBBT	Perturbation-Based Balance Training
PBBAT	Perturbation-Based Balance Assessment and Or/ Training
EP	Evidence-Based
CC	Client-Centered
SFT	Surefooted Trainer
MT	Motorized Treadmill
OGW	Overground Walkway
TSS	The Spring Scale
NIHSS	National Institutes of Health Stroke Scale

SUMMARY

Falls are a major concern among community-dwelling older adults and people with neurological disorders (e.g., stroke, Parkinson's disease, and multiple sclerosis). Presence of motor, sensory, and cognitive declines in the aging population as well as disease-induced impairments in the neurological population impose a higher risk of falls. These falls create a huge economic burden on the health care system as they are associated with significant non-fatal injuries and fatal accidents. Various clinical assessment and conventional interventions are widely used to assess and improve impaired balance; however, they suffer from ceiling effect and limited predictive capacity of falls. In addition, interventions lack task specificity, which may be the reason for lacking greater reductions in falls.

Perturbation-based balance assessment and training (PBBAT) has recently emerged as a paradigm involving unexpected perturbations in a safe (laboratory) environment. These perturbations are induced via motorized devices or manual devices. The devices vary in perturbation simulation and intensities as well as diverse perturbation characteristics (type, direction, and magnitude) and program (frequency and volume).

Due to the promising findings of PBBAT in research, few recent studies evaluate the efficacy and feasibility of translating the training for the clinical setting, thus current evidence remains limited. One potential reason for such poor clinical transition is the limited availability of commercial perturbation devices and therapists' safety concerns. In addition, client acceptability to PBBAT may also relate to the delayed transition to clinical setting. Focusing on the clients' needs and perspective by using the client-cantered approach might play an important role in their recovery experience and enhance their transition to the community.

For this reason, our purpose is to explore the clients' perspective from different populations - healthy older adults, populations with a neurological condition, and people who perceive themselves at risk of fall - by conducting a survey questionnaire. The questionnaire aims to explore 1) clients' knowledge and awareness of PBBAT, 2) clients' willingness to try devices and the most preferred device, 3) clients' perception of devices and perception of safety. We conducted statistical analyses on the data collected from 101 responses of the questionnaire to explore the client's knowledge and awareness, willingness, perception of safety, and tolerability of PBBAT. The exploratory findings indicate that the majority of clients acknowledged PBBAT by its definition rather than its name alone. Furthermore, the Overground Walkway device had the higher portion of willingness to try; however, the Surefooted Trainer device and the Spring Scale devices were the most preferred devices to be picked for training or assessment, respectively. For perception of devices, "Curiosity" was the dominant feeling across all devices. Moreover, clients felt safe to undergo the assessment or training with one therapist by their side in addition to the overhead harness. The device design (e.g., harness) had been the majority of how they perceive safety. Also, the most expected outcome of PBBAT is physical improvement in walking and balance. Finally, the most accepted dosage for PBBAT is thirty minutes session twice a week for six weeks duration. The data is presented in Chapter III.

CHAPTER I INTRODUCTION

1.1 Background

Epidemiology of falls

Falls are a major concern among community-dwelling older adults, and they have an increased fall risk owing to a higher frequency of comorbidities, age-related physiological changes, and delayed functional recovery, which leads to additional de-conditioning and more future falls (Ambrose et al., 2013). Fall is defined as "unintentional change in the position of the body in which it comes to rest on the ground or strikes an object" (Pignolo et al., n.d.). Additionally, falls are associated with significant fall-related injuries with 3 million older adults being treated in the emergency department along with increased mortality. Evidence suggests that falls result in 95% of hip fractures, joint dislocation, severe head injuries, decline in their mobility, decline in their ability to perform activities of daily living (ADL), and moving into a nursing home (Ambrose et al., 2013). As reported by Centers for Disease Control and Prevention (CDC), falls have been a leading cause of death in older adults aged 65 years and older such that a 30% increase of death rates have been noted from 2009 to 2018 (CDC, 2017). Consequently, falls and fall-related injuries impose a huge economic burden on the health care system, such that non-fatal falls cost 50 billion dollars and fatal falls cost 754 million dollars (CDC, 2020).

Similar for people with neurological disorders (e.g., stroke, Parkinson's disease, and multiple sclerosis) (Wagner et al., 2009), falls occur due to the presence of motor, sensory, and cognitive induced impairments (Todd & Skelton, 2004; DeMaagd & Philip, 2015; Geurts et al., 2005; Khan et al., 2008). Due to the typical consequences of neurological diseases that affect integrative motor functions such as balance and gait regulation, a high prevalence of falls is to be expected in these populations (Stolze et al., 2004). Falls have been associated with serious injuries and death resulting in economic burden (Mazumder et al., 2014; Pelicioni et al., 2019; Mansfield et al., 2019; Batchelor et al., 2010). Such injuries can lead to an increased risk of fracture, especially hip fracture, fear of a new fall (Cho et al., 2015), and even a substantially decreased survival time (Wagner et al., 2009). Studies found approximately 73% of people with stroke (PwS) experience falls within the first 6 months after stroke (Batchelor et al., 2010), 85% of people with Parkinson's disease (PwPD) report falls after 20 years of disease onset (Peterson & Horak, 2016), and 50% of people with multiple sclerosis (PwMS) fall annually (Mohamed Suhaimy et al., 2020).

People of different populations who experience a fall, regardless of their injury severity, develop fear of falling. Fear of falling is defined as "lower or decreased perceived self-efficacy or confidence in avoiding falls while completing activities" (Schmid et al., 2011). It is a common problem among populations predisposed to risk of falls, and community-dwelling older adults report 56.7% fear of falling in one study and 75.6% in another (S. Lee et al., 2018), and the prevalence is even higher in certain subpopulations, such as females and those with a previous history of falls (Deshpande et al., 2009). Similarly for people with neurological disorders, fear of falling has been reported 54% in hospitalized patients with acute stroke (Da Silva et al., 2014) and 70% in PwPD (Lindholm et al., 2014). Fear of falling was also correlated with risk of fall in PwMS (Kasser et al., 2014). This fear of falling will further lead to adverse consequences such as greater risk of falling, functional constraints, lesser quality of life, lower level of physical activity, mental impact, and even higher mortality (Drummond et al., 2020).

Risk Factors of Falls

Previous studies have identified the factors increasing the risk of falls (Todd & Skelton, 2004). These risk factors have been categorized into intrinsic factors such as lower-body weakness, impaired balance, impaired functional mobility, sensorimotor impairments, use of psychoactive medications, and presence of comorbidities as well as extrinsic environmental factors such as tripping hazards, slippery floors, and lack of stair railings or grab bars (Stevens, 2005; Pelicioni et al., 2019; Tan & Tan, 2016; Carling et al., 2018). The risk of falling increases with the number of risk factors present and with age. In older adults and people with neurological disorders, poor postural control, stiffer, and less coordinated gait pattern are present in addition to declined reflexes orienting the body, muscle strength, and tone (Ambrose et al., 2013). In multiple reviews, balance and gait disorders have been consistently identified as among the strongest risk factors of falls (Ambrose et al., 2013).

Balance Control Mechanisms

Balance is a complex motor skill that depends on interactions between multiple sensorimotor processes and environmental and functional contexts to maintain postural equilibrium to avoid falls. Balance control is the ability to maintain one's center of mass (CoM) relative to base of support (BoS) in static and dynamic stability. Wherein static stability, CoM is positioned above BoS, while dynamic CoM is positioned outside BoS and must be brought back above BoS or the BoS must be moved to attain the same situation (Woollacott & Tang, 1997). It is also further subdivided into proactive balance control (i.e., anticipation of an expected perturbation) and reactive balance control (i.e., maintain postural balance in response to a mechanical unexpected perturbation) (Gschwind et al., 2013; Mohamed Suhaimy et al., 2020). As balance control and gait are affected by age and neurological disorders, assessing these two intrinsic risk factors can aid in identifying individuals at risk of falls (Gschwind et al., 2013).

Traditional Balance Control Assessment

Various clinical measures had been widely used to assess several intrinsic/volitional risk factors and to serve as fall risk predictors (Gangwani et al., 2020). Such measures are the Berg Balance Scale, Timed Up and Go, and posturography. These measures vary in subject requirement, while some require maintaining position or complete movement tasks of varying difficulty (e.g., sit-to-stand, standing unsupported, placing alternate foot on stool), others require one task (e.g., stand up and walk 3 m, then turn back and sit down again). The success and failure of these measures are determined by the performance of a specific balance task at a specific time during testing (van Dieën & Pijnappels, 2017). As falls occur while walking, they are caused by extrinsic unexpected risk factors (e.g., slips or trips) (Arienti et al., 2019; Sosnoff et al., 2011), and reactive balance control is needed to avoid such fall. However, the aforementioned measures fail to assess reactive balance control. Moreover, these measures demonstrate high ceiling effect and lack outcome validity as they have failed to classify between fallers and non-fallers (Bhatt et al., 2011).

For instance, Berg Balance Scale included static and dynamic assessing components, however, lacked assessment of functional tasks of locomotion (Gangwani et al., 2020; Bhatt et al., 2011). The scale also lacks item requiring postural response to external stimuli or uneven support surfaces, and it was found to be a poor predictor of falls in some populations (A.F. Ambrose et). On the other hand, Timed Up and Go includes gait measures and focuses on assessing the level of functional mobility, however, it also has been suggested that it is more appropriate for older adults who have comorbidities than for community-dwellers (Bhatt et al., 2011). Moreover, sophisticated instrumented measures have been used, such as Sensory Organization Test, that provide quantitative assessment of postural sway (i.e., the body ability to maintain stability during static and dynamic tasks); however, these tests fail to assess stability while walking, wherein most falls occur (Gangwani et al., 2020). In addition, these measures have limited predictive capacity (overall accuracy < 70%) (Wang et al., 2019). Furthermore, spatio-temporal gait parameters such as step length and height, slower gait speed, and gait features reduced performance (such as swing double-support, phase swing time variability, and stride length variability) had predicted fall risk.

Although these parameters have a higher predictive capacity for risk of falls, many studies indicated heterogenic findings that further limited their clinical application (Wang et al., 2019). Therefore, the limited availability of clinical tools with high accuracy to predict falls has created a gap in literature (Inness et al., 2015). Assessing fall risk factors are imperative to implement fall prevention strategies

Perturbation-Based Balance Control Assessment

Perturbation-based balance assessment (PBBA) has recently emerged as a paradigm involving unexpected perturbations in a safe (laboratory) environment to assess reactive balance control and fall-risk (Pai et al., 2014). These unannounced perturbations destabilize balance by challenging the CoM out of the BoS in order to mimic the accidental and unexpected environmental falls in daily life, hence, reactive balance reactions are induced to prevent such a fall. The perturbation-based studies reported higher accuracy of predicting fall risk by measuring reactive balance recovery induced by laboratory unexpected perturbations (Bhatt et al., 2011). Inducing the perturbations in these environments are via motorized devices including Surefooted Trainer (SFT), Motorized Treadmill (MT) (Okubo et al., 2019), Overground Moveable floor walkway (OGW) (Gerards et al., 2017) devices, or manual device like the Spring Scale (TSS) (Pigman et al., 2019). Each device has different perturbation characteristics (type, direction, and magnitude) and program (frequency and volume) (Okubo et al., 2019). Also, all motorized devices are equipped with an overhead safety harness. A study by Wang et al. (2019) found their fall prediction model based on laboratory slips have predicted 77.2% of fall recovery while clinical tools and demographic characteristics-based model have predicted 47.4% of fall recovery. A higher predictable risk of fall assessments are imperative to develop and enhance therapeutic strategies specific for fall prevention (Wang et al., 2019). Identifying at-risk individuals is a vital concern to design interventions that influence factors increasing the risk of falls.

Traditional Balance Control Training

With such high fall incidence, there has been an exponential increase in fall prevention interventions over the last decade. While several interventions have emerged (e.g., Tai Chi, virtual reality, dance therapy), conventional balance exercises are still most widely used. The main aim of these conventional (traditional) exercises is to restore independent gait and balance because they, in turn, are associated with independent mobility and reduce risk of fall (An & Shaughnessy, 2011). Many studies have reported that several exercises programs, such as gait-oriented training, aerobic treadmill training, intensive mobility training, and physiotherapeutic intervention, are beneficial in improving walking and balance ability (An & Shaughnessy, 2011). There is strong evidence for PwS that a combination of balance, gait, and aerobic exercises would be ideal to improve balance. Further, for older adults, a systematic review by Papalia et al. (2020) reported physical exercise as an effective treatment to improve balance and reduce fall rates in older adults. Moreover, Sherrington et al. (2008) systematic review findings were that exercises challenging balance, use a higher dose of exercise, and do not include a walking program have reduced falls by 17% in older adults.

Although fall reduction is evident in these studies, the reduction is limited (Gerards et al., 2017). The nature of these trainings (e.g., voluntary stepping exercises) (Gerards et al., 2017) are based on performance by including self-initiated, self-motivated (Pai et al., 2014), and volitional activities (Kajrolkar et al., 2014; Pigman et al., 2019). Meanwhile, most falls are caused by environmental perturbations (e.g., slips or trips) (Arienti et al., 2019; Sosnoff et al., 2011). To recover from such a fall, necessary strategies such as ankle and hip strategies or stepping and grasping reactions (Mansfield et al., 2018) must be executed. These strategies (i.e., reactive balance reactions) are not targeted for improvements in conventional exercises. Lack of task specificity in these exercises might be the reason for lacking greater reductions in falls (Gerards et al., 2017).

Perturbation-Based Balance Control Treatment

Perturbation-based balance training (PBBT) involves experiencing repeated unexpected perturbations in a safe (laboratory) environment (Pai et al., 2014) and is task-specific training aimed to elicit an individual's own neuromuscular protective mechanisms (Allin et al., 2020) and reactive balance reactions (Pai et al., 2014) adequate for fall incidence reduction (Bhatt et al., 2011). A randomized control trial by Bhatt et. al (2012) reported a significant reduction of falls and balance loss incidence in healthy older adults after imposing a single training session. Also, these reductions were retained after 6 months of training. Notably, training tasks that are specific to balance recovery reactions might provide a promising fall prevention method (McCrum et al., 2017). Furthermore, motor skill learning (Bhatt et al., 2012) and locomotor adaptations (Okubo Y et al., 2018) required for reducing real-life falls caused by unexpected perturbations are possibly better learned in environments that are mimicking environmental unexpected perturbations (e.g., slips or trips) (Pai & Bhatt, 2007).

Perturbation-Based Balance Assessment and/or Treatment in Clinical Setting

Perturbation-based balance assessment and/or treatment (PBBAT) is now widely used in research laboratories (Mansfield et al., 2018; Pai et al., 2014; Mohamed Suhaimy et al., 2020). Due to its promising findings, few recent studies evaluated the efficacy and feasibility of translating it for clinical setting (Gerards et al., 2017). A study by Pigman et al. (2019) had developed motorized treadmill training in a clinical setting for people with stroke (n=13). They have found that their training was acceptable (determined by adherence), practical (determined by the equipment, space, time, and personnel), safe (documented by adverse events), and potentially beneficial (determined by the number of successful recoveries and the highest perturbation magnitude achieved on the first and last sessions). Another systematic review by Gerards et al. (2017) found that PBBAT is a feasible fall prevention method in clinical setting. The review stated that motorized treadmill and manual perturbations are the most practical methods and that combining multiple perturbation types, and directions might be of most benefit.

1.2 Statement of the problem

Implementing PBBAT in clinical setting

Results from previous PBBAT based studies have shown promising findings and thereby was recommended to assess and improve reactive balance control; however, implementing PBBAT to clinical setting is limited. One potential reason for such poor clinical transition is the limited availability of commercial perturbation devices because they vary in perturbation simulation and intensities. For example, SFT has a low-intensity perturbation, MT's belt produces perturbations with abrupt acceleration (Okubo et al., 2019) and its intensity range from low to high, and OGW perturbations are produced by concealed slipping tiles or tripping boards (Okubo et al., 2019) and its intensity is dependent on the client's walking speed. While there are different motorized devices used in research laboratories, the majority of PBBAT conducted in the clinical setting use treadmill-based perturbations due to its commercial availability and convenient implementation (A. Lee et al., 2016).

Another potential reason for limited use in the clinic is therapists' safety concerns regarding PBBAT, despite the training's acceptance to be incorporated into treatment plans. A study by Mansfield et al. (2019) reported therapists' perspectives on facilitators and barriers of adopting PBBAT in clinics. The most prominent barriers were the therapists' lack of knowledge and training, lack of additional personnel assistance, various patients' qualities, lack of space for equipment, and lack of safety equipment.

Therapists' perspective, and clinical acceptability in terms of resources, facilitators, and barriers of implementing PBBAT in clinics have been explored, despite the little knowledge found in literature about it. However, deliberately exposing high fall-risk populations to unexpected perturbations is challenging, not only for therapists but also for these populations to tolerate. Therefore, absence of client acceptability of PBBAT might also relate to the delayed transition to clinical setting. Focusing on the clients' needs and perspective has been disregarded by the evidence based (EB) approach (Cott, 2004), which is the current cardinal approach used by the health care system. The EB approach is led by clinical expertise to hold decision-making of treatment plans, in addition to, the best available clinical evidence from systematic research (Cott, 2004). On the contrary, the client-centered (CC) approach is mainly committed to meet the values, beliefs, preferences, and special needs of the client (McMillan et al., 2013; Xu et al., 2019).

1.3 Significance of the problem

Client Perspective of PBBAT

When the CC approach is practiced, enhanced patient outcomes have been reported by many studies (Cott et al., 2006). Such reported improvements include enhanced functional abilities, well-being, and quality of life in addition to higher satisfaction with care and a lower financial burden (Cott et al., 2006). Operationalize the CC approach in delivering rehabilitation services might provide high-quality services that in turn will lead to greater functional outcomes for the client (Yun & Choi, 2019). The imperative goal for rehabilitation services is to optimize independence and expedite the transition of disabled individuals into the community again (Yun & Choi, 2019). Therefore, actively involving the client in the process of decision-making might play an important role in their recovery experience and enhance their transition to the community.

Although only one study has explored the client's perception, their findings were limited to perturbation assessment of one population (chronic stroke) and one type of perturbation (lean and release cable method) (Pak et al., 2015). Therefore, expanding the exploration to all populations predisposed to the risk of fall are important findings to minimize the gap of translating PBBAT to clinical setting, especially if perturbation-based balance is the most effective assessment and training for reactive balance reactions required to prevent falls. Meanwhile, therapists in this study addressed barriers to implementing PBBAT in their practice and they all interacted with safety concerns. Some therapists expressed that the patients' fear had prevented them from conducting the training, while others noted their fear of patients might sustain an injury had prevented them. Acknowledging the positive results and purpose behind these assessments and training by the client might optimize the therapist's insight on adopting PBBAT.

To explore the client's perspective of PBBAT, a theoretical framework was developed based on reviewing the findings of Pak et al. (2015) and Mansfield et al. (2019) since there is a paucity of questionnaire-based studies on clients' PBBAT experience. Only respective parts of these studies to the client's attitude, characteristics, and client's barriers of PBBAT had been taken into consideration in addition to reviewing the literature for accessible perturbation devices and different used paradigms.

1.4 Purpose of the study

For these reasons, our purpose is to explore the client's perspective from different populations – healthy older adults, populations with a neurological conditions, and people who perceive themselves at risk of fall – by conducting a survey questionnaire. The questionnaire aims to explore the following:

1) Clients' knowledge and awareness of PBBAT
2) Clients' willingness to try devices and the most preferred device
3) Clients' perception of devices and perception of safety

CHAPTER II METHODS

2.1 Study Design

This study was a cross-sectional survey targeting heathy older adults, people with neurological disorders, and people who perceive themselves at risk of fall. The theoretical framework was used to identify the study themes. This study was approved by the Institutional Review Board of the University of Illinois at Chicago, and written informed consent was obtained from all participants prior to their enrollment.

2.2 Questionnaire Development

2.2.1 Initial draft

Based on Pak et al. (2015) and Mansfield et al. (2019) findings, four themes have been identified to build the questionnaire: knowledge and awareness of PBBAT, willingness to try devices and most preferred devices, perception of safety and devices, and dosage and cost. The initial draft was a printout and comprised of three parts. Demographic information (five items) (Table I) and medical history and physical function (eleven items) (Table II) were the first and second parts, respectively. These parts were included to establish any potential remarks of the four themes to the clients characteristics. The third part of the questionnaire was twenty-one items, all pertaining PBBAT (Table III).

2.2.1.A The first part (Demographic Information)

Five items were included, (gender, age, living arrangement, education level and race/ethnicity).

Table I: (Part 1) Demographic Information Questionnaire Items

Part 1	*Reflective Item*	***Item* Structure (*Close Ended)***
Demographic Information	"Gender"	○ Male ○ Female
	"Living arrangement"	○ Alone ○ With 1 or more persons ○ Other situations, please specify
	"Education Level"	○ Less than primary school ○ Primary school ○ High school ○ Higher education
	"Race/Ethnicity"	○ Caucasian ○ African-American or black ○ Hispanic ○ Other, please specify

2.2.1.B The second part (Medical History and Physical Function Information)

This part has eleven items with close-ended choices (Yes, No, I don't know, Maybe) (Table II). The opening first item was to investigate the perceived health: "Do you perceive yourself as healthy older adult?" The definition of healthy older adult had been added in attempt to simplify the item for the reader, "Healthy older adult is defined as: a person who has optimal physical, mental, function and social well-being." This was followed by three medical history items to investigate the following: presence of neurological diagnosis, presence of non-neurological diagnosis, and number of medications. Next, two items were included to investigate their perception of being at risk of fall: "Would you consider yourself at risk of fall?" choices ranked (Yes, No, Maybe) and "How high do you perceive your fall risk to be?" with ranked choices (Mild, Moderate, and High) to explore the perceived risk of fall. The proceeding five items were to investigate physical information, "Have you experienced a fall in the past year?", "How long are you able to stand?", and "Can you walk independently?" with sub-item: "If no, please specify your walking aid", "How far can you walk independently or with an assistive device”, and finally, “Are you currently in any rehabilitation program (inpatient or outpatient) research study or going to the gym?”.

Table II: (Part 2) Medical History and Physical Function Information Questionnaire Items

Part 2	Reflective Item	Item structure (Close Ended)
Medical History and Physical Function Information	"Do you perceive yourself to be a healthy older adult?" "Healthy older adult is defined as: a person who has optimal physical, mental, function and social well-being aged 65 years and older."	○ Yes ○ No ○ I don't know. If no or I don't know please feel free to specify why:
	"Have you been diagnosed with any neurological disease/disorder (some examples are stroke, Parkinson's disease, Multiple sclerosis):"	o Yes. If yes, please specify: o No o Other, please specify
	"Have you been diagnosed with any non-neurological disorder?"	○ Yes. o Cardiovascular disease/disorder o Musculoskeletal o Systemic – cancer, lupus, kidney problems o Other, please specify: ○ No.
	"How many medications do you take?"	○ None ○ 1 ○ 2 ○ 3 ○ 4 or more, please specify
	"Would you consider yourself at risk of fall?"	○ Yes ○ Maybe ○ I don't know ○ No
	"How high do you perceive your fall risk to be?"	○ Mild ○ Moderate ○ High
	"Have you experienced a fall in the past year?"	○ Yes. o If yes, please specify how many in the past year? ○ No
	"For how long are you able to stand?"	○ less than 5 minutes ○ 5 minutes ○ More than 5 minutes ○ Other, please specify
	"Can you walk independently?"	○ Yes, without any assistive device ○ No. If no, please specify your walking aid: o Cane o Walker o Need external assistance ○ Other assistive device, please specify
	"How far can you walk independently or with an assistive device?"	○ Less than 1 block ○ One block ○ blocks ○ More than 2 blocks ○ Other, please specify:……
	"Are you currently in any rehabilitation program (inpatient or outpatient) or research study or going to the gym?"	○ Yes o Inpatient rehabilitation program o Outpatient rehabilitation program o Research study o Other, please specify: ○ No

2.2.1.C The third part (PBBAT Items)

To investigate prior knowledge and/or experience of PBBAT, five items were designated and consist of the following: “Have you heard of perturbation-based balance assessment and training PBBA before?” The “Yes” option has a sub-item: “Please tell us how?” and “No” option has sub-text of the assessment and training definitions. The definitions are followed by another sub-item: “After reading the definitions, have you heard of such training before?” Proceeding items were, “Do you think that perturbation-based assessment and training (PBBAT) is a diagnostic tool for fall-risk?”, “Have you undergone any kind of perturbation assessment and/or training before?”, “Do you think that perturbation-based (disturbance-based) assessment and training (PBBAT) can reduce risk of falls?”, and “Do you know there are more than one device for PBBAT?” All the above items were close ended, and the choices were (Yes, No, Maybe, or I don’t know).

One item was designated to explore feelings of safety of each device with 4 sub-items for each device. Written descriptions of each device’s function and pictures of Surefooted, Motorized Treadmill, Overground Movable Walkway, The Spring Scale, Balance Tutor, and CAREN (The Computer Assisted Rehabilitation Environment) device, were added. Each definition and picture had three open-ended items: “How do you feel?”, “Why?”, and “Comments.” In addition, one close ended item aimed to explore safety: “Choose how safe you feel when you look at each perturbation-based (disturbance-based) assessment and training (PBBAT) device?” In light of Pak et.al (2015) study findings, PwS expressed their source of security as their trust for their therapist as well as the harness setup, and Mansfield et al. (2019) therapist’s addressed additional assistance were required. Therefore, choices were formulated based on these findings by ranking safety as (“Unsafe”, “Safe with harness”, “Safe when I have 2 trained therapists by my side for the whole training with given instruction before the assessment and/or training starts”, “Safe when I have 1 trained therapist by my side for the whole training given instruction the assessment and/or training starts”, “Safe when given clear instructions before training starts and without therapist by my side"). An additional choice was included for text entry ("Other, please specify").

The eighth item was included to explore the perception of safety, "For the options given below, which statements come to mind when you think of a safe experience." Choices were also based on Pak et.al (2015) findings, which were the following: "I feel safe with how the training device is designed (for example, there is a harness)", "I feel safe because I trust the therapist", and "I feel safe that I am not going to get injured."

To explore tolerability of the devices, one item was included: "Which device are you most likely to choose for your assessment or training? Why did you choose it?" All devices were included as choices, with an open-ended sub-item, "Why?" to each choice.

To explore the client's knowledge and awareness of PBBAT, five items were asked in regard of physical improvement in walking pattern and balance, reduction of falls, increased confidence, reduced fear of falling while performing daily activities (such as transferring from bed to chair, standing in a moving bus, or walking on icy sidewalks, increase in physical activity), presence of any side effects of the training, and being ineligible for PBBAT training due to health problems (like hypertension, heart disease, arthritis or back pain). All the above items were close ended, and the choices were (Yes, No, Maybe, or I don't know).

To explore the accepted dosage and cost of the assessment and/or training, three items were designated as follow: "What is maximum length of the training in weeks to adhere to the program?" with answers ranked ("1 week", "3 weeks", "6 weeks", "12 weeks"), " What is maximum number of sessions per week to adhere to the program?" with answers ranked ("1 time per week", "2 times per week", "3 time per week"), "If PBBAT had to be paid out of pocket per session, how much you're going to pay?" with answers ranked ("$30-50", "$50-100", "$100-200", "$200-400"). All items included an additional choice allowing participants to add text (Other, please specify…).

Table III: (Part 3) PBBAT Questionnaire Items and Themes

Theme	Reflective Item	Item structure
Knowledge of PBBAT	"Have you heard of perturbation-based balance assessment and training (PBBAT) before?"	Close ended
	"Do you think that perturbation-based (disturbance-based) assessment can be a diagnostic tool for fall-risk?"	
	"Have you undergone any kind of perturbation-based (disturbance-based) assessment and training before?"	
	"Do you think that perturbation-based (disturbance-based) assessment and training (PBBAT) can reduce risk of falls?"	
	"Do you know that there is more than one device for perturbation-based (disturbance-based) assessment and training (PBBAT)?"	
	"Do you expect to see a physical improvement in your walking pattern and balance from perturbation-based (disturbance-based) training (PBBT)? "	
	"Do you expect a reduction in your falls after perturbation-based (disturbance-based) training (PBBT)?"	
	"Do you expect increased confidence and reduced fear of falling following perturbation-based (disturbance-based) training (PBBT) while you perform daily activities such as transfer from bed to chair, standing in a moving bus or walking on icy sidewalks?"	
	"Do you expect your physical activity levels to increase following perturbation-based (disturbance-based) training (PBBT)?"	
	"Do you think there are any side effects to perturbation-based (disturbance-based) training (PBBT)?"	
	"Do you think other health problems like hypertension, heart disease, arthritis or back pain might make you ineligible for perturbation-based (disturbance-based) training (PBBT)?"	
	"What should be the maximum length of the training in weeks for you to adhere (stick) to the program?"	
	"What should be the maximum number of sessions per week for you to adhere (stick) to the program?"	
	"If you had to pay out of your pocket for such fall-prevention training how much would you be willing to pay per session?"	
Perception of safety	"Choose how safe you feel when you look at each perturbation-based (disturbance-based) assessment and training (PBBAT) device?"	Close ended
	"For the options given below, which statements come to mind when you think of a safe experience"	
Willingness to try device	"Look at each device and kindly answer the questions on the side: How do you feel when you look at the picture? Why? Comments"	Open ended
	"Are you willing to participate in perturbation-based (disturbance-based) assessment and training (PBBAT) for fall risk prevention?"	Close ended
Most desirable device	"Which device are you most likely to choose for your assessment or training? Why did you choose it?"	Open and close ended

2.2.2 First Pilot testing

The initial draft had been shared with our lab members for further professional opinion about the clarity of items, the wording, and the questionnaire's ease of flow. More than 5 responds were received. Their highlighted concerns were pertaining the length of the questionnaire, the ambiguity of differentiating between perturbation assessment and training as well as between slips and trips. To shorten the questionnaire, Balance Tutor and CAREN devices were removed and only devices available in the CogMoBal laboratory were included. Also, each term had been defined to increase the questionnaire's readability and flow. At this point, an element manifested itself, as the willingness of trying the devices may vary due to the differences in the setup and functionality of each device. Therefore, an item for each device particularly exploring the client's willingness to try it had been added, in addition to the previous item: "Which device are you most likely to choose for your assessment or training? Why did you choose it?", which explores the most preferred device. Furthermore, the questionnaire had been transitioned to an online format to increase accessibility in addition to the current printout option. The online version had four parts, and the first part was an attached PDF written consent form. After clients consented their participation, the rest of the questionnaire automatically unlocked to proceed to the following parts. The second, third, and fourth parts were demographic information, medical history and physical function, and PBBAT items, respectively.

2.2.3 Second Pilot testing

In order to test the questionnaire's relatability to the respective populations of the study, the second revised draft was tested on a convenient sample size who were eligible for the survey study. More than thirteen responses were received with frequent comments about the survey length, requests of including videos to the devices instead of pictures and expressed vagueness of the open-ended item. To further shorten the questionnaire, five items were merged into one item (Table IV). Also, pictures were replaced by videos to generate a clearer visual illustration of each device's function. Moreover, to examine the client's feelings on these devices, the open ended item, "How do you feel when you look at the picture?" had been converted to a close ended question by adapting a selection of multiple objectives used by Mansfield et.al (2019) that examined the therapists' attitude of PBBAT. Therefore, to parallelly discover the client's feelings and attitude towards PBBAT, the same objectives were used. To accommodate different attitudes, three objectives carrying negative attitudes, two neutral attitudes, and three positive attitudes were included.

2.2.4 Final Version

The third revised version (Table IV) was finalized and published including online and printout format.

Table IV: Questionnaire Third Draft Changes

Initial and Second Draft Item	Third Draft Revised Item	Purpose of Change
"Do you think that perturbation-based (disturbance-based) assessment and training (PBBAT) can reduce risk of falls?" "Do you know that there is more than one device for perturbation-based (disturbance-based) assessment and training (PBBAT)?" "Do you expect to see a physical improvement in your walking pattern and balance from perturbation-based (disturbance-based) training (PBBT)? " "Do you expect a reduction in your falls after perturbation-based (disturbance-based) training (PBBT)?" "Do you expect increased confidence and reduced fear of falling following perturbation-based (disturbance-based) training (PBBT) while you perform daily activities such as transfer from bed to chair, standing in a moving bus or walking on icy sidewalks?" "Do you expect your physical activity levels to increase following perturbation-based (disturbance-based) training (PBBT)?" "Do you think there are any side effects to perturbation-based (disturbance-based) training (PBBT)?" "Do you think other health problems like hypertension, heart disease, arthritis or back pain might make you ineligible for perturbation-based (disturbance-based) training (PBBT)?"	"What do you expect of perturbation-based (disturbance-based) balance training (PBBT)? (You can select all that apply)" ☐ Physical improvement in your walking pattern and balance ☐ Increased confidence and reduced fear of falling while you perform daily activities, such as transferring from a bed to a chair, standing in a moving bus, or walking on icy sidewalks ☐ Reduction in your falls ☐ Increase in physical activity levels ☐ There are side effects of the training You expect to be ineligible for the training due to health problems like hypertension, heart disease, arthritis or back pain	*To shorten the questionnaire*
"Look at each device and kindly answer the questions on the side: How do you feel when you look at the picture?, Why?, Comments"	What do you feel when you look at the device? (You can select all that apply: ☐ Optimistic ☐ Excited ☐ Curious ☐ Worried ☐ Afraid ☐ Cautious ☐ Satisfied ☐ Safe Other. please specify	*Increase Clarity*
Pictures	Videos	*Increase Clarity*
"Which device are you most likely to choose for your assessment or training? Why did you choose it?"	"Which device are you most likely to choose for your assessment or training? Why did you choose it?" In addition to: "Are you willing to try this device?"	*Increase specificity*

Figure 1: Pictures Taken from The Questionnaire Videos

(A) Picture taken from the original video of SFT included in the questionnaire. **(B)** Picture Taken from the original video of MT included in the questionnaire. **(C)** Picture Taken from the original video of OGW included in the questionnaire. **(D)** Picture Taken from the original video of TSS included in the questionnaire.

2.3 Questionnaire Dissemination and Participants' Recruitment

An online tool (Qualtrics^{XM}) was used to collect questionnaire data. Participants were recruited if they understand and communicate in English in addition to the following inclusion criteria: healthy older adults (60-90 years), people with neurological disorders (18-90 years), and people who perceive themselves at risk of fall (18-59 years). The only exclusion criterion was the inability to understand and communicate in English.

Potential participants were recruited through posting flyers in various community centers and exercise centers. They were also recruited via online channels by sending emails to directors and/or coordinators of various inpatient, outpatient, community centers, and support groups. In addition to posting flyers and the questionnaire link on our lab social media page, the survey was shared with different organizations, hospitals, community centers, and associations related to older adults and people with different neurological disorders. Flyers also mentioned an option of a live session via "Zoom" with a research member in attempt to assist participants who have difficulty with technology throughout the questionnaire.

2.4 Data and statistical analysis

Descriptive statistics (summary) were employed for demographical information as well as medical history and physical function. Chi-square was used in following items: if there is difference between acknowledging PBBAT by its name alone or definition, expectation for PBBAT to be as a diagnostic tool, prior experience of PBBAT, expectation for PBBAT to reduce risk of falls, prior knowledge of PBBAT devices. Friedman's test was used on the following PBBAT items; improvement expectations of PBBAT, willingness to try the devices, most preferred device for assessment or training, safety on devices, PBBAT accepted session duration, accepted number of sessions per week, accepted length of training per weeks, and accepted cost per session. Text analysis was used to analyze the open-ended item designated to participant's justifying their preference of device. SPSS Version 1.0.0.1508 (1.0.0.1508) was used, and a p-value (0.05) was chosen as the significance level.

2.5 Perception Testing

The questionnaire incorporates a number of items depending on visual perception, therefore, to assess participants' visuo-spatial intact skills and visuoperceptual skills, the National Institutes of Health Stroke Scale (NIHSS) (National Institute of Neurological Disorders and Stroke (U.S.), 2011) picture has been used.

The NIHSS (Appendix A) is used to assess stroke severity by including 15 items assessing the following domains: level of consciousness, eye movements, integrity of visual fields, facial movements, arm and leg muscle strength, sensation, coordination, language, speech and neglect. Each item ranging from 0 to 2, 0 to 3, or 0 to 4, then summed to a total score ranging from 0 to 42. Higher scores are related to a higher stroke severity (Kwah & Diong, 2014).

The scale has a "best language" item, which is comprised of picture, list of pictured objects, and two sentences list, aimed to assess comprehension by asking the patient to describe what is happening in the picture, to name items on the naming sheet (pictured objects), and to read from the sentences list. The description picture (Appendix A) has been selected in our study to test perception, because it has two improper information that participants must identify in order to assess their visual-spatial and visuoperceptual skills, that are required to comprehend and answer the questionnaire items following the videos. The NIHSS is widely used for stroke patients, however, in our study we used the picture only on healthy older adults and people with neurological disorders. This application is due to the possibility of these populations to develop a perceptual deterioration (Owsley, 2016; Faubert, 2002) as a result of their aging process or their neurological impairment.

A random selection of participants were contacted via the provided contact information item at the end of the questionnaire and asked to identify the improper information in the picture. Participants had been asked "What is wrong in that picture?", or "Is there anything out of the ordinary in this picture?".

CHAPTER III RESULTS

3.1 Questionnaire Dissemination and Participants Characteristics

One hundred and eleven responses were received via online platform (Qualtrics^{XM}); however, 10 responses were incomplete, hence, excluded from analysis. Therefore, 101 final responses were included in the analysis. One participant requested a live Zoom session for technological assistance and the remainder were completed without any assistance. Participants' characteristics are presented in Table V. Medical history information is presented in Table VI. Most participants do not consider themselves at risk of fall (34%), and the majority perceive themselves in a mild risk of fall (Figure 2). However, further analysis between groups, healthy older adults (n=59 participants) and people with neurological disorders (n=36 participants), showed the latter group considers themselves at more risk of fall (44 %), wherein healthy older adults are (20%) (Figure 3). They also, perceive themselves in a moderate risk of fall (42%), wherein healthy older adults who perceive themselves in moderate risk of fall are only (29%) (Figure 3). Moreover, people with neurological disorders reported a higher percentage of the history of falls (47%) than healthy older adults (34%) (Figure 3). The general analysis of physical function results are presented in Figure 2.

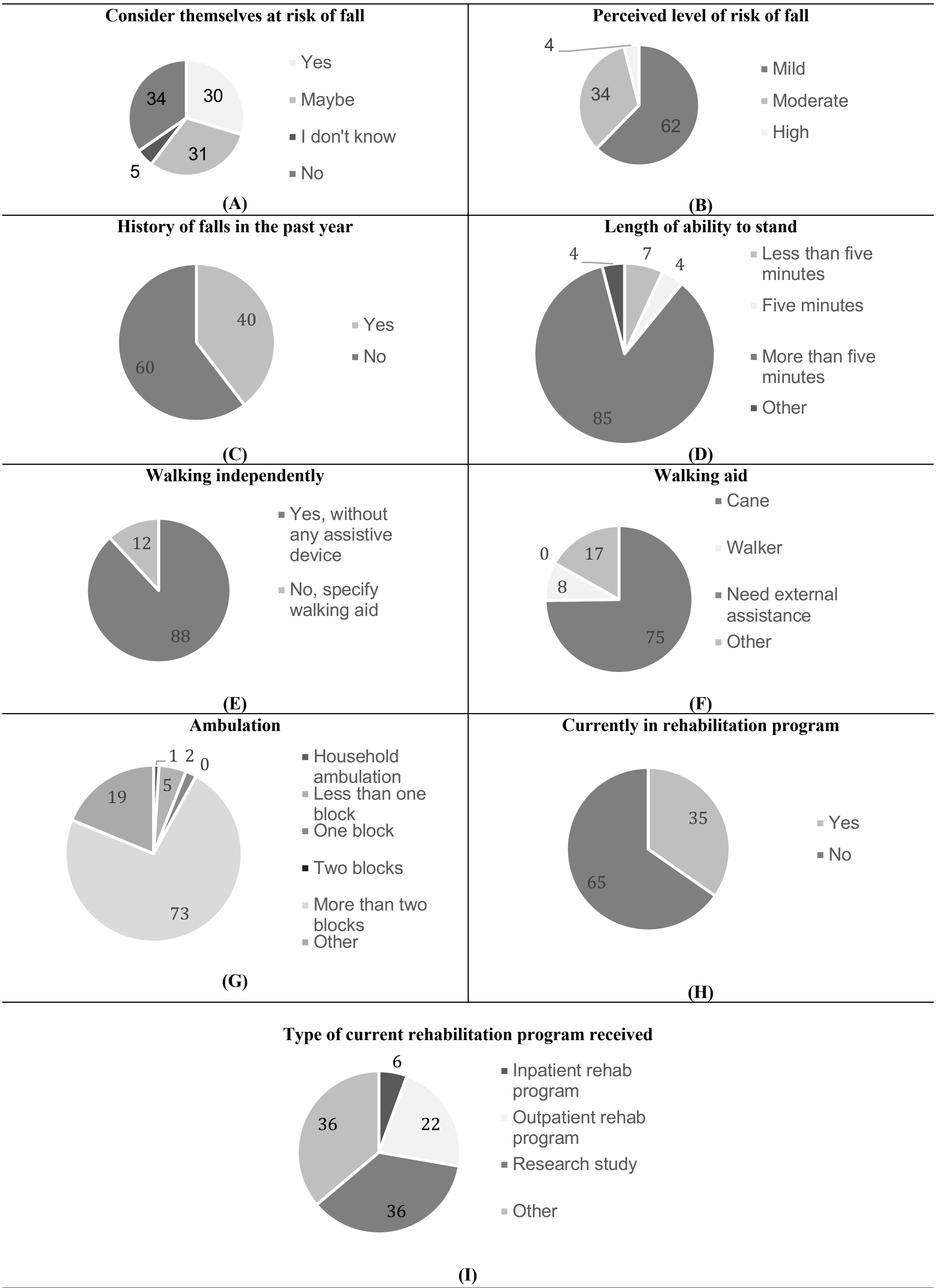
Table V: (Results) Participants Demographic Characteristics

	Count of responses (percentage) *Age presented in means and (standard deviation)
Gender (female)	54 (53.5)
Age (y)	63.14 (SD 13.91)*
Living Arrangement	
Alone	33 (32.7)
With one or more person	66 (65.3)
Other	2 (2)
Education Level	
Primary school	1 (1)
High school	14 (13.9)
Higher education	86 (85.1)
Race/Ethnicity	
Caucasian	52 (51.5)
African-American or black	25 (24.8)
Hispanic	5 (5)
Other	19 (18.8)

Table VI: (Results) Participants Medical History

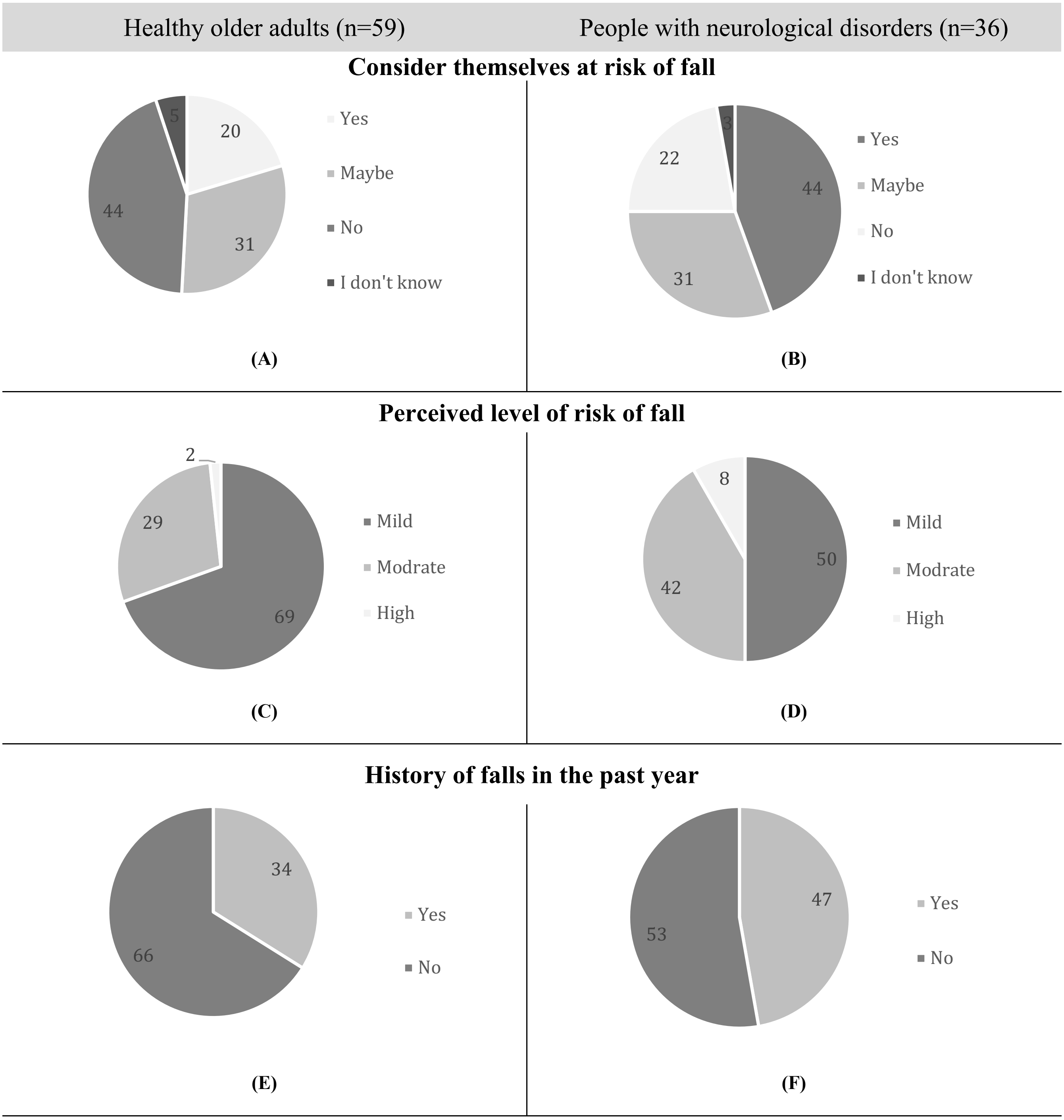
		Count of responses (percentage)
Perceived as healthy older adults		
Yes		77 (76.2)
No		20 (19.8)
I do not know		4 (4)
Diagnosed with ND		
Yes		36 (35.6)
No		64 (63.4)
Other		1 (1)
Diagnosed with non-ND		
Yes		38 (37.6)
	Cardiovascular disease	13 (12.9)
	Musculoskeletal disorder	15 (14.9)
	Systematic disorder	0 (0)
	Other	10 (9.9)
No		63 (62.4)
Number of taken medications		
None		18 (17.8)
One		18 (17.8)
Two		13 (12.9)
Three		17 (16.8)
Four or more		35 (34.7)

Figure 2: Percentages of Medical History and Physical Function Items



(A):"Would you consider yourself at risk of falling?", **(B):** "How high do you perceive your fall risk to be?", **(C):** "Have you experienced a fall in the past year?", **(D):** "For how long are you able to stand?", **(E):** "Can you walk independently?", **(F):** "If you can't walk independently please specify your walking aid", **(G):** "How far can you walk independently or with an assistive device?", **(H):** "Are you currently in any rehabilitation program (inpatient or outpatient) or research study, or going to the gym?", **(I):** "Select all that apply of what you receiving currently".

Figure 3: Percentages of Between Groups Physical Function (Further Analysis)



(A):"Would you consider yourself at risk of falling?" Healthy older adults' answers (n=59). **(B):** "Would you consider yourself at risk of falling?" People with neurological disorders answers (n=36). **(C):** "How high do you perceive your fall risk to be?" Healthy older adults' answers (n=59). **(D):** "How high do you perceive your fall risk to be?" People with neurological disorders answers (n=36). **(E):** "Have you experienced a fall in the past year" Healthy older adults' answers (n=59). **(F):** "Have you experienced a fall in the past year" People with neurological disorders answers (n=36).

3.2 PBBAT Items Responses

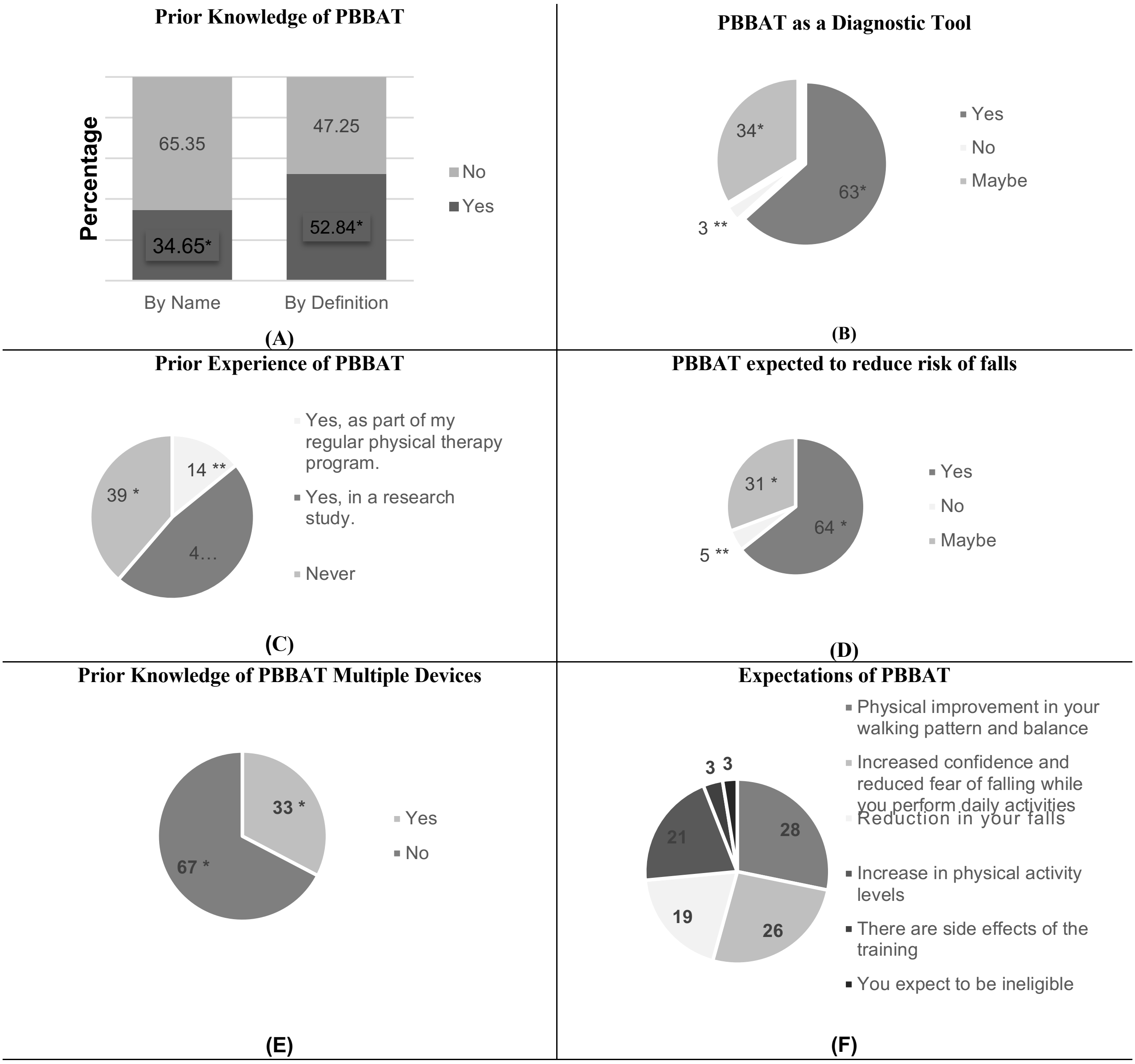
After asking about prior knowledge of PBBAT, a higher portion of answers were “No” (n=66); however, after providing the definition, the higher portion of answers were “Yes” (n=53) (Figure 4). Chi-square test showed almost significant difference (p-value = .055) between acknowledging PBBAT by name alone (“Yes,” n= 35) or with definition (“Yes,” n=53). Further analysis between populations showed healthy older adults (n=59 participants) acknowledged PBBAT by its name alone as their “Yes” choice count was 44, which is more than people with a neurological disorder (n=36 participants) with was 25 “Yes” choice count, and people who perceive themselves at risk of fall (n=6 participants) with “Yes” choice count was 0 - (Figure 5). Chi-square test showed significance for people with neurological disorder (p-value= .004) and people who perceive themselves at risk of fall (p-value <.00001), however it showed no significance in healthy older adults (p-value= .066) (Figure 5). The remainder of knowledge items (Figure 4), chi-square showed significant difference between choices. For statistical purposes, choice with 5% or less of responses was merged with the other least percentage choice. Participants think of PBBAT as a diagnostic tool for risk of fall (p-value < .001). The majority (n= 65) have undergone PBBAT before (p-value = .020). Participants considered PBBAT to reduce risk of falls (p-value = .004), and they did not acknowledge that PBBAT have more than one device (p-value = .001). The most expected outcome of PBBAT (after introducing devices with videos and descriptions) was, “Physical improvement in your walking pattern and balance,” with significant p-value <.001 using Friedman’s rank test (Figure 4). Following the video and description presentation of each device, willingness to try each device varied in “Yes” choice (SFT n=77, MT n=75, OGW n=82, and TSS n=81) and was significant (p-value < .001) using Friedman’s rank test (Figure 6). For the questions regarding the most preferred device for assessment or treatment, SFT was the highest picked (n=59), followed by TSS (n=54), then MT (n=53), and lastly OGW (n=44). Friedman’s rank test was significant at p-value < .001 (Figure 6). These preferences were justified in a qualitative text entry item, and four themes emerged from text analysis that participants picked the device(s) based on: prior knowledge, curiosity, outcome expectations, and safety concern. Some examples are mentioned in Table (VI). Six responds were invalid text entries (such as numbers, names), therefore, were excluded from text analysis.

Participants' perception of devices reported "Curious" feeling as the most frequent feeling for all devices (SFT n=53, MT n=55, OGW n=45, and TSS n=44) (Figure 7). In terms of safety on devices, "Safe with one trained therapist by my side," was the highest picked choice across all devices (SFT n=46, MT n= 44, OGW n=42, and TSS n=46) with significant Friedman's test p-value ($< .001$) across all choices (Figure 7). Moreover, the perception of safety, "Safe with how the device is designed (e.g., there is harness)," (n=63) was the most frequent picked perception, followed by, "Safe because I trust the therapist," (n= 59) and lastly, "Safe because you are not going to get injured" (n=50) (Figure 7). Regrading dosage and cost theme items, Friedman's rank test showed significant difference between all items' choices with Friedman's test p-value $< .001$ (Figure 8).

3.3 Perception Testing

A random selection of 24 participants have been contacted via the provided contact information at the end of the questionnaire and had been asked to identify the improper information in the picture (Appendix A) All participants have identified the improper information except one participant identified only one. All participants have answered the question in a timely manner frame that did not exceed two minutes.

Figure 4: Percentages of Prior Knowledge Items



(A) "Have you heard of PBBAT for fall risk prevention before?" and "PBBAT definition" *: Chi-square p-value (.055).
(B) "Do you think that PBBAT can be used as diagnostic tool for fall-risk?" *: Chi-square p-value (>.001), **: merged with "No" option.
(C) "Have you undergone any kind of perturbation-based (disturbance-based) balance assessment and training before? (You can choose all that apply)" *: Chi-square p-value (>.001), **: merged with "Yes, in a research study".
(D): "Do you think that perturbation-based (disturbance-based) balance assessment and training (PBBAT) can reduce the risk of falls?" *: Chi-square p-value (>.001), **: merged with "No" option.
E) "Do you know that there is more than one device for perturbation-based (disturbance-based) balance assessment and training (PBBAT)?" *: Chi-square p-value (>.001).
(F) "What do you expect of perturbation-based (disturbance-based) balance training (PBBT)? (You can select all that apply)", *: Friedman's rank test p-value (>.001).

Figure 5: Percentages of Prior Knowledge of PBBAT by Name Alone or by Definition Between Groups (Further Analysis)

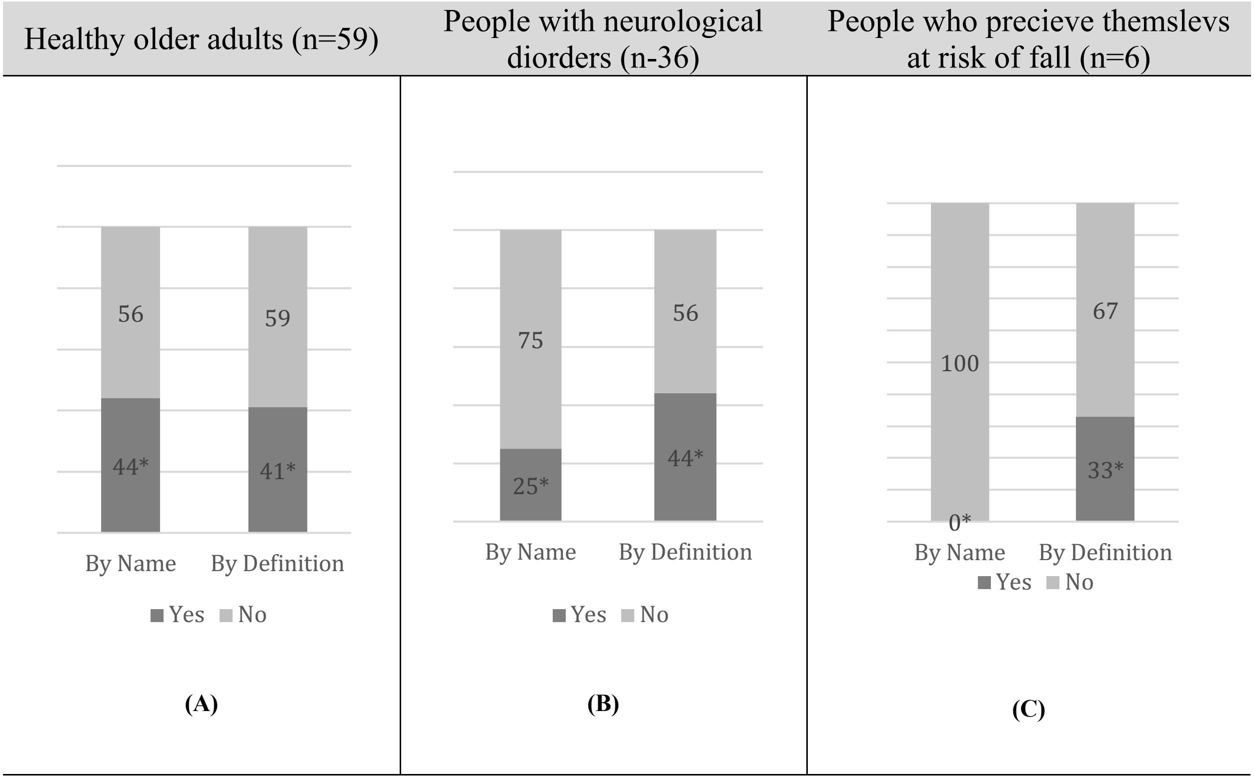
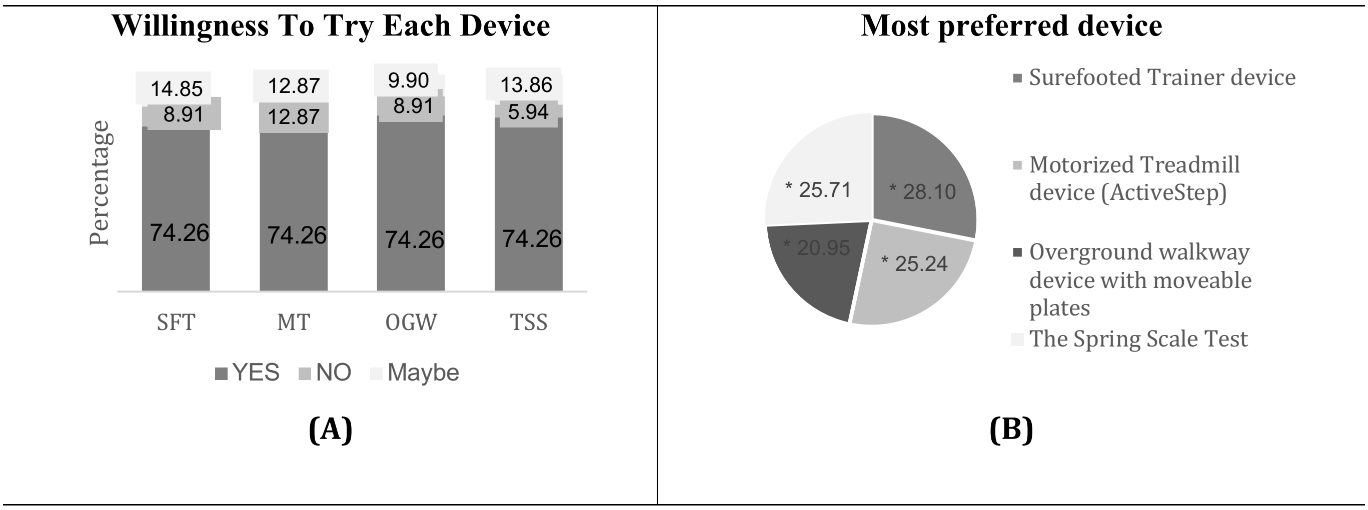


Figure 5: "Have you heard of PBBAT for fall risk prevention before?" and "PBBAT definition" **(A):** Healthy older adults' answers * Chi-square p-value (.066). **(B):** People with neurological disorder, * Chi-square p-value (.004). **(C):** People who perceive themselves at risk of fall, *Chi-square p-value (<.00001).

Figure 6: Percentages of Willingness to Try Devices

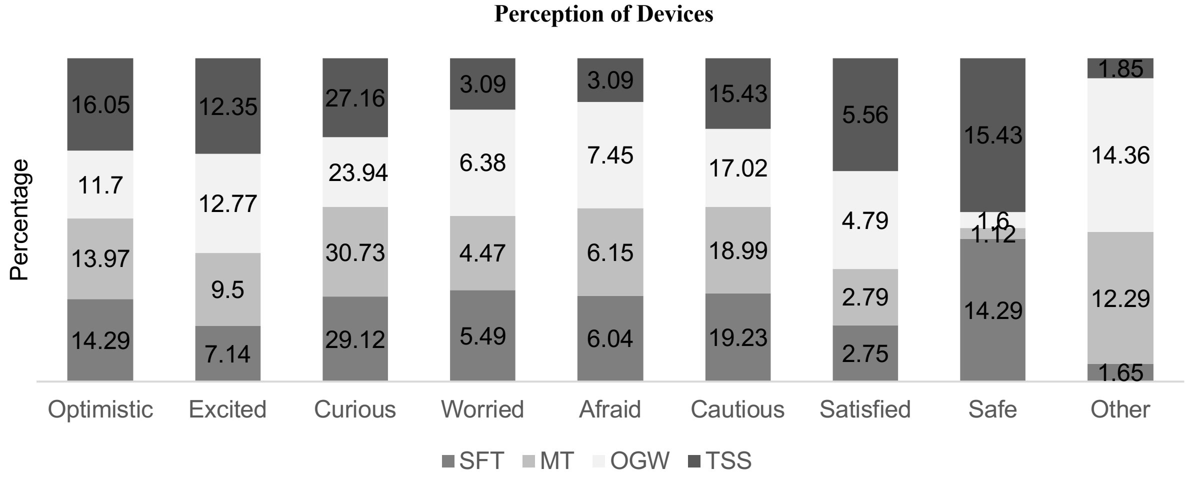


A): "Are you willing to try this device?", **(B):** "Which device are you most likely to choose for your assessment or training? (You can select all that apply)" *: Friedman's rank test p-value < .001.

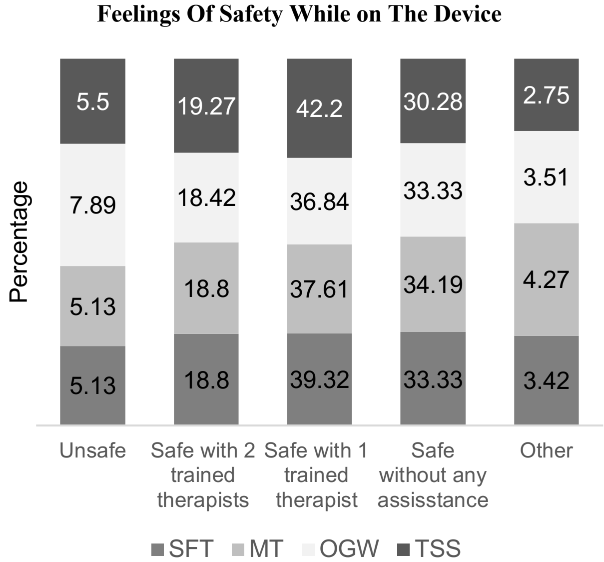
Table VII: Emerged Themes of Text Analysis Item "Please Tell Us Why You Chose the Selected Devices

Participants Text Entry	Picked Device(s)	Emerged Theme
"I used all devices"	All devices	Prior knowledge or experience
"When I tried the movable overground walkway device there was a lot of stopping and standing and that causes fatigue for me."	SFT, MT, TSS	
"Heard of it"	TSS	
"I have tried it many times, and it's safe."	OGW	
"Because I am familiar with terminology and how it works."	MT	
"I've already done the overground walkway device. I believe that rebounding has actually helped me to increase my balance."	All Devices	
"Curious to see what device works best for me"	All devices	Curiosity
"Curious"	SFT	
"Seemed more different than what I did (I did overground)"	OGW	
"I would be extremely curious how I to react. I think I would be fine, but it would be cool to know for sure. "	All devices	
"More experience"	SFT, MT, TSS	
"Because my walking and balance is off now and sometimes my foot give me trip over so I think these devices will be helpful"	All devices	Outcome Expectations
"Willing to try anything to help me walk better."	All devices	
"It looks like it would improve a person's balance."	TSS	
"These seem to be fit more towards my concerns of walking"	MT, OGW	
"They all look easy to use"	SFT, MT, OGW	
"I feel more in control and the reaction isn't as severe."	TSS	Safety
"safely ...I feel safe."	MT, TSS	
"Least disruptive to balance; day-to-day movement doesn't include aerial harness"	TSS	
"I feel safe, but I don't feel safe on motorized treadmill"	SFT, MT, TSS	
"Appears safe and ample"	TSS	

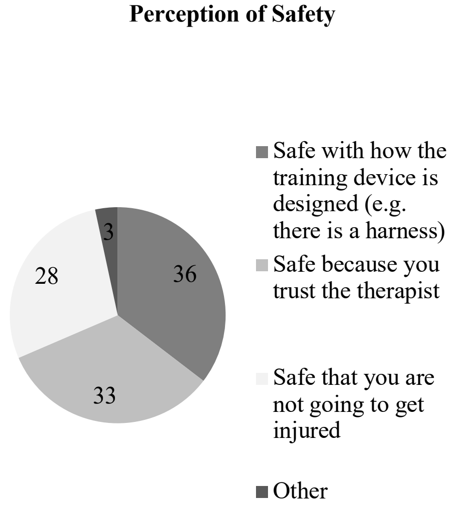
Figure 7: Percentages of Perception of Devices and Perception of Safety



(A)



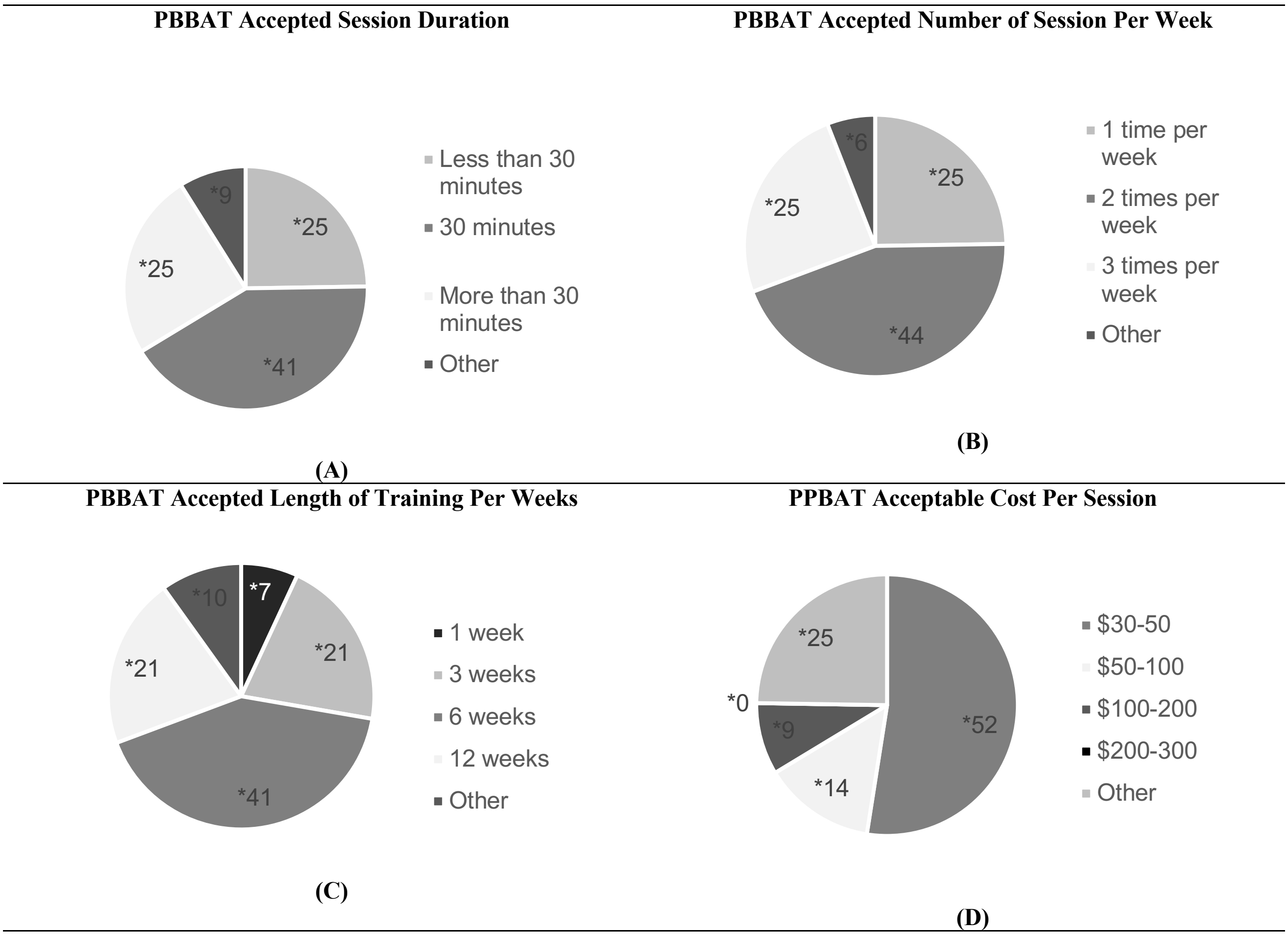
(B)



(C)

(A) "What do you feel when you look at the device? (You can select all that apply)", **(B)** "Choose how safe you feel when you look at The Spring Scale Test perturbation-based (disturbance-based) balance assessment and training (PBBAT) device? (You can select all that apply)", Friedman's rank test p-value (< .001). **(C)** "What is your perception of safety? (You can select all that apply)".

Figure 8: Percentages of Dosage and Cost Items



(A) "What do you think is the acceptable time to spend on each session for training?", *: Friedman's test p-value (< .001). **(B)** "What should be the maximum number of sessions per week for you to adhere (stick) to the program?", *: Friedman's test p-value (< .001). **(C)** "What should be the maximum length of the training in weeks for you to adhere (stick) to the program?", *: Friedman's test p-value (< .001). **(E)** "If you had to pay out of your pocket for such fall-prevention training, how much would you be willing to pay per session?", *: Friedman's test p-value (< .001).

CHAPTER IV DISCUSSION

4.1 Discussion

The study aims to explore the client's knowledge and awareness, willingness to try PBBAT devices, and their perspective of safety on these devices.

The higher percentage of participants do not consider themselves at risk of fall. However, the between-group analysis showed people with neurological disorders consider themselves in a higher percentage of fall risk than healthy older adults had reported. This may be due to their higher incidence of falls in comparison to healthy older adults' group, and what all groups analysis results showed. They also, perceive their fall risk to be in a moderate risk rather than mild, which was reported by healthy older adults. Their higher reported falls may cause fear of falling development, that in turn had influenced their perception of fall risk.

The higher portion of responses had acknowledged PBBAT by its definition rather than its name alone, so this might indicate the nomenclature of PBBAT to be research environment friendly terminology. Mansfield et al. (2019) proposed naming PBBAT as "reactive balance training" after reporting therapists' confusion of applying perturbation after ligament injury of a single joint with PBBAT. Arguably, the name "reactive balance training" may also carry vague understanding for clients, since it is a deep subdivision of what's commonly known "balance." Thus, we propose naming that is relatable, simple, and self-defined: "fall training with slips and trips."

Noteworthy, further analysis of participants who only undergone PBBAT as part of their physical therapy program (n=9), failed to acknowledge PBBAT by name and definition. This confusion may translate client-therapist misunderstanding of which therapy they are receiving.

Furthermore, this study was conducted in the Chicagoland area, where more than one research laboratory in different locations are experimenting PBBAT, hence, the higher portion of participants with prior experience with PBBAT. These participants are possibly active in the research studies being conducted elsewhere, therefore, their participation in this questionnaire-based study is possibly due to their response to the study flyers located in different physical locations in the Chicagoland area. In addition, MT device is commercially adopted and can be readily found in several physical therapy clinics, hence, greater number of participants are familiar with it. The option "physical improvement in your walking pattern and balance" had highest portion of responses of PBBAT expectations rather than "reduction of your falls" options. This may due to the higher number of highly functioned clients who took part of our survey.

Although, OGW device had a higher portion of reported willingness to try, the most desired device for assessment or training was SFT followed by TSS. Text analysis indicate that safety concerns frequently related to choice of SFT and TSS devices, wherein these devices have relatively low perturbations intensities in comparison to MT and OGW, thus participants might perceive them as more tolerable to experience and safer than the others. Surefooted Trainer is equipped with two side safety straps in addition to the overhead harness, which might give the impression of a more controlled environment against falls and injuries. A number of participants justified their reason for choosing SFT due to these additional safety straps on the sides of the device and the low perturbation intensity. Conversely, TSS is a manual device, and participants justified their choosing of TSS for the device's low intensity and the sense of control. Furthermore, it is possible that therapists' proximity and close distance can influence one's overall sense of security and might reinforce the therapist-client relationship in addition to the task outcome. Contrary to SFT and TSS, MT and OGW most frequent themes emerged from text analysis is related to prior knowledge. It is highly possible that clients' prior participation in research studies had involved assessment or training on MT or OGW, which may have facilitated a familiarity that influenced their preferences. Also, the abrupt high intensities of OGW may yield improvement in participants' balance, which increased their tolerance to these high intensities. Based on this observation, an introductory session prior to the actual training to familiarize the client of PBBAT to reinforce trust, compliance, and performance of the task is suggested in addition to the task instructions provided during the session. These findings are consistent with Pak et al. (2015) findings of task familiarity related to an improved sense of security, as seen in this study prior knowledge influenced clients' willingness to try different devices.

The higher portion of perceived safety responses were in favor to device design (e.g., harness) in addition to feeling safe with one therapist by their side across all devices. Applying additional safety equipment such as side safety straps, foam floors around the training area, and including an overhead harness for manual perturbation may encourage clients to participant freely with PBBAT. Also, this additional safety equipment may minimize therapists' safety concerns, lessen the burden of recruiting additional assistance, and positively push therapists to include PBBAT in their practice.

Although clients perceive SFT and TSS as the most tolerable and preferred devices to experience for their assessment or training, clinical perspective suggests MT device and manual perturbations applied by the therapist as the most clinically feasible perturbation types (Gerards et al., 2017). Based on these views, TSS might best feasible and preferred device for therapists and clients with increased safety and additional equipment such as an overhead harness and side safety bars. However, research shows OGW to have superior characteristics of mimicking unpredicted environmental perturbations than other devices (Okubo et al., 2019). To mediate the research rationale of mimicking real-life falls as well as respecting the clinical space and equipment challenges while considering the client's perspective, MT can be the most suitable device that accommodates all these views. Nonetheless, there is a research responsibility to manufacture a device that functions as an OGW mechanism of inducing perturbation and owning MT portability characteristics to facilitate commercial adoption with subsequent clinical implementation.

In regard to dosage and cost, the questionnaire results showed consistent preference for session duration of thirty minutes twice a week for six weeks. It appears that clients prefer shorter session durations for PBBAT. While the traditional physical therapy session is sixty minutes, incorporating PBBAT for thirty minutes and allocating the remainder of time for volitional task assessment or training may be a time-effective strategy for therapists to cover all aspects of balance.

The open-ended item of suggestions and comments on PBBAT received a few responses and mostly carried positive views, as most participants mentioned the promising potential of PBBAT to gain balance and restore independence. These attitudes may encourage therapists to specifically further challenge balance and general physical function of these populations, especially if PBBAT has a promising retention effect. Short-term retention was found in PwMS and PwS, the former has shown twenty-four hours of retention (Mohamed Suhaimy et al., 2020), while the latter had three weeks of retention (Bhatt et al., 2019). Also, PBBAT showed long-term retention effects of six to eighteen months for healthy older adults (Bhatt et al., 2012).

4.2 Study Limitations

Regardless of the exploratory nature of this study, it has its limitations. For one, the higher portion of participants were with prior experience of PBBAT, thus, may have influenced the overall analysis of willingness and perception of safety. The exploration tool (i.e., questionnaire) also has a number of limitations of including and lacking certain elements. First, the multiple-choice feature was included as part of comprehensiveness purposes, however, it adversely affected the analysis of narrowing down the statistically significant findings. Moreover, the videos served as an illustrative demonstration of the devices for healthy older adults and people with neurological disorders, but it must be mentioned that the videos included a healthy young adult, and this depiction may interrupt the mental image of placing oneself in these devices. One participant commented: "*If people over 65 are taking this survey you should show someone over 65 walking. The younger person doing the video could make older adults fearful where an older person doing it may make them less afraid to try it*," and another participant commented: "*Video is not good enough to experience.*". Lastly, thematic interactions have been drawn from the text entry questionnaire items designed to explore clients' reasoning why they prefer a device(s) for their assessment or training. Additional thematic interaction could possibly be found between prior knowledge influencing the perception of safety, that in turn will influence willingness to try different devices. However, an item designated to investigate this interaction was lacking in this study and should be considered in upcoming explorations.

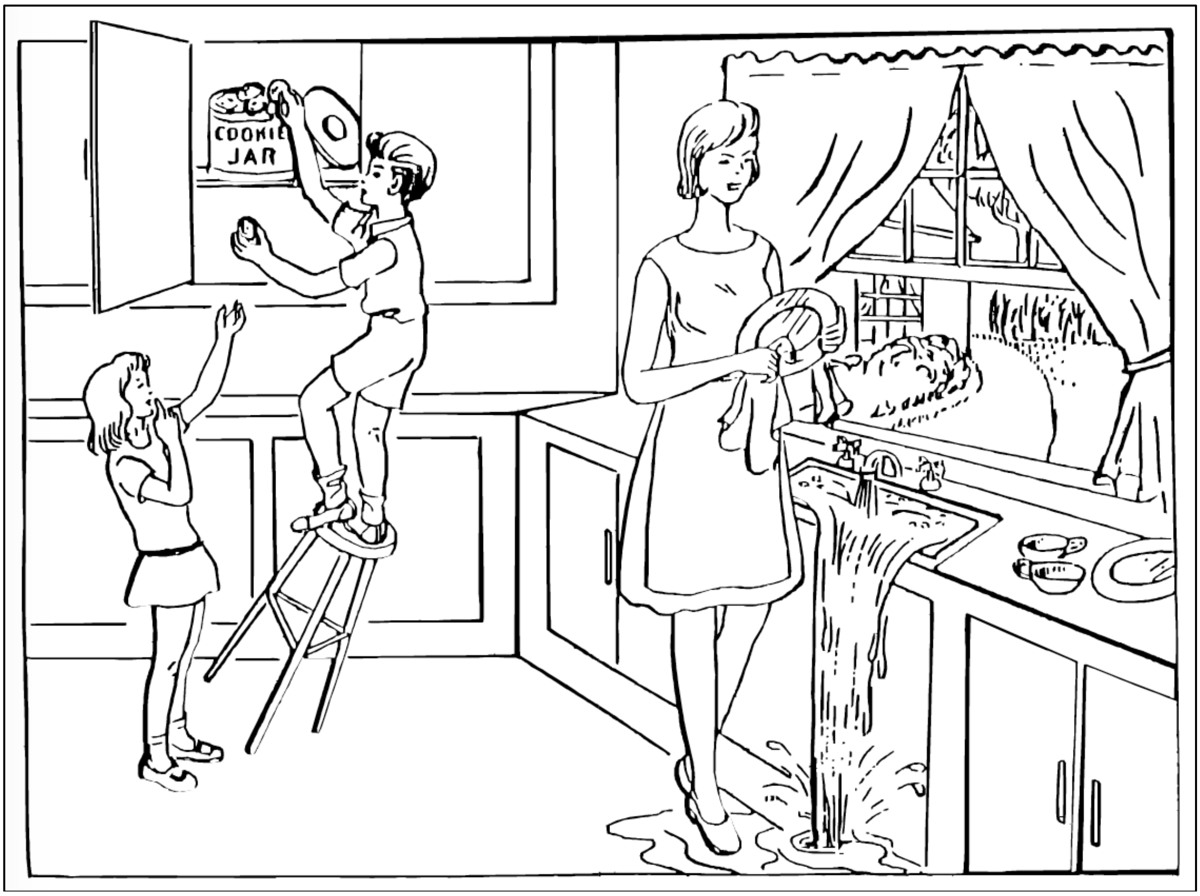
Therefore, future studies examining these limitations to further narrow down best options of device intensity, safety equipment and most appropriate device in attempt to facilitate PBBAT to clinical transition under the perspective of clients. This may start with the consideration of improved terminology for PBBAT that is suitable for all environments and groups. In addition, focus groups with in-depth discussion of the impact of devices' intensities on tolerating PBBAT for clients may be beneficial.

4.3 Conclusion

Our study aims to explore the client's knowledge and awareness, willingness to try, and perception of safety on PBBAT devices. These exploratory findings indicate that the majority of client's acknowledged PBBAT by its definition rather than its name alone. Furthermore, the Overground Walkway device had a higher portion of participants who reported willingness to try; however, Surefooted Trainer and The Spring Scale devices were the most preferred devices to be picked for training or assessment, respectively. For perception of devices, "Curiosity" was the dominant feeling across all devices. Moreover, clients felt safe to undergo the assessment or training with one therapist by their side in addition to the overhead harness. The device design (e.g., harness) had been frequently indicated as a component of safety. Also, the most expected outcome of PBBAT is physical improvement in walking and balance. Finally, the most accepted dosage for PBBAT is thirty minutes session twice a week for six weeks duration.

Appendix A
NIHSS (Selected Picture)

Figure 9: NIHSS Picture (This Picture Was Used in Our Study to Test Perception)



Picture retrieved from: National Institute of Neurological Disorders and Stroke (U.S.). (2011). NIH stroke scale. [Bethesda, Md.?] :National Institute of Neurological Disorders and Stroke, Dept. of Health and Human Services, USA.

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Education

Physiotherapy bachelor's degree: **Aug 2009 - Jan 2016**

- Princess Norah bint Abdulrahman University in Riyadh, Saudi Arabia.
- GPA: 4.48/5
- Academic Highlight: Second Class Honor.

Rehabilitation Sciences Master's degree:

- University of Illinois at Chicago, Chicago, United States of America.
- GPA: 3.81/4
  (Expected graduation Summer 2021)

Experience

- King Fahad Specialist Hospital (KFSH) Al-Qassim, Saudi Arabia: **Jan 2015- Jan 2016**
  - Intern
  - 6 months
- Prince Sultan Medical Military Hospital (PSMMH) in Riyadh, Saudi Arabia:
  - Intern.
  - 1 month
  - Home Health Care.
- Sultan Bin Abdulaziz Humanitarian City (SBAHC) in Riyadh, Saudi Arabia:
  - Intern.
  - 5 months
  - General rehab unit (GRU) , traumatic brain injury (TBI) , Pediatrics.

Riyadh care hospital **Nov 2016 -- Oct 2017**

- As Medical Record Analyst.
- Held Health Information Management in-patient supervisor for one month in Riyadh care hospital.

Summer training in Dallah hospital **Jun – Jul 2011**

Volunteer Experience

- Conducted audit about Joint Commission of International (JCI) accreditation in physiotherapy department of King Fahad Specialist Hospital (KFSH) in 2015.
- Volunteered in International Pediatric Neuro Rehabilitation conference in 2015 held in Riyadh, Saudi Arabia.

Skills and Certificate

- Microsoft Word and Excel.
- Statistical programs: SPSS and Jamovi
- Attendance Certificate of Principles of Taping in 2015, Apr 12-13.
- Attendance Certificate of Spine Manual Therapy in 2015, Feb 23-26.
- Appreciation letter from Kuwaiti Specialized Hospital in Sudan for humanitarian visit in 2015.
- Certificated by the Saudi Commission for Health Specialties from Jan 2016 to Feb 2018.