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UNIVERSITY OF TARTU
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1632

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The dissertation is accepted for the commencement of the Degree of Doctor of Philosophy in Exercise and Sport Sciences on August 24th, 2023 by the Institute Council of the Institute of Sport Sciences and Physiotherapy, Faculty of Medicine, University of Tartu, Tartu, Estonia.

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Commencement: Senate Room of the University of Tartu, Ülikooli St 18 on 5th of October, 2023, at 14.00.

Publication of this dissertation is granted by University of Tartu.

ISSN 1406-1058 (print)
ISBN 978-9916-27-309-8 (print)
ISSN 2806-2361 (pdf)
ISBN 978-9916-27-310-4 (pdf)

University of Tartu Press
www.tyk.ee

CONTENTS

ABBREVIATIONS

ADL	Activities of daily living
EPGPD	European Physiotherapy Guideline for Parkinson's Disease
CG	Control group
CWS	Customary walking speed
FOG	Freezing of gait
FOGQ	Freezing of Gait Questionnaire
FTSTS	Five-Times-Sit-To-Stand Test
FWS_SI	Fast walking speed with simple instruction
FWS_MI	Fast walking speed with motivational instruction
IG	Intervention group
HABD	Hip abduction, range of movement
HFLEX	Hip flexion range of movement
HY	Hoehn and Yahr Scale
MDS-UPDRS	Movement Disorder Society-Sponsored Revision of the Unified Parkinson´s Disease Rating Scale
ModPSFS	Modified Patient-Specific Functional Scale
MMSE	Mini Mental State Examination
PD	Parkinson's disease
PROMs	Patient-reported outcome measures
PSC	Patient Specific Complaints instrument
PSFS	Patient-Specific Functional Scale
PwP	Person with Parkinson's disease
QoL	Quality of life
ROM	Range of motion
SPPB	Short Physical Performance Battery
StWS	Sanding-to-Walking gait speed, calculated based on the walking test of SPPB
UPDRS-Mot	Motor examination score of MDS-UPDRS
10mWT	10-meter Walk Test

LIST OF ORIGINAL PUBLICATIONS

I Medijainen, K., Pääsuke, M., Lukmann, A., & Taba, P. (2019). Versatile guideline-based physiotherapy intervention in groups to improve gait speed in Parkinson's disease patients. *NeuroRehabilitation*, *44*(4), 579–586. https://doi.org/10.3233/NRE-192723

II Medijainen, K., Pääsuke, M., Lukmann, A., & Taba, P. (2022). Structured guideline-based physiotherapy reduces difficulties in activities of daily living in Parkinson's disease. *NeuroRehabilitation*, *50*(1), 47–56. https://doi.org/10.3233/NRE-210181

III Medijainen, K., Pääsuke, M., Lukmann, A., & Taba, P. (2015). Functional Performance and Associations between Performance Tests and Neurological Assessment Differ in Men and Women with Parkinson's Disease. *Behavioural neurology*, *2015*, 519801. https://doi.org/10.1155/2015/519801

Paper I, II and III. Kadri Medijainen had a primary responsibility for study protocol development, leading the design of the studies, coordinating and implementing data collection, performing statistical analyses and interpretation, and drafting the manuscripts.

1. INTRODUCTION

Typical motor symptoms in patients with Parkinson's disease (PD) include tremor, rigidity, bradykinesia/akinesia, and postural instability (Balestrino & Schapira, 2020), flexed posture, and freezing (Jankovic, 2008). These hallmark clinical manifestations are caused by selective loss of dopaminergic neurons (Cacabelos, 2017). PD is a progressive neurodegenerative disease, and these symptoms progresses over time (Poewe et al., 2017).

Currently, there is no therapy to halt the progression of PD (Bloem et al., 2021). A person with PD (PwP) receive treatment that is focused on symptomatic control, using primarily pharmacological treatment with physiotherapy and exercise being adjuvants to dopaminergic medication (Bouça-Machado et al., 2019). The role of physiotherapists in the rehabilitation of PwP include promotion of regular physical exercise, management of motor symptoms, and prevention of secondary impairments and complications (Pang 2021).

A diverse range of physiotherapy interventions has been used for treating PwP (Radder et al., 2020). To date, there is numerous evidence that interventions with single specific focus will result in varying degrees of improvement – PwP benefit from aerobic training, resistance training, treadmill training, dance, balance training, aquatic exercise, tai chi, etc. (Pang, 2021; Osborne et al., 2022). American Physical Therapy Association's clinical practice guidelines declare strong evidence for the benefits of gait and task-specific training along with external cueing (Osborne et al., 2022).

Despite the progressive nature of the disease, it is encouraging to acknowledge that there is a potential for improvement in individuals with PD. However, interventions that have been shown to be effective in the literature are often not realistically available to PwP or their therapists in the average clinical setting.

In the clinical setting, the timeframe for an intervention is often significantly more constrained than the interventions in research trials. A study investigating the availability of physiotherapy in Czechia revealed the median duration of physiotherapy sessions to be 30 minutes with total of 8 sessions on average for those who receive physiotherapy (~28% of the study sample) (Gal et al., 2017). Conversely, the meta-analysis conducted by Radder et al. (2020) revealed that the studies included in their analysis had an average intervention duration ranging from 4 to 12 weeks. The average session duration was reported to be 67 minutes, with participants typically engaging in sessions 3 to 4 times per week.

Besides time restrictions, interventions found to be beneficial for PwP in research context might lack clinical feasibility due to lack of means (e.g., no treadmill available) or other constraints. In clinical environment, the physiotherapy interventions often include more than merely one mode of exercise, especially as physiotherapists are encouraged to provide a patient-centered intervention (Stevens et al., 2017). When concentrating solely on a single type of intervention, such as balance training, there is a possibility that several concerns relevant to the

patient may remain unaddressed. This approach does neither meet the criteria of being patient-centered or specific to PD.

Often even PwP who experience problems in the core areas of PD, indicating the need for referral to physiotherapy, do not receive any treatment (Keus et al., 2004). Not being referred to physiotherapy can be partly attributed to various misconceptions among physicians. According to Domingos et al. (2018), one of the misconceptions is the belief that physiotherapy is only necessary at later stages of the disease. Despite there being a strong Grade A evidence supporting the recommendation of offering physiotherapy as rehabilitation to individuals newly diagnosed with PD (CPG, 2014), the majority of PwP consult with a physiotherapist only after noticeable mobility issues arise (King & Horak, 2009).

Specialized physiotherapy is associated with better outcomes, quality of care and lower costs (Ypinga et al., 2018) and the intervention for PwP needs to be versatile (EPGPD, Keus et al., 2014). The European Physiotherapy Guideline for Parkinson's Disease (EPGPD, Keus et al., 2014) has highlighted the following core areas to be targeted in specialized physiotherapy of PwP: gait, transfers, manual activities, balance, and physical capacity, indicating that physiotherapy needs to be multifaceted and PD-specific.

Providing physiotherapy as a group intervention is potentially lowering healthcare costs (O'Keefe et al., 2016). However, there exists a research gap in determining the feasibility and effectiveness of implementing multi-targeted PD-specific group physiotherapy within a clinical setting. Gaining a deeper understanding of the impacts of PD-specific physiotherapy would yield valuable information for physiotherapists working in clinical environments.

A physiotherapeutic assessment prior and after interventions is fundamental (Lahelle et al., 2018). Gait impairment is common in PD (Hackney & Earhart, 2009; Pistacci et al., 2017), and gait speed is often used as a measure to assess the effectiveness of intervention programs. Considering the potential effects of the intervention on daily life functioning are often overlooked in previous studies. The primary aim of this study was to investigate the effects of a PD-specific group physiotherapy on functional performance and patient-reported outcomes in patients with mild to moderate PD. Nascimento et al. (2012) suggested that verbal instructions could influence gait speed in stroke patients, and Lohnes and Earhart (2011) indicated that attentional cueing provided by physiotherapists could increase gait speed in individuals with PD. Therefore, the second primary aim of this study was to investigate aspects related to the physiotherapy assessment, including the impact of different instructions on gait speed in men and women with PD.

2. REVIEW OF LITERATURE

2.1. Overview of the Parkinson's disease

PD is one of the most common neurodegenerative disorders in elderly (Poewe et al. 2017). The occurrence of PD increases with age (Bloem et al., 2021). The prevalence of PD in Estonia is 197 per 100,000 (Kadastik-Eerme et al., 2018). The etiology of PD remains indistinct and therefore, PD is often classified as idiopathic or sporadic (Falup-Pecurariu et al.,2017). Degeneration of neurons due to complicated interactions between genetic and environmental factors is currently considered the reason behind development of the disease (Bloem et al., 2021).

The pathophysiology of PD is related to loss of dopaminergic neurons in central nervous system, more specifically in *substantia nigra* of the basal ganglia. The degeneration leads to insufficient levels of dopamine (Bloem et al., 2021) resulting in characteristic symptoms of PD. In addition, α-synuclein is accumulated into Lewy bodies in neurons (Poewe et al., 2017). Clinical presentations of PD includes both motor and non-motor symptoms, wherein tremor, rigidity, bradykinesia/akinesia, and postural instability are considered cardinal signs (Balestrino & Schapira, 2020).

The diagnosis of PD is based mostly on clinical findings and patient's self-reported symptoms (Bloem et. al, 2021), although recent studies exploring diagnostic biomarkers utilize neuroimaging techniques (positron emission tomography, single-photon emission computerized tomography, magnetic resonance imaging) to facilitate early and differential diagnosis (Poewe et al., 2017). For a long time, the most widely used criteria for PD clinical practice and research have been the criteria of United Kingdom Parkinson's Disease Society Queen Square Brain Bank. The core parkinsonian features for diagnosing PD are bradykinesia, rigidity, and rest tremor (Postuma et al., 2015).

Presence of bradykinesia defined as slowness of movement and decreased movement amplitude is an obligatory diagnostic criteria of PD. The most easily recognizable symptom of PD is resting tremor (Poewe et al., 2017). It is usually more pronounced on one side of the body and is often the most common presenting sign of PD, occurring in either one hand or leg (Falup-Pecurariu et al., 2017). Rigidity, usually also lateralized, refers to a continuously increased muscle tone (Delwaide, 2001). The EPGPD states that changes in posture (increased flexion of the neck, trunk, and upper and lower limbs) are associated with rigidity (Keus et al., 2014), indicating the dominance of flexor tone over the tone of extensor muscles (Falup-Pecurariu et al., 2017). Lastly, characteristic motor symptom is postural instability. Postural instability usually occurs in the later stages of the disease (Poewe et al., 2017) and it is not included as a diagnostic criterion (because when present early, it is suggestable to an alternative diagnosis) (Postuma et al., 2015). PD symptoms do not become apparent until a significant loss of dopamine neurons in the *substantia nigra pars compacta* (over 60%) has occurred (Zhou et al., 2021).

Next to the motor deficit, individuals with PD experience several non-motor symptoms, including autonomic and cognitive dysfunction (e.g., depression and dementia, constipation, bladder disorders, orthostatic disorder, and sleep disorders or hyposmia etc.). The existence of distinct non-motor symptoms which signals the prodromal phase of PD, can persist for several years or even decades prior to the emergence of motor symptoms (Poewe et al., 2017). The onset of PD is usually gradual, and progression is slow (Bloem et al., 2021). The symptoms may vary day to day and among patients. In early stages of the disease the clinical features can be intermittent (Falup-Pecurariu et al., 2017). The stages of the disease are described in the paragraph 2.2. of this dissertation.

2.2. Comprehensive assessment of Parkinson's disease

PD is a complex disorder with wide-range of motor and non-motor manifestations and as noted earlier, the diagnose is made through the clinical assessment (Bloem et al., 2021). The use of clinical rating scales is essential to quantify neurological symptoms, impairment and disability (AlMahadin et al., 2020). The most commonly used rating scales of PD motor symptoms are Hoehn and Yahr (HY) scale (Hoehn & Yahr, 1967) and the Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale Unified Parkinson's Disease Rating Scale (MDS-UPDRS) (AlMahadin et al., 2020).

HY scale is a widely used for assessing the current stage and progression of the disease. HY scale divides the disease into 5 stages where stage 1 refers to the beginning of the disease and stage 5 is the most progressed stage of PD (the patient typically bedridden) (Hoehn & Yahr, 1967). Stages 1.5 and 2.5 are included in the modified HYscale (Goetz et al., 2004) (see Table 1). PD is a complex disorder with wide range of motor and non-motor manifestations and as noted earlier, the diagnose is made through the clinical assessment (Bloem et al., 2021). The use of clinical rating scales is essential to quantify neurological symptoms, impairment, and disability (AlMahadin et al., 2020). The most commonly used rating scales of PD motor symptoms are Hoehn and Yahr (HY) scale (Hoehn & Yahr, 1967) and the Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale Unified Parkinson's Disease Rating Scale (MDS-UPDRS) (AlMahadin et al., 2020).

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Table 1. Modified Hoehn and Yahr Scale (Goetz et al., 2004).

Stage	Description
1.0	Unilateral involvement only
1.5	Unilateral and axial involvement
2.0	Bilateral involvement without of impairment of balance
2.5	Mild bilateral disease with recovery on pull test
3.0	Mild to moderate bilateral disease; some postural instability; physically independent
4.0	Severe disability; still able to walk or stand unassisted
5.0	Wheelchair bound or bedridden unless aided

In the clinical setting, physicians employ the HY scale to categorize patients according to the progression of their disease. However, this tool does not encompass non-motor symptoms and lacks a linear progression (Goetz et al., 2004). Using the HY scale stages, patients are classified as being in the early or uncomplicated phase, the complicated phase, or the late phase (Keus et al., 2014) of PD. However, according to HY scale, PwP can also be staged as having mild (stages 1–2), moderate (stage 3) and severe PD (Martinez-Martin et al., 2014).

MDS-UPDRS looks at the severity of PD on a more holistic level. MDS-UPDRS is divided into 4 parts: non-motor experiences of daily living; motor experiences of daily living; motor examination and motor complications. Each item is rated from 0–4 ("0" is considered normal and "4" is severe (Goetz et al., 2008). The assessment is carried out by a clinical specialist of PD neurologist, specialized nurse, or physiotherapist, with some items self-rated by patients or with the help from a caregiver and some items require observation and/or physical examination conducted by the examiner. MDS-UPDRS requires ~30 min administration time (AlMahadin et al., 2020). Martinez-Martin et al. (2014) have established specific thresholds for each of the four components of the scale to distinguish between mild, moderate, and severe stages of the disease. Clinical rating scales enable researchers and clinicians to evaluate signs and symptoms, as well as current severity, progression, and overall impact of the disease. In addition, response and side effects of the medical treatment, and comparison of people can be performed (Falup-Pecurariu et al., 2017).

Besides clinical scales assessing PD severity, the use of other assessment measures is necessary. Basically, two kinds of measure can be used for the evaluation of PD: the objective and the subjective (based on either examiner-based interview or patient self-reported outcomes) assessments. Both objective and subjective measures in PD are complementary to each other, with each method having its strengths and weaknesses (Bhidayasiri & Martinez-Martin, 2017).

Physiotherapists mainly focus on functional performance assessment. Appropriate assessment of functionality is the key to proper management of patients with PD and one crucial aspect is evaluating the functional capacity is how individuals manage their daily activities. This assessment holds significance because

alterations in disability levels require corresponding adjustments in clinical management. Furthermore, it is essential to identify any changes in order to ensure patient safety, alleviate the burden of the caregiver, and establish the necessity for referrals to additional services for the management of disabilities (Shulman, 2010).

One of the objective features often used for assessment of PwP is the gait speed (Nadeau et al., 2014; Pellechia et al., 2004; Rochester et al., 2010). Differences in gait parameters (e.g., cadence, stance and swing duration, stride length) between individuals with PD and controls have been widely reported (Hackney & Earhart, 2009; Pistacci et al., 2017). Research indicates that gait impairment is closely associated with decrease in mobility and independence (Rochester & Espay, 2015).

A characteristic feature of the gait of PwP is freezing of gait (FOG). It is a common symptom of PD (Nonnekes et al., 2015). During FOG, patients suddenly feel as if their feet are glued to the ground when they try to move forward. Generally, FOG is a brief episode lasting only a few seconds. However, there are instances where the duration of this phenomenon is longer, even surpassing 30 seconds. FOG is primarily triggered by activities such as initiating movement, navigating narrow passages, turns etc. (Schaafsma et al., 2003). FOG is a disabling symptom of PD resulting in decrease of quality of life (Nonnekes et al., 2015), therefore assessment of FOG justifies itself.

FOG is often assessed with self-reported questionnaire, with the Freezing of Gait Questionnaire (FOGQ) being the most often used questionnaire. The FOGQ questionnaire can be easily administered and scored in less than 10 minutes, making it a clinically practical and time-efficient tool (Rozenfield et al., 2017). A common component of FOG is gait initiation failure (McCandless et al, 2016), reported to occur in up to 86% of PD patients (Giladi et al., 1992). The process of gait initiation holds particular significance in PD due to its involvement in integrating both motor and cognitive aspects of movement preparation, and is therefore, important to be studied (Delval et al., 2014).

Movement Disorders Society review (Bloem et al., 2016) has provided several measurement instruments (both tests and questionnaires) as recommended for assessment of gait and balance in PD, including the 10 meter walk test (10mWT), Timed Up-and-Go test and FOGQ. Short-distance walking speed assessment can effectively differentiate variations in gait function among individuals with PD (Combs et al., 2013). They suggest conducting both the comfortable walking test and the fast walking test of 10mWT to detect changes in individuals with PD. Although there are indications that Parkinson's disease (PD) may affect male and female patients in varying ways (Bloem et al., 2021), the influence of gender has largely been overlooked as a contributing factor in functional performance assessment.

Over time, the majority of PwP encounter limitations in performing Assessing the activities of daily living (ADL) such as getting out of bed or a chair and walking, is essential as these fundamental movements contribute to maintaining independence. Hence, a careful assessment of disabilities in ADL is imperative,

especially from the patient's perspective. By incorporating patients' subjective experiences using patient-reported outcome measures (PROMs) the assessment of patients' health status is more comprehensive, and treatment planning is aided by identifying specific areas of concern or priorities for the patient. PROMs promote shared decision-making between patients and healthcare providers as well as patient-centeredness of care (Kyte et a., 2015). Moreover, the loss of independence in daily activities and social situations negatively impacts the patient's well-being (Biemans, 2001). It is important to promptly address any decline in functionality in PwP to ensure patient safety, alleviate caregiver burden, and identify the need for additional support for managing disabilities (Shulman et al., 2016).

2.3. Pharmacological treatment and physiotherapy in Parkinson's disease

As the symptomatology of PD is a result of loss of dopaminergic neurons in the *substantia nigra pars compacta*, the symptoms are mainly controlled by substituting striatal dopamine loss with dopamineergic medication (Poewe et al., 2017). Currently, there are no pharmacologic treatments available that can modify the progression of the disease (Armstrong & Okun, 2020), and no neuroprotective therapies with available clinical evidence (Kulisevsky, 2022).

Levodopa, the precursor of dopamine is a medication widely used in management of PD (Rascol, 2016). It works by replacing the depleting levels of dopamine, resulting in reduced presence of symptoms. Levodopa continues to be the primary and most effective treatment for motor symptoms in PD, offering consistent relief throughout the progression of the condition. However, after a period of two to three years on levodopa treatment, some fluctuations in motor and non-motor responses may begin to emerge in response to varying doses of levodopa (Kulisevsky, 2022). Unfortunately, there are many side-effects associated with long term use of Levodopa. The side effects are involuntary and abnormal movements and fluctuations in motor performance that are so called on-off periods (Rascol, 2016). Often, a combination of drugs is required to effectively manage PD symptoms (Connolly & Large, 2014). Non-motor symptoms necessitate alternative approaches that do not rely on dopamine. In addition to pharmacologic treatments, rehabilitative therapy and exercise are utilized to complement the effects of medication (Armstrong & Okun, 2020).

Despite relative PD symptom control by medication, most patients with PD experience residual motor disabilities affecting gait and mobility, postural control, and balance etc. (Poewe et al., 2017). Balance and gait deficits in PD are not significantly improved by pharmacological or surgical treatment (Vu et., al 2012). Therefore, there is a distinct need for other non-pharmacological management strategies such as exercise to impact mobility impairments in PD (van der Kolk & King, 2013) because unmanaged movement disorder may lead to substantial disability (Morris et al., 2000). Exercise in PD should be regarded as a therapeutic

intervention and prescribed with equal rigor to pharmacological treatments (Boucha-Machado et al., 2020).

A multidisciplinary team management, including input from physiotherapists is needed for PwP (Rochester & Espay, 2015). Physiotherapy is recommended for individuals with PD with the objective of preserving independence, enhancing safety and well-being, improving performance in activities of daily living (ADL), and mitigating the risk of secondary complications (Keus et al., 2014, Tomlinson et al., 2014). Furthermore, the role of a physiotherapist includes empowerment of patients to manage their condition outside clinical settings (Long, 2019). In addition to exercise programs conducted in the clinic, physiotherapists recommend tailored home-based exercise programs to the patients and motivate them to enhance their daily physical activity levels (Boucha-Machado et al., 2020).

Even when PwP experience problems that could be potentially alleviated by physiotherapy or other allied health professionals, patients are often not referred (Nijkrake et al., 2009*). Most PwP do not consult with a physiotherapist until they already experience obvious mobility problems (King&Horak, 2009) despite referral to physiotherapy is recommended from the onset of the disease (Keus et al., 2014).

At present, there is no available information regarding the current availability of physiotherapy for PwP in Estonia. Despite self-referral to physiotherapy is the norm in some European countries like the Netherlands, Norway, and Sweden (Long 2019), in Estonia, to receive physiotherapy service funded by Estonian Health Insurance Fund, a physician referral is required. As for the quantity and duration of physiotherapy, the Estonian Health Insurance Fund's list of healthcare services specifies a duration of 30 minutes per session, with a maximum of 60 sessions over a 6-month period (Eesti Haigekassa tervishoiuteenuste loetelu, 2018). In Estonia, it is common to schedule two consecutive sessions, which would result in a maximum of 30 hours of physiotherapy over 6 months. However, many PwP do not receive physiotherapy as the historical referral rates for individuals with Parkinson's disease have been consistently low, even in countries like the United Kingdom (Tomlinson et al., 2012).

Regarding the content, often all exercise or training interventions with a therapeutic goal are considered as a physiotherapy intervention (Radder et al., 2020). Physiotherapy, in fact, is a much broader term, defined by as a non-pharmacological therapeutic intervention using a patient-centered approach, which aims to restore and maximize the quality of movement and functional independence, while supporting patient self-management and participation (WCPT, 2011). In PD management, physiotherapy is mainly an exercise-based intervention (Bouca-Machado et al., 2020).

Most available scientific literature has reported positive effects of specific intervention programmes (e.g., gait training with usage of cueing (Rochester, et al. 2010) or treadmill training (Nadeau et al., 2014) or balance training (Wallen et al., 2018)). The evidence for resistance training, balance and gait training is considered strong (Osborne et al., 2022). The beforementioned types of exercises are included in the physiotherapy guidelines (CPG, 2014; Keus et al., 2014; Osborne

et al., 2022). However, the guideline recommendations are derived from research studies where the beneficial effects are attributed to interventions focused on a single modality.

In clinical settings, traditional use of physiotherapy is often much different, and mostly multimodal training is used (Hoskovcova et al., 2022), often referred to as "conventional physiotherapy". It is defined by Radder et al., (2020) "as all active (exercise) interventions traditionally used by physiotherapists to manage people with PD, such as traditional physiotherapy techniques or multifaceted interventions combining different physiotherapy techniques". Nevertheless, within the scientific literature, the term "conventional physiotherapy" frequently refers to the intervention received by the control group (CG), as indicated by Hoskovcova et al. (2022). Hence, it is occasionally regarded as a relatively less effective treatment option (e.g., in a study by Pazzaglia et al. (2020).

The need for identifying core elements of physical therapy training that apply to all people with PD was already highlighted by Morris (2000) nearly half a century ago. Core areas for physiotherapy, stated by EPGPD are the following: physical capacity, transfers, manual activities, balance, and gait (Keus et al., 2014). Consequently, it is necessary to gather evidence regarding whether the implementation of these core areas through a versatile and clinically feasible intervention, targeting multiple aspects, would also yield positive outcomes.

Most studies evaluating the effects of physical therapy have been conducted as individual interventions. There is less data on the effects of group therapies. O'Keeffe et al., (2016) has suggested considering their comparable effectiveness and potential cost savings, considering group interventions. Current study looks into the effects of a PD-specific group intervention.

The effectiveness of physiotherapy interventions is generally based on measures of quality of life as a whole, motor symptoms, balance, and gait outcomes (Radder et al., 2020). Patient's perception of the impact of an intervention on the performance of basic ADL has often remained discarded, though physiotherapists are encouraged to provide a patient-centered care (Stevens et al., 2017). In present study both the self-reported and functional effects of the intervention programme are examined.

2.4. Summary of the background

PD is an incurable condition characterized by a wide array of symptoms, necessitating a comprehensive approach that includes physiotherapy. Considering the unique aspects of the disease and the patient's viewpoint, it is crucial for both physiotherapy intervention and patient evaluation to be comprehensive. Available scientific literature does not provide an answer, whether integrating recommendations from PD physiotherapy treatment guideline into a practical physiotherapeutic group intervention would result in improvement of PwP from both physiotherapists and the patient's perspective.

3. OBJECTIVES OF THE STUDY

The aim of the study was to assess the effects of a disease-specific group physiotherapy on functional performance and patient-reported outcomes. In addition, the study sought to examine the influence of preceding instructions and gender on gait speed, as well as exploring the connections between gait speed and disease severity.

The specific objectives were:

1. To analyse the effects of an 8-week disease-specific group physiotherapy on gait speed, sit-to-stand transfer, and range of motion in patients with Parkinson's disease (Paper I).
2. To analyse the effects of an 8-week disease-specific group physiotherapy on patient-reported freezing of gait, functional activity limitations and overall health status in patients with Parkinson's disease (Paper II).
3. To assess how different instructions employed during gait assessment affect the gait speed of male and female individuals with Parkinson's disease (Paper III).
4. To examine the relations between gait speed, as measured using different instructions, and disease severity in both male and female individuals with Parkinson's disease (Paper III).

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4. METHODS

This dissertation was based on a multi-methods study assessing the effects of a multi-targeted group physiotherapy intervention along with examining important aspects of functional performance assessment of patients with PD.

4.1. Participants and study design

This dissertation includes three studies. The third study incorporates data from a three-part baseline assessment (including interviews, neurological evaluations, and functional assessments), while the first and second study additionally encompass the final assessments conducted after an eight-week physiotherapy intervention. The studies are explained in the study design section (chapter 4.1.2.)

The study was conducted in accordance with the Declaration of Helsinki and approval was granted by the Tartu University Ethics Committee (Certificate No 221/T-9). The study was additionally registered on Tartu University's Clinical Research Database (No. 12125) and on ClinicalTrials.gov (Identifier: NCT03568903).

4.1.1. Participants

Characteristics of the participants are provided in Table 2. Participants included in this study were derived from a larger epidemiological database of Tartu University Hospital, conducted in the city and county of Tartu (Kadastik-Eerme et al., 2018). The database was filtered based on residence in a city where the study was conducted (Tartu, Estonia).

The author of the study contacted by telephone with fifty patients from the before mentioned database, introduced the study, and asked to participate. With 31individuals meeting the inclusion criteria according to the preliminary information obtained via phone call, assessment time for the first part of the baseline assessment, the interview, was scheduled. The flow chart of the formation of the study sample is illustrated in Figure 1.

The inclusion criteria confirmed by the phone call included: (1) volunteering to participate; (2) age 60–80; (3) no other neurological conditions nor other severe chronic diagnoses affecting mobility; (4) an ability to walk without an assistive device in the home setting (using an assistive device for community-based ambulation was acceptable to meet the inclusion criteria); (5) absence of acute medical problems and conditions based on medical interview (including severe impairment in vision, and hearing); (6) absence of severe dyskinesia and long "off"-periods; and (7) not having participated in physiotherapy intervention during the previous year.

Table 2. Clinical and anthropometric characteristics of the participants (mean, SD in brackets) at baseline assessment.

	Study I and II		Study III	
Variable	**IG (n=12, 5M/7F)**	**CG (n=12, 5M/7F)**	**M (n=14)**	**F (n=14)**
Age, years	71.1 (4.2)	69.9 (5.1)	68.2 (6.4)	71.9 (4.4)
Disease duration, years	8.0 (6.9)	7.7 (5.4)	8.5 (6.2)	8.9 (5.0)
HY scale stage	2.2 (0.5)	2.3 (0.7)	2.3 (0.5)	2.3 (0.6)
MDS-UPDRS total score	62.2 (21.5)	60.4 (26.7)	58.5 (10.7)	66.4 (25.5)
UPDRS-Mot score	39.1 (14.7)	36.4 (18.4)	37.8 (6.9)	39.4 (18.5)
MMSE score	28.0 (1.9)	27.2 (1.5)	27.4 (2.1)	27.1 (1.9)
Height, cm	165.1 (10.4)	166.6 (10.1)	175.7 (5.6)	157.9 (5.4) *
Bodyweight, kg	72.8 (14.7)	78.1 (14.6)	85.7 (10.3)	68.6 (14.5) *

Note: SD: standard deviation; IG: intervention group; CG: control group; M: number of male participants; F: number of female participants; HY: disease stage according to Hoehn & Yahr scale; MDS-UPDRS: Movement Disorders Society Unified Parkinson's Disease Rating Scale; UPDRS-Mot: motor examination score of MDS-UPDRS; MMSE: Mini Mental State Examination; * significant difference between baseline and final assessments value on a level of $p<0.05$.

To be included in the final study sample, the following inclusion criteria needed to be confirmed during second part of the baseline assessment, that is neurological assessment: (1) a diagnosis of idiopathic PD according to the Queen Square Brain Bank criteria (Lees et al., 2009); (2) disease severity according to modified HY scale stages 1.5–3.0 (Goetz et., al 2004) and on standard medical treatment for PD; (3) absence of cognitive impairment based on Mini Mental State Examination (typical cut-off score being 24 (Arevalo-Rodriguez et al.,2021)).

As three of the participants were found not to correspond to the inclusion criteria based on neurological assessment (one due to cognitive decline and two because of Parkinson plus syndrome was confirmed, instead of idiopathic PD), they were not included in the data analysis. Further, as after the third part of baseline assessment, the functional assessment, four male participants decided not to participate in the rest of the study, the remaining 24 participants were assigned to either the intervention group (IG, n=12) or control group (CG, n=12) using randomized block design (7 females and 5 males in both groups) to study the effects of a multi-targeted physiotherapy group intervention. There were no dropouts from the study from either group after assigning the participants into study groups. The intervention provided is explained in chapter 4.2.1.

All participants continued taking commonly used dopaminergic medications prescribed by their neurologist at all times of the study, without any change in the pharmacological management. The members of CG were offered the opportunity to participate in 16 sessions of individual physiotherapy after final assessments. All participants were given instructions to maintain their current level of physical activity without making any changes.

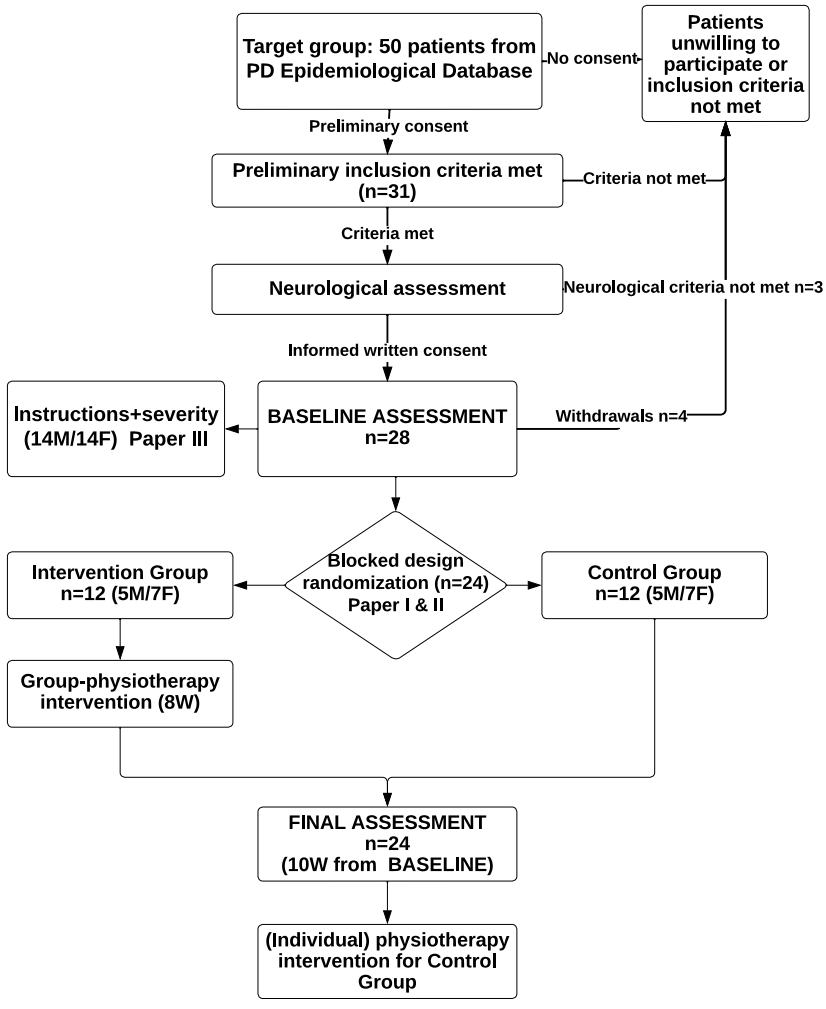

Figure 1. Flowchart of the sample formation.

Note: PD: Parkinson's disease; M: number of male participants, F: number of female participants; W: week.

4.1.2. Study design

The study was designed with two assessments: baseline and final assessments. Both assessments included an interview, neurological assessment, and functional assessment, with altogether six researchers participating in data collection.

The assessments were carried out as individual assessments in participants' home (patient interview, to reduce the burden related to the study), in Department of Neurology of Tartu University Hospital (neurological assessment) and at the Institute of Sport Sciences and Physiotherapy, University of Tartu, Estonia (functional assessment). The time expenditure was of few hours divided to 2–3 days (depending on their usual medication regimen) for the participant at both the

baseline and the final assessments. The time gap between baseline and final assessment was 10 weeks. As circumstances of measurement can influence the assessment outcome in PD, the time of assessment (in relation to medication state and time of day) was kept as near to the same time as possible at the final assessments, as is recommended by EPGPD (Keus et al., 2014).

The assessment began with a patient interview preceding the rest of the examination by few days (same researcher conducted both baseline and final interview). During the interview, other parts of the assessments (namely neurological and functional assessment) were scheduled (to ensure being "on-state" during all the assessments). The interview began by collecting data regarding relevant demographic status, social and medical anamnesis (the course of the disease, medications) and PROMs assessments FOGQ (Paper I) and ModPSFS (Paper II) were conducted. Patient interview was followed by neurological assessment.

The neurological assessment was carried out by two movement disorders experts, blinded throughout the study regarding group assignment of the participants. The neurological assessment included assessment of current disease severity and cognitive status. The cognitive status was determined by using the Mini Mental State Examination (MMSE). MMSE is a widely recognized and frequently utilized brief screening tool for tracking changes in cognitive functioning and to screen cognitive impairment in various clinical, research, and community environments (Arevalo-Rodriguez et al.,2021) and was included in the study as a descriptive characteristic of the participants, because mental functioning of the individual with PD influences physiotherapy options (Keus et al., 2014). Methods used for assessment of disease severity are provided in chapter 4.2.4.

After the neurological assessment, the functional assessment was conducted within the next two days. At functional assessment, three physiotherapists, uninformed about the group assignment of the participant, were present at all times to ensure the safety of participants during the tests. To further enhance patients' safety, blood pressure was measured on a minimum of three occasions (prior to and during the assessments) throughout the functional testing process. Prior to conducting the test trials of the functional assessment, each of the tests were explained and demonstrated. Patients were barefoot and none of the participants required an assistive device during functional testing. Possible bias among assessors was avoided by having the same assessor provide instructions and perform assessments (e.g., range of motion (ROM) measurement) of each participant at both baseline and final assessments.

Members of IG groups took part in a PD-specific, multi-targeted physiotherapy program, in groups of three, starting within a week after baseline assessment. The description of the physiotherapy is provided in chapter 4.2.1. The dissertation covers three studies, the results of which are published in Papers I–III. The study design is illustrated in Figure 2.

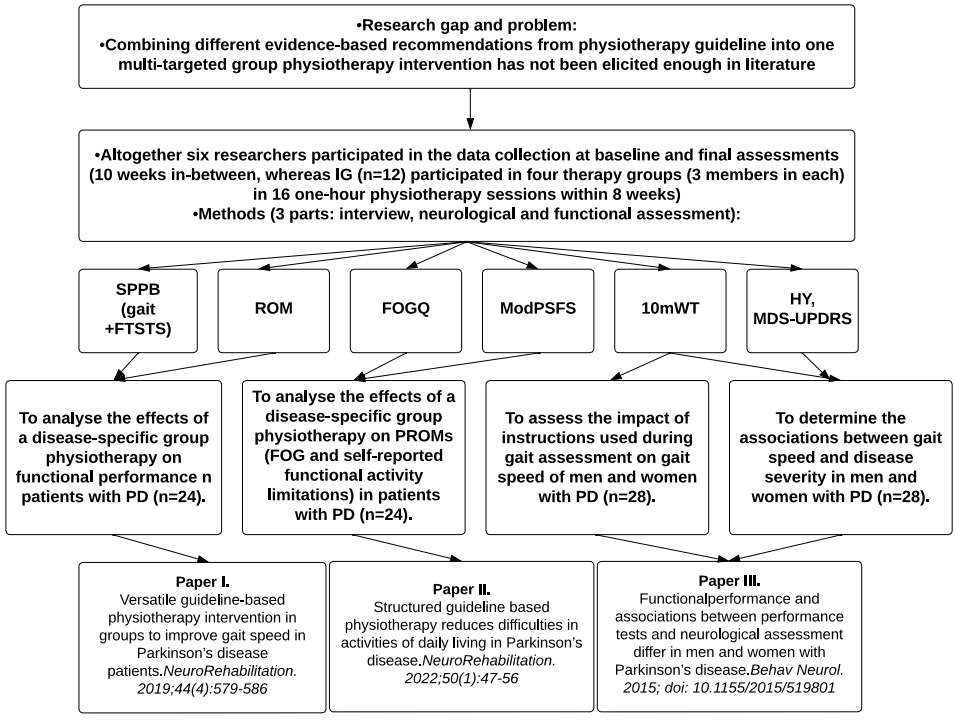

Figure 2. The study design.

Note: SPPB: Short Physical Performance Battery; FTSTS: Five-times-sit-to-stand test; ROM – range of motion; FOGQ: Freezing of Gait Questionnaire; ModPSFS: Modified Patients Specific Functional Scale; 10mWT: 10 m walk test; HY: Hoehn & Yahr Scale; MDS – UPDRS: Movement Disorders Society Unified Parkinson Disease Rating Scale; PD: Parkinson's disease.

4.2. Measures of the intervention study

4.2.1. Parkinson's disease specific physiotherapy

In this study, a PD-specific physiotherapy intervention, incorporating the recommendations from clinical guidelines EPGPD (Keus et al., 2014) was conducted aiming to influence different aspects of motor performance in a practical and feasible manner for clinical implementation. For the members of the IG, within a week from baseline assessments, a physiotherapy intervention led by a specialist in neurological physiotherapy was initiated. The therapy was provided as outpatient intervention in groups of three (four therapy groups). For 8 consecutive weeks, twice per week, the IG took part in altogether 16 physiotherapy group sessions (with the participation rate of 100%).

The facility, where the sessions took place was a therapy room with three wide therapy plinths of adjustable height (to allow safe practice of in-bed-transfers), located in Tartu University Hospital, at an in-patient ward of Department of

Sports Medicine and Rehabilitation Clinic. However, those subjects that participated as outpatients came to the department for the designated therapy times. Additionally, the therapy room included wall mirrors, used for visual feedback regarding body positioning/alignment during posture exercises etc. Gait training was carried out in a hallway next to the therapy room.

The focus of the physiotherapy was on the core areas recommended as PD-specific in the EPGPD: physical capacity, transfers, manual activities, balance, and gait (Keus et al., 2014). The goal was to adhere to the recommendations in a clinically feasible manner, ensuring that every session includes each recommended core area for a certain duration. As recommended in the guideline for group interventions (Keus et al., 2014), exercises for physical capacity and functional mobility were combined and mainly the focus was on functional-task exercises, using large movements. The EPGPD guideline outlines the physical capacity as comprising of muscle strength, endurance, coordination, and range of motion. However, the intervention did not specifically prioritize the endurance component.

The speed of movement was varied and augmented feedback (manual when needed) was provided. In addition, stretching exercises along with exercises to improve range of motion (ROM) and posture were carried out. Different types of cueing strategies (including focus on attention to the movement) were used during therapy wherever appropriate, e.g., during gait training. The gait training part of each session included teaching and repetitive practice of walking with maintaining correct posture, achieving an appropriate stride length, establishing a proper step pattern, and addressing other essential elements of walking, such as turns, dual tasks, and changing one's gait speed. The terms "freezing", and "festination" were explained and strategies for overcoming them were provided during sessions. Emphasis was placed on functional-task exercises performed in various positions and each 60 minute-session was divided into five parts with exercises in laying, sitting, standing, gait training, and hand function/manual dexterity. The intervention involved also isolated resistance exercises.

At times, additional equipment, common in every physiotherapy setting (therapy balls, canes, gymnastic stick etc.) were used. Each of the therapy groups was provided with comparable exercises. To ensure this, the exercises prescribed for the first therapy group were recorded in writing and same exercises were assigned to the other therapy groups (with minor adaptations, when necessary).

The structure and content of physiotherapy sessions are described in short in Table 3.

Table 3. The structure and content of a one-hour physiotherapy session.

Section (duration)/ Core areas targeted	**Aim and focus of performed exercises**
Horizontal exercises (supine, prone, and side-laying (and quadruped) – on plinth or on a mat on the floor) (15 minutes)/ Physical capacity, transfers	Improvement of QoM and speed of in-bed transfers and transfers (from laying-to-sitting and vice versa, transfer to and from the floor) Improvement in ROM (e.g., spinal, neck, shoulder, hip, knee) Muscle stretching (e.g., hamstrings, pectoral, neck muscles) Muscle strengthening (e.g., spinal extensors, knee and hip extensors, hip and knee flexors, abductors)
Vertical exercises in sitting (10 minutes – on plinth or a chair, including lift-off exercises)/ Physical capacity, transfers, balance	Improvement of QoM and speed of transfers (sitting-to-standing and standing-to-sitting transfers, scooting movements in sitting) Improvement of spinal ROM and posture in sitting Muscle strengthening (e.g., spinal/thoracic extensors, hip flexors)
Vertical exercises in standing (15 minutes – with and without a chair for support when needed)/ Physical capacity, transfers, balance	Improvement of standing posture Improvement of weight transference and gait initiation Improvement of static balance (incl. exercises with eyes closed) Muscle strengthening (e.g., hip abductors) Improvement of dynamic balance (e.g., practicing turns in place)
Gait training (10 minutes)/ Physical capacity, transfers, balance, gait	Improvement of gait initiation Increase of step length Improvement of gait speed Improvement of reciprocal upper limb movement during gait Muscle strengthening of lower limbs Improvement of physical capacity/endurance Improvement of dynamic balance (e.g., including turns (U-turn), stepping over obstacles, gait with head turns etc.)
Manual dexterity exercises (10 minutes)/ Manual activities, physical capacity	Improvement of manual dexterity (including different bilateral and unilateral activities with different grasp types, e.g., tearing paper, braiding ribbons, writing exercises etc.) Improvement of joints of ROM upper limbs Muscle strengthening of upper limbs

Note: QoM: quality of movement; ROM: range of movement.

4.2.2. The assessment of the effects of the disease-specific physiotherapy on functional performance

The effects of the physiotherapy intervention on the functional performance were assessed based by the Short Physical Performance Battery (SPPB), Five-Times-Sit-To-Stand Test (FTSTS) and assessment of selected proximal ROM. The researcher demonstrated all tests to familiarize the participant with the task before proceeding with the actual test. The subject was given one or two practice trials to ensure their understanding of the task without measuring the performance time during these trials.

SPPB was assessed according to the standard protocol (Guralnik et al., 1994). The gait performance was assessed by measuring the duration of the 3-meter gait test of SPPB. Based on the test duration the corresponding standing-to-walking gait speed (StWS) was calculated, reflecting on the gait initiation performance, known to be commonly impaired in PD. SPPB incorporates static balance tests – side-by-side-stand, semi-tandem-stand, tandem-stand, but balance test section of the SPPB were not included as an outcome measure of the efficacy of the intervention because almost all of the participants acquired the maximum points for balance tests already at the baseline functional assessment. The total and sub-scores of SPPB are not included in the dissertation.

SPPB includes assessment of sit-to-stand transfer: if a single chair stand was considered to be safely performed, a repeated chair stand test was performed. The repeated chair raise is analogous to the FTSTS test, however, includes merely one test trial, whereas in the FTSTS two test trials are executed and measured. An additional trial was provided for the participant in order to obtain the results of FTSTS, as FTSTS has been repeatedly used in PwP (Duncan et al., 2011; Paul et al., 2012). The resting period between two trials was a minimum of one-minute.

Prior to performing the FTSTS test, the participant sat on a chair of 43 cm in height, with feet on the floor, arms crossed on the chest, and the back supported by the chair's backrest. The instruction of the FTSTS test is to stand up and sit back down five times as quickly as possible (Muñoz-Bermejo et al., 2021). In this study, a variation of the test was employed, where the subject was instructed to remain standing after the fifth repetition (Verheyden et al., 2014). The time measurement commenced at the beginning of the performance and was ended upon the completion of the fifth stand. The time taken to complete the gait test of SPPB and FTSTS was recorded using a stopwatch.

Since range of motion (ROM) is indicative of rigidity, which is known to affect gait by restricting arm and leg swing during walking (Kwon et al., 2014), assessment of selected ROM was also considered of importance. In the present study, the ROM of dominant hip flexion (HFLEX) and hip joint abduction (HABD) were measured using a standard goniometer with the subject supine lying on a plinth. Before obtaining the measurement results, the researcher performed 5 passive movements to the end range of the movement. One researcher read the result from the goniometer in the end-range of the movement, other researcher provided stabilization if necessary. While measuring the ROM, it was

considered acceptable for the participant to feel a slight stretching sensation, but not pain. To prevent potential bias among assessors, the same researcher conducted the same functional assessment at both baseline and final assessments.

4.2.3. The assessment of the effects of the disease-specific physiotherapy on patient reported outcomes

Assessment of the effects of the physiotherapy intervention on PROMs included the FOGQ and the Modified Patient-Specific Functional Scale (ModPSFS).

Managing freezing of gait is essential for improving gait function in PD patients. To encompass the entire complexity of FOG, no ideal tool is available (Barthel et al., 2016). In clinical setting the use of a self-reported assessment seems to be the preferred option, with the FOGQ used in present study being the most common one. FOGQ is a questionnaire comprising 6 items that assess the severity of FOG in PwP, focusing on FOG frequency, disturbances in gait, and its relationship to clinical features associated with gait and motor aspects, such as turning. Based on severity of symptoms, each item is self-rated on a 5-point scale, ranging from 0 (no symptoms) to 4 (most severe) (Giladi et al., 2000). FOGQ is considered to be a valid tool to assess the freezing of gait in the "on" state in PD patients (Taghizadeh et al., 2021). To ensure accurate responses, the researcher provided assistance in filling out the FOGQ, explaining the meaning of FOG beforehand. This step was necessary as PD patients experiencing FOG might not readily recognize it as such (Snijders et al., 2008).

As a second PROMs, the participant was asked to record the extent of self-perceived functional activity limitations during commonly occurring ADL by answering questions of ModPSFS. In Paper II, the term "difficulties" was utilized, whereas in the dissertation, the term "(self-reported) functional activity limitations" is employed.

ModPSFS combines aspects of the Patient-Specific Complaint instrument (PSC) (Beurskens et al., 1999) and Patient-Specific Functional Scale (PSFS) (Stratford et al., 1995). PSC has been found to be the instrumental in supporting a patient-centered approach to address individual concerns of the patient effectively as it enables patients to identify and rate their own problems (Stevens et al., 2016). The PSC (Beurskens et al., 1999) is a structured tool with stepwise approach that facilitates the selection and evaluation of a patient's primary concerns. In the first step, the physiotherapist identifies the specific daily activities that the patient finds challenging. In steps two and three of PSC, the patient rates on a numeric rating scale (analogous to visual analogue scale (VAS) ranging from "0" (easy to perform) to "10" (impossible to perform) to the identified activities and prioritizes the most important one(s). Similarly, the PSFS involves identifying functional activities that individuals with PD desire to improve upon. Same applies to ModPSFS, which includes listing three specific activities patients seeked improvement in, however, the listed activities are not used in data analysis of the present study. (However, the activities that patients identified as areas for

improvement were incorporated into the therapy process to serve as motivational tools, when appropriate – e.g., "this exercise helps with your aim to improve in-bed-transfers").

Utilizing PROMs, such as PSC, PSFS and ModPSFS have the potential to increase patient involvement and empowerment, thereby facilitating collaboration (Santana & Feeny, 2013) and thereby patient engagement. However, PSC and PSFS fail to allow for comparison regarding functional activity limitations of daily life. As presentation of PD can vary substantially, the most difficult daily activities would also differ from person to person (furthermore, pre-, and post-intervention) Therefore, to allow comparison, a predefined list of of 24 activities (assumed to be performed daily and that are at oftentimes to some extent problematic to patients with PD) was provided to the participant during the interview at baseline assessment.

Participants were asked to indicate whether the listed activities are actually a part of their basic ADL. In addition, the subject gave a rating of each activity on a 11-point VAS scale as in original PSC, as described earlier. From the predefined list, only the activities that all participants indicated that they perform were included in the self-assessment questionnaire and defined as a ModPSFS in present study. The final ModPSFS (Figure 3) was used for comparison between groups regarding the efficacy of the physiotherapy intervention on self-reported functional activity limitations.

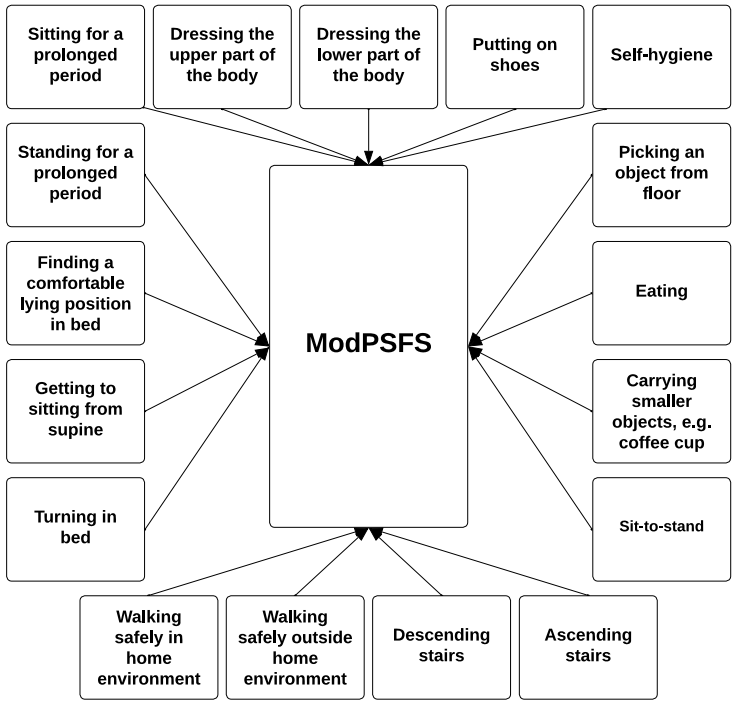

Figure 3. Modified Patient Specific Functional Scale.

Note: ModPSFS: Modified Patient-Specific Functional Scale.

Lastly, during the interview of the final assessment, in addition to giving their ratings for functional activity limitations of the 17 activities included in ModPSFS, a one-item question was added to the ModPSFS – all participants provided an answer to a question regarding their current over-all health status in comparison to health status perceived at the baseline assessment (choosing what best applies from the following response options: “worse/deteriorated”; “same/unchanged”; “better/improved”).

4.3. The assessment of the impact of instructions used during gait speed assessment on gait speed

To investigate the potential influence of instructions provided on gait speed to PwP, the 10-meter Walk Test (10mWT) was employed. The 10mWT is a widely used and recommended measure of gait speed in PD (Bloem et al., 2016). The EPGPD states 10mWT to be valid and reliable in PD population, as well as feasible in terms of time and costs, being therefore suitable for usage in context of healthcare and physiotherapy practice (Keus et al., 2014).

The gait assessment took place in a hallway measuring 2.4 meters in width and 50 meters in length. A specialized walkway was utilized, consisting of a designated area (of 1 meter in width and 12 meters in length) in the middle of the hallway. The walkway differed in colour from the surrounding floor and included red stripes one meter from both ends of the walkway to indicate the starting and finishing points of a 10mWT (illustrated in Figure 4). Additionally, each meter along the walkway was marked. For the 10mWT, the participant was instructed to walk from one red stripe to the other. Three trials were measured when three different instructions were used.

First, the participant was given instruction to walk at their customary walking speed (CWS), representing their conventional, everyday walking pace. Subsequently, the participant was instructed to walk as fast as possible (yet safely and not running, defined as simple instruction), referred to as fast walking speed (FWS_SI) in this study. Finally, the participant’s fast walking speed with motivational instruction (FWS_MI) was assessed. The motivational instruction used in this study was based on the work of Nascimento et al. (2012), who recommended employing modified verbal commands to ensure accurate information about maximal gait speed. The motivational instruction was “Walk as quickly as you can while ensuring safety, but without running, in order to catch a bus that is about to depart”. Consistently, the same examiner always provided instructions to the participants.

To account for acceleration and deceleration, the time taken to pass the intermediate 6 meters was measured. The use of three different instructions aimed to capture functional gait performance on a broader level, considering the need to adjust walking speed in everyday life situations. For data analysis, an average of three trials was calculated with each testing condition, allowing rest in between the test trials when needed and the performance of each walking test was secured

by two investigators at all times. Additionally, for each participant the percentage difference in FWS_SI and FWS_MI compared to CWS was calculated to assess the relative change in walking speeds.

The results were compared in men (n=14) and women (n=14) with PD.

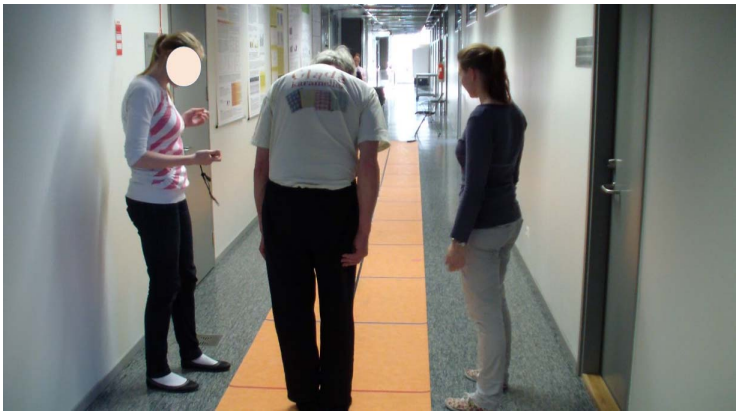

Figure 4. Illustration of the gait assessment with 10mWT (10 meter walk test).

4.4. Relations between gait speed and disease severity in men and women with Parkinson's disease

The evaluation of disease severity encompassed the use of the HY scale and the MDS-UPDRS assessment methods commonly used in PwP as described in chapter 2.2. The HY scale is a straightforward clinical rating system employed to stage the progression of PD and characterize the motor impairments of PD patients (Hoehn & Yahr, 1967). The modified version (Goetz et al., 2004) was used in present study. The MDS-UPDRS is a comprehensive neurological assessment tool designed to evaluate the various manifestations of PD. It consists of four parts that assess the impact of PD on both non-motor and motor aspects of daily life, motor examination, and motor complications of PD (Goetz et al., 2008). In the current study, the total score, and the motor score (which sums the items from part III of the MDS-UPDRS) were utilized for data analysis.

Regarding the examination of the relationship between gait speed, as measured using different instructions, and disease severity in men and women with PD, the CWS, FWS_SI and FWS_MI obtained with the 10mWT were employed (described in the previous chapter). The results were compared in men (n=14) and women (n=14) with PD.

4.5. Statistical analysis

Data analysis was performed using commercially available software (SPSS 20.0, IBM, Armonk, USA). Normality testing (Shapiro–Wilk test) was conducted. In the case of a normal distribution of parametric variables, the functional performance of the IG and CG were compared using the student t-test, and the in-group comparison of baseline and final assessments utilized a paired t-test (Paper II). In other cases, Wilcoxon Signed Ranks test or Mann-Whitney U-test was used to compare differences between assessments. Data are presented as mean (and SD in brackets).

The effect size (ES) was calculated based on the coefficient of product-moment correlation (r) (Téllez et al., 2015). The coefficient of product-moment correlation (r) was chosen to allow a comparison between parametric and non-parametric data. In Paper II the correlation coefficient (r) was then converted into Cohen-d according to Borenstein et al., (2009) to allow better comparison with previous results. ES was considered to be large when the r-value exeeded >0.5 and Cohen-d >0.8.

Cronbach's alpha value was calculated for assessing internal consistency of the ModPSFS.

For Paper III descriptive analysis and one-way ANOVA was used to compare male and female participants. Furthermore, the results of gait speed assessments were height-adjusted (gait speed divided by the height of the participant), to allow more precision in comparing the impact of the instructions provided on male and female participants. Kendall's tau-b correlation analysis was used to assess possible relationship between functional performance tests and neurological assessment. Value $p<0.05$ was considered to be statistically significant.

5. RESULTS

5.1. The effects of the disease-specific physiotherapy on functional performance

At baseline assessment, both the IG and CG exhibited similarities in terms of their functional performance (Table 4), demographic characteristics, and clinical parameters (Table 2). However, at the final functional assessment, the study groups differed in the duration of the FTSTS test and HABD. Notably, these parameters did not show improvement in the IG when comparing the pre- and post-intervention assessments. On the other hand, at final assessment IG demonstrated improvements of large effect size in StWS and HFLEX. The detailed results can be found in Table 4.

Table 4. Functional performance among the intervention group and control group at baseline and final assessments (mean, SD in brackets).

	Intervention group			Control group		
Variable	Baseline	Final	ES (r)	Baseline	Final	ES
StWS, m/s	1.0 (0.3)	1.3 (0.3) *	0.85	0.9 (0.3)	1.0 (0.3)	0.22
FTSTS, sec	10.7 (7.5)	8.8 (3.7) #	0.22	14.6 (11.1)	12.0 (3.7)	0.06
HFLEX,°	122.5 (12.5)	133.8 (6.6) *	0.61	124.3 (15.8)	125.5 (20.5)	0.23
HABD,°	21.3 (5.6)	24.2 (2.5) #	0.42	20.3 (5.6)	20.2 (3.8)	–0.08

Note: SD: standard deviation; Baseline: baseline assessment; Final: final assessment; ES (r): effect size according to product-moment correlation; '–': effect size indicating deterioration between baseline and final assessment; StWS: standing-to-walking gait speed calculated based on SPPB gait test; FTSTS: five-times-sit-to-stand test; HFLEX: dominant side hip flexion range of motion; HABD: dominant side hip abduction range; * significant difference between baseline and final assessment on a level of $p<0.05$; # significant difference between intervention and control group on a level of $p<0.05$.

5.2. The effects of a disease-specific physiotherapy on patient-reported outcomes

At baseline, there were no significant differences between the IG and CG in terms of PROMs. However, at final assessment, the IG reported a reduction of large effect size in self-reported FOG and functional activity limitations in the total score, median score, and average scores of the ModPSFS (results are summarized in Table 5).

After the intervention, 10 participants in the IG reported improvement in overall health status, while 7 subjects in the CG reported a deterioration.

It is worth noting that at the final assessment, many participants did not explicitly list the activities they found challenging or wanted to improve; instead, they expressed concerns about issues such as poor sleep, poor vision, back pain, and hand tremor.

The Cronbach's alpha value for ModPSFS was above 0.9 in both IG and CG at both baseline and final assessments, indicating excellent internal consistency of the ModPSFS (in IG at baseline and final assessment 0.94 and 0.91; CG 0.93 and 0.92, respectively).

Table 5. Patient-reported freezing of gait and functional activity limitations among the intervention group and control group at baseline and final assessments (mean, SD in brackets).

Variable	Intervention group			Control group		
	Baseline	Final	ES	Baseline	Final	ES
ModPSFS total score, points	48.7 (31.2)	35.3 (25.7) *	1.39	30.8 (20.8)	34.3 (21.3)	–0.49
ModPSFS median item score, points	2.9 (0.7)	1.8 (0.5) *	0.97	1.3 (0.5)	1.7 (0.4)	–0.36
ModPSFS average item score, points	3.0 (0.6)	2.1 (0.4) *	1.39	1.9 (0.4)	2.1 (0.4)	–0.49
FOGQ, points	7.4 (6.1)	4.7 (3.9) *	0.41 (r)	5.8 (3.6)	5.9 (3.3)	–0.03

Note: SD: standard deviation; Baseline: baseline assessment; Final: final assessment; ES: effect size; –: effect size indicating deterioration between baseline and final assessment; ModPSFS: Modified Patients Specific Functional Scale; FOGQ: Freezing of Gait Questionnaire; (r): effect size according to product-moment correlation; * significant difference between baseline and final assessment on a level of $p<0.05$.

5.3. The impact of instructions used during gait speed assessment on gait speed of men and women with Parkinson's disease

The average gait speed of both men and women with PD differed significantly depending on the instruction given before the gait assessment (Table 6).

Table 6. Differences in gait speed with different instructions in men and women with Parkinson's disease. (Mean, SD in brackets).

	Men	Women
CWS	1.39 (0.25)	1.15 (0.30)
CWS_height	0.79 (0.14)	0.73 (0.18)
FWI_SI	2.06 (0.42) *	1.40 (0.43) *
FWS_SI_height	1.76 (0.06) *	0.88 (0.26) *
FWS_MI	2.29 (0.35) #	1.65 (0.52) #
FWS_MI_height	1.3(0.19) #	1.04(0.31) #

Note: CWS: customary walking speed; CWS_height: height-adjusted customary walking speed; FWS_SI: fast walking speed with simple instruction; FWS_SI_height: height-adjusted fast walking speed with simple instruction; FWS_MI: fast walking speed test with motivational instruction; FWS_MI_height: height-adjusted fast walking speed test with motivational instruction; * significantly faster gait speed compared to customary walking speed on a level of $p<0.05$; # significantly faster gait speed than customary and fast walking speed with simple instruction on a level of $p<0.05$.

Men with PD exhibited significantly higher walking speed compared to women across all gait assessments, except for CWS when the results were adjusted for height (Figure 5). The latter was 8.2% smaller in female participants, not reaching statistical significance (without adjusting for height, the difference in CWS was 20.1% between men and women).

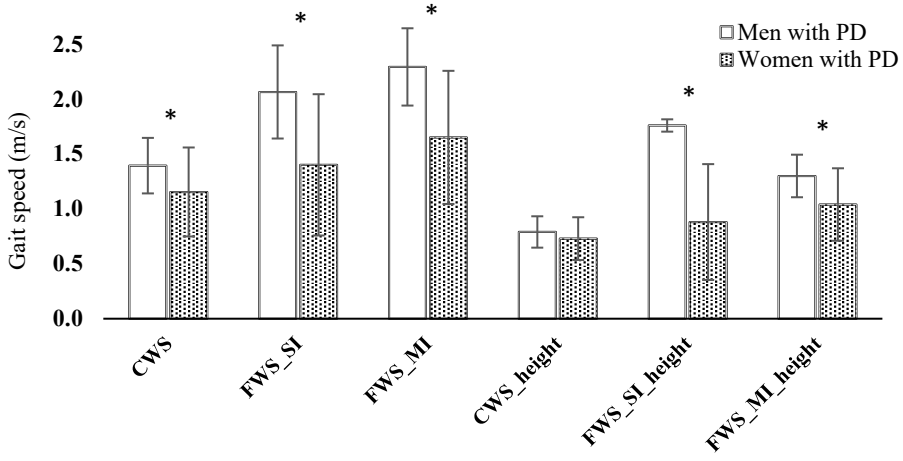

Figure 5. Comparison of gait speed with different instructions in men and women with Parkinson's disease.

Note: CWS: customary walking speed; FWS_SI: fast walking speed with simple instruction; FWS_MI: fast walking speed with motivational instruction; CWS_height: height-adjusted customary walking speed; FWS_SI_height: height-adjusted fast walking speed with simple instruction; FWS_MI_height: height-adjusted fast walking speed test with motivational instruction; * significant difference between male and female participants on a level of $p<0.05$.

Results revealed that the men with PD increased their walking speed from customary walking speed to fast walking speed significantly more than women with simple and motivational instructions used ($p=0.003$ for FWS_SI and $p=0.007$ for FWS_MI, see Figure 6).

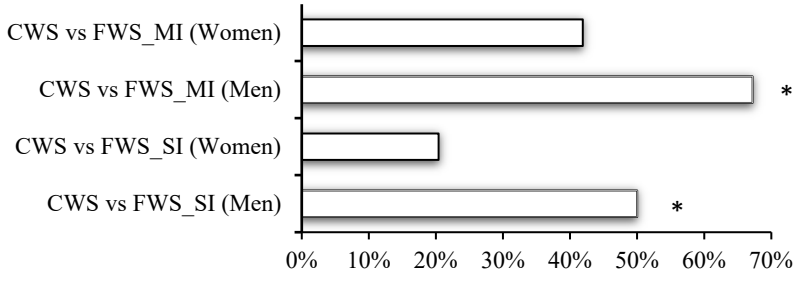

Figure 6. Relative change (%) of gait speed with different instructions in men and women with Parkinson's disease.

Note: CWS: customary walking speed; FWS_SI: fast walking speed with simple instruction; FWS_MI: fast walking speed with motivational instruction; * significant difference between male and female participants on a level of $p<0.05$.

5.4. Relationship between gait speed and disease severity in men and women with Parkinson's disease

In women with PD, distinct associations between gait speed and disease severity were evident, indicating that as the severity of the disease increased, the gait speeds slowed down (as illustrated in Figure 7). Among the different instructions, FWS_MI displayed the strongest associations with the results of the neurological assessment. On the other hand, CWS showed no association with the MDS-UPDRS total score and HY, but only with the motor score of the MDS-UPDRS. The results remained analogous when using the height-adjusted gait speeds.

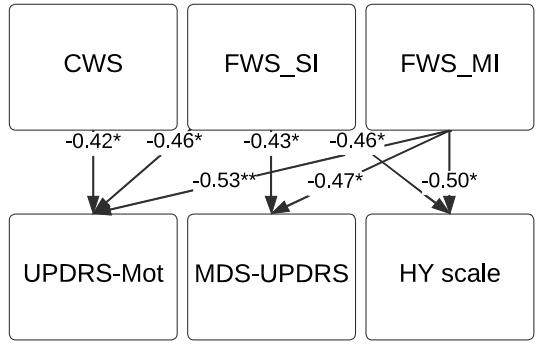

Figure 7. Associations (correlation coefficient, r) between gait speed and disease severity in women (n=14) with PD.

Note: PD: Parkinson's disease: n: number of patients; CWS: customary walking speed; FWS_SI: fast walking speed with simple instruction; FWS_MI: fast walking speed with motivational instruction; UPDRS-Mot: motor examination score of MDS-UPDRS; MDS-UPDRS: Movement Disorders Society Unified Parkinson's Disease Rating Scale; HYscale: Hoehn & Yahr staging scale; *: significant correlation at the $p<0.05$ level (2-tailed); **: significant correlation at the $p<0.01$ level (2-tailed).

In men with PD, no statistically significant relationship was observed between gait speed, as measured with different instructions, and disease severity, assessed using MDS-UPDRS total and motor scores and HY scale.

6. DISCUSSION

6.1. The effects of disease-specific physiotherapy on functional performance and patient-reported outcomes

This dissertation aimed to present further empirical evidence to substantiate the advantageous outcomes of (group) physiotherapy, in an effort to promote higher rates of referral for Estonian patients diagnosed with PD.

This study revealed that physiotherapy intervention that focuses briefly on different core areas, recommended by EPGPD physiotherapy guideline, resulted in improvement of both patient-reported outcomes and physiotherapeutic assessment results – a reduction in the self-reported functional activities limitations and FOG, as well as improvement in gait speed at gait initiation and in proximal ROM was evident.

A notable percentage of physiotherapists provide interventions that have limited or uncertain value, despite the availability of highly effective interventions. According to Zadro and co-authors (2020), a mere 25% of physiotherapists were found to provide high-value interventions to patients with PD. Yet, while evidence-based PD-specific recommendations are accessible to most of the physiotherapists, there is a lack of guidance on how to effectively combine them into clinical practice interventions as the available time to address each of PD- specific core area is always limited in the clinical setting. Present study provides some insight in this matter.

Quinn & Morgan (2017) emphasized that physiotherapists should embrace a rehabilitation model that prioritizes prevention in all ages with neurological conditions and should contribute to providing proactive approaches. According to the author of this study, this indicates that physiotherapists should be familiar with the PD diagnosis in order to provide interventions that could be considered proactive PD-specific therapy. This is in line with King & Horak (2009), who declared that implementing an exercise program that addresses anticipated challenges for PD patients who have not yet experienced mobility issues is beneficial. The author of this study contends that the intervention employed in the present research embodies a proactive therapeutic approach and was also beneficial to the participants.

To assess the potential benefit or efficacy of an intervention gait speed has often been used as an outcome measure, often assessing an intervention targeted merely to improve gait. As the transition from static to dynamic (tasks such as gait initiation, turning, and gait termination) often poses a challenge for individuals with PD (Bovonsunthonchai et al., 2013) and affects gait speed, gait initiation (StWS) was evaluated in present study. Despite gait training of each session was relatively brief, only 10 minutes, improvement in StWS in the IG was found.

Gait training in present study included instructions and walking practice with proper posture, stride length, step pattern, and other components of walking (such

as turns) with and without cues, with and without dual task, including practicing walking with different speeds etc. However, exercises included in other parts of the intervention (exercises for balance, coordination, strength, and flexibility) also can be considered as techniques of gait training.

It can be argued that this increase in StWS suggests a reduction in start hesitation and enhanced gait initiation. Further supporting this notion, the FOG questionnaire score was markedly lower post-intervention in the IG. Additionally, considering the observed improvements in ROM during the intervention period and upon re-evaluation, it is likely that the enhanced mobility of the lumbar and pelvic girdle (which were targeted by ROM and stretching exercises in the intervention) contribute to reducing episodes of FOG and faster StWS. Also, previous research has established an association between rigidity and a decreased arm and leg swing during walking, thereby influencing gait (Kwon et al., 2014), and at the same time performing stretching exercises led to an increase in gait speed (Cristiansen, 2017).

FOGQ indicated reduction of FOG in the study. The alleviation of freezing episodes and improvement of gait parameters were likely a result of the strategies, such as cueing strategies, rhythmic auditory stimulation, visual cues, and exercises targeting balance and coordination employed in the sessions.

As stated by Rubinstein et al (2002), although the specific types of cues and their mechanisms of action in PD remain not fully understandable, nearly every study on cueing has demonstrated significant positive effects on gait.

Apart from the direct impact of exercises on reducing freezing episodes, providing information about freezing and festination was considered an important aspect of patient-specific intervention in current study. When an episode of freezing occurs unexpectedly, patients may experience balance loss, increasing the likelihood of falls and associated injuries. Knowing when FOG episodes could potentially occur (e.g., when turning, initiating movement, navigating through narrow passages etc.) (Schaafsma et al., 2003) helps to anticipate the episode and therefore reduce the unexpectedness, thereby reducing risk of falls in individuals with PD. The educational component of the intervention aimed to alleviate the fear and anticipation of freezing episodes that may lead to heightened anxiety during walking and further aggravate gait abnormalities. Previous work (Nonnekes et al., 2015) suggests that it is beneficial to provide education regarding FOG which encompasses information about the risk of falls, factors that can trigger it, and potential preventive measures

While FOG is one aspect that PwP may seek professional help from physiotherapists for, it is important to recognize that there are numerous other concerns and issues that require attention and intervention from physiotherapy. Mainly an exercise-based physiotherapy intervention is used in PD management (Bouca-Machado et al., 2020). If an intervention combines different active exercises to manage people with PD, it is often referred to as conventional physiotherapy (Radder et al., 2020).

The concept of conventional physiotherapy encompasses not only active exercises, but also passive interventions provided by physiotherapists (Thomlinon et al., 2012). At times, the term "conventional physiotherapy" is used in research to refer to a control group intervention (Feng et al., 2019). Despite how conventional physiotherapy is defined, beneficial effects of conventional physiotherapy on various symptoms in PD has been reported in several meta-analysis studies (Radder et al., 2020, Saluja et al., 2023). Hoskovcova et al. (2022) declare that categorization of different physiotherapy techniques under the term "conventional physiotherapy" in PD, lacks content and may even be risky, suggesting the need to discard it. One of the potential alternatives to consider as a replacement was "multimodal training".

One unique aspect of present study was that the guideline based recommended core areas (physical capacity, transfers, balance, gait, and manual activities) (Keus et al., 2014) were combined into a multimodal approach. There are not many studies that have reported to be purportedly following physiotherapy guidelines when designing their intervention. One of these is a study by Pazzaglia et al. (2020) who claimed that the intervention for the group of conventional physiotherapy was PD physiotherapy guideline based. However, a direct comparison between the interventions in Pazzaglia et al. (2020) and present study is not feasible due to substantial differences in various aspects, including the duration of intervention sessions and the intervention period. Nevertheless, Pazzaglia et al. (2020) reported significant improvement in arm function for both interventions in their study, which included virtual reality therapy and conventional physiotherapy intervention. Improved arm function plays a significant role in enhancing daily activity performance. In the present study, 10 minutes of manual activities were incorporated during each therapy sessions, potentially contributing to a reduction in functional activity limitations that were assessed using a PROMs-type questionnaire ModPSFS (without any assessment test of upper limb functionality).

According to Kyte et al. (2015), the routine use of PROMs in clinical practice has the potential to enhance physiotherapists' ability to monitor impact of treatment effectively, thereby, facilitating the development of optimal management strategies. PROMs play a vital role in placing patients at the center of care and are expected to have a greater influence on physiotherapists. Individualized problem identification holds particular significance for individuals with chronic conditions as they frequently encounter multiple challenges in their daily lives and often require long-term treatment approaches (Stevens et al., 2016).

While patient-centered physiotherapy aims to identify patients' specific issues (Donnelly & Carswell, 2002), it is crucial to have a reliable method for measuring functional aspects of each individual, yet yields comparable outcome data (Mathis et al., 2019). Through the utilization of ModPSFS, this fundamental requirement in physiotherapy examination could be fulfilled. The latter would have not been possible using PSC or PSFS, as according to Bohannon and co-authors, patients with PD identified 60 different activities that they were unable to do or they were experiencing difficulties as a result of their PD (Bohannon et al., 2020). Further,

a patient might not fully inform their physiotherapist on present activity limitations, because a PwP might lack understanding on what problems could be reduced by physiotherapy (Keus et al., 2014).

Assessing disabilities in activities of daily living is an important aspect that should be given careful consideration (Biemans et al., 2001). However, in the context of assessing the impact of a physiotherapy intervention, this assessment is generally overlooked. According to a review conducted by Radder et al. (2020), in general there is a lack of studies that have examined the impact of physiotherapy on the quality of life of individuals with PD. Clarke et al. (2016) found that physiotherapy did not lead to significant immediate or long-term improvements in activities of daily living or quality of life for patients with mild to moderate PD.

Nonetheless, it remains important to assess functional limitations as it allows for the timely identification of deterioration in functionality, enabling necessary actions to ensure patient safety, prevent excessive caregiver burden, and determine the need for further referrals (Shulman et al., 2016). This was done in the present study and the results of this dissertation revealed substantial reduction in post-intervention scores of ModPSFS.

However, it must be acknowledged that the ModPSFS is not an ideal tool – as noted in the results section, at final assessments, rather than listing specific activities they struggled with or desired to improvement in, participants voiced concerns regarding various issues. They also expressed some difficulty in rating the extent of difficulties as the symptoms of PD are variable. In the study conducted by Stevens et al. (2016), participants encountered difficulties in evaluating their fluctuating performance and measuring the extent of their burden despite providing similar ratings on PSC. Nevertheless, the authors recommended the full integration of such instruments into the diagnostic and therapeutic process of physiotherapy, rather than using them as standalone tools. Bhidayasiri and Martinez-Martin (2017) also emphasized the limitations of clinical assessments in capturing a comprehensive picture of a patient's symptoms as they can only provide a snapshot of the moment. This further justifies the need for an instrument that encompasses the patient's perspective.

In this study, 80% of the participants in the IG group reported post-intervention improvement health status, whereas nearly 60% of CG members perceived their health status to have deteriorated at the second assessment. A health status check was just a one-item question in ModPSFS. Nonetheless, according to Rosenzveig et al. (2014), abundant evidence exists to support the utilization of individual items in clinical practice, both for immediate implementation and for long-term monitoring purposes (Rosenzveig et al., 2014). Despite that, lack of time has been identified as one of the key barriers to patient-centered care (West et al., 2005). Nevertheless, there should always be time to ask the patient to provide a one-item estimation on their health status, both pre- and post-intervention.

The approach of providing physiotherapy as group treatment is well supported by EPGPD (Keus et al., 2014) that emphasizes focusing on prevention and general improvement of physical capacity and functional mobility and adjust

group size to levels of functioning of the PwP in the group, stating it to be eight on average. In present study, a group size of 3–4 participants was considered optimal for harnessing the beneficial aspects of group therapy. This approach allowed to find a balance between individualized attention, such as providing manual facilitation or correction of the execution of an exercise when necessary, and at the same time was optimal resources-wise. By resources, finance, time and therapy setting related issues are considered – e.g., practicing in-bed transfers on a wide plinth was possible with a small group, which is usually not an option with larger groups. Practicing transfers is one core areas of PD –specific physiotherapy (Keus et al., 2014). Transfers should be practiced from early stages of the disease as longer turning time and reduced turn magnitude during nocturnal turns was already evident in recently diagnosed patients (with less than 1 year from diagnosis) (Mirelman et al., 2020).

In addition, group therapy offers valuable opportunities to learn from peers and has a significant social component which is beneficial not only for individuals with PD but also for their caregivers. The incorporation of conventional physiotherapy within a group environment has been shown to have a positive impact on attitudes and foster optimism in individuals with PD, as observed in a study by Park et al. (2014). The 100% participation rate in therapy sessions in this study indicates that participants were not reluctant and found the therapy environment to be pleasant.

Nonetheless, when interpreting the results of this study, it must be acknowledged that physiotherapy intervention was provided in small groups instead of individualized intervention, which might somewhat influence the results. King et al. (2015) have reported different outcomes of individual vs group interventions and found that individual exercise demonstrated higher enhancements in functional and balance measures, whereas the group intervention resulted in the most notable improvements in gait.

In addition, it must be acknowledged that the gait speed of PwP is slower in daily life than in research settings (Corrà et al., 2021), with only approximately 3% of the strides exhibiting gait speeds equal to or greater than the patients' capacity in the clinic (Atrsaei et al.,2021). The latter further illustrates the need for a comprehensive assessment of PwP.

6.2. The impact of instructions used during gait speed assessment on gait speed of men and women with Parkinson's disease

Gait speed is widely utilized in PD research. In present study, gait speed assessment was used for assessment of efficacy of the intervention and to assess the impact of the instructions provided by the physiotherapist prior gait assessment, 10mWT was used. The 10mWT allows for the assessment of comfortable and fast walking speeds (Keus et al., 2014).

The main findings of this dissertation highlight the impact of provided instructions on gait speed in individuals with PD. The study revealed that, overall, men with PD performed the 10-meter walk test (10mWT) faster than women, except for height-adjusted CWS. Furthermore, male participants demonstrated a significantly greater ability to increase their walking speed compared to their female counterparts.

These findings shed light on the influence of both instructions and gender on gait speed among individuals with PD.

The primary concern for individuals diagnosed with PD is often the fear of losing their ability to walk or maintain proper posture while sitting or moving (Giladi et al., 2013). Evaluating the patient's gait is, therefore, of great importance both for the patient and the professional. For the healthcare specialists, gait assessment provides valuable information regarding motor control deficiencies and offers insights into the effectiveness of therapeutic interventions (Morris et al., 2001). Walking speed is a vital factor for the safety of individuals with PD, particularly when performing activities like crossing the street.

The significantly faster walking speed observed in male participants aligns with previous studies (Samson et al., 2001, Al-Makhalas et al., 2023). Samson et al. (2001) demonstrated lower absolute values of walking speed in healthy women compared to men across all age groups, while studies in individuals with PD (e.g., Hass et al, 2011; Vila et al., 2021) have also reported faster walking speeds in men compared to women, although the speeds in those studies were slower than in the present study. Hass et al. (2011) reported an average speed of 1.02±0.02 m/s for men in stages 2–2.5 according to the HY, whereas the average CWS in present study was 1.39±0.25 m/s. A comfortable gait speed of less than 1.1 m/s has been reported to be predictive for future falls in individuals with PD (Duncan et al., 2015, Lindholm et al., 2016). Nonetheless, decision of the fall risk of a PwP cannot be based merely on gait speed.

The faster walking speed in present study compared to the study by Hass and co-authors (2011) can likely to be attributed to the methodology used in present study, as the gait speed differs in tests with different lengths (Salbach et al, 2015). In the study by Hass et al. (2011), the participants walked across a pressure sensitive walkway with the length of a walkway not specified. In present study, the acceleration and deceleration were excluded, and the walking speed was calculated based on the intermediate six meters of the 10mWT.

The gait speed was also higher than of those participating in a study by Novaes et al. (2011) conducted on Brazilian cohort. Salbach et al. (2015) has stated the country-based differences in reference values for different gait tests, therefore the probable explanation for this can be attributed to the use of a specific walkway with visual cues, such as red and black stripes, which may have influenced the walking speed. Previous studies have demonstrated the positive effect of visual cues on gait speed and step length in patients with PD (Suteerawattananon et al., 2004; Jiang & Norman, 2006).

The use of visual cues, such as the marked walkway might have been more effective in increasing the walking speed of male participants. For example, Jiang

and Norman showed that transverse visual lines enable individuals with PD to initiate walking with longer steps and higher velocity. As the stride length is longer in men (Hass et al., 2011), the effect could have been greater. Serrao et al. (2019) also observed men with PD exhibiting greater susceptibility to improvements in gait function (following a rehabilitation program, in their case). There may be specific, yet unidentified, gender-related aspects of gait in women and men with PD, possibly also effected by the learning or retest effect, which has been reported in previously (Behrman et al., 2000) for improvement in movement speed among PD patients.

Men exhibited a significant increase in gait speed when instructed to walk faster than their usual pace. For the observed gender differences in walking speed there are additional potential explanations. One possibility is that the test environment which required participants to walk as fast as possible while being timed was perceived as competitive by men. Also, Mayr et al. (2012) have reported greater inclination towards engaging in competitive activities in men. In the study by Crispino et al. (2021) being female was also associated with a higher likelihood of experiencing poor physical functioning.

Furthermore, anthropometric differences between men and women, such as height and lower extremity length can also explain the disparities in walking speed. Taller individuals naturally cover a greater distance in a given time period. Height has been shown to account for a significant proportion of the variance in walking speed in both men and women (Samson et al., 2001). However, even after adjusting for height, men still exhibited higher movement speeds, except for CWS likely being indicative that women with PD preserve their customary walking speed relatively better than fast walking speeds.

In present study, the extent of how much the fast walking speeds were greater than the habitual gait speed, was also higher in male participants. This result is in alignment with a study by Nemanich et al. (2013), where also the difference between self-selected and fast walking speed was significantly higher in men with PD and was significantly associated with falling in males but not females. Recent findings from von der Recke and co-authors (2023) suggest that a decreased range of gait speed may be a symptom specific to PD.

The impact of instructions during gait in PwP has been studied previously. The results of Behrman and co-authors (1998) demonstrated that patients effectively followed the given instructions showed immediate changes in various walking variables.

The effect of the instructions used was also examined by Shaw et al. (2011), who conducted a comparison between gait with no focus and gait with skill-focus. The skill-instruction meant that the participant was guided to focus on the foot contacting the floor with each step. During walking at a self-selected pace, providing skill-focused instructions resulted in faster walking velocity, longer step length, reduced step time, increased step velocity, decreased swing and double support time compared to no instructions. However, when walking at maximum speed, skill-focused instructions led to slower walking velocity, shorter step length, increased step time, decreased step velocity, and increased double support

time compared to no instructions. In present study the instructions given were different. It is likely that the skill-focus instruction could be more seen as a gait with dual-task, which was reported as not showing an improvement in gait velocity, despite the cues used, also in a study by Lohnes & Earhart (2011), whereas the motivational instruction used in present study could have been perceived as a use of attentional cue.

In a study by Canning (2005), it was found that when guided to focus their attention on walking while holding the tray and glasses, participants demonstrated increased walking speed and longer strides. She suggested that specific instruction can be employed to manipulate attention and improve the execution of daily dual-tasks in individuals with mild to moderate PD. Directing one's focus could also be considered as a use of attentional cues, which are also reported to be beneficial in PwP by Rubinstein and co-authors (2002).

Overall, the instructions provided by a physiotherapist play an important role in shaping the assessment results of a PwP. The instructions can influence participant's performance, motivation, focus, and overall test reliability. Additionally, gait speed of men and women with PD differs and gender should be considered during gait assessments.

6.3. Relationship between gait speed and disease severity in men and women with Parkinson' s disease

The associations between functional performance, including gait speed and neurological assessments in women and men with PD provides a better understanding of the disease and its impact on performance and daily functioning ability. This information can aid the development of targeted interventions and personalized treatment approaches for PwP.

The main finding of this study underscores the relationship between gait speed and disease severity in individuals with PD. Notably, the research revealed gender differences in these associations, emphasizing that the relationship between gait speed and disease severity varies between men and women with PD. Namely, relationships were found between gait speed and neurological assessment measures in women, and as PD is a progressive disorder (Bloem et al., 2021) these results were expected. Similar relationship was not evident in male participants in the present study. However, Qutubuddin et al. (2005) found UPDRS motor and HY to be associated with functional performance in men with PD, namely with the results of Berg Balance Scale. This differences in the study results can likely be attributed to conceptually different assessment methods. The Berg Balance Scale rates balance and consists of 14 items. Each of these items is scored from 0 to 4 and are added together for a total score between 0 and 56, with a higher score indicating better balance (Downes et al., 2013). While the Berg Balance Scale has been established as a reliable measure for assessing functional balance in community-dwelling older adults (Langley & Mackintosh, 2007), the scoring

of the performance likely introduces level of subjectivity compared to objective registration of performance characteristics which was the case in the present study.

In a study by Corrà et al. (2021), also no correlation was found between home-base gait speed and UPDRS motor part score, except for one item (item 30, gait assessment). Similarly, there were no significant correlation observed with the assessed gait parameters among the patients with PD between the UPDRS total score, UPDRS motor score, and HY staging in a study by Weiss et al (2011). However, in neither of the studies the authors have specified the gender distribution, so it cannot be concluded whether the gait speed not being associated with neurological assessment results is specific to male gender. Rather, it is likely that scales used for assessment of disease severity are not suitable for quantifying the impact of the disease on actual performance. The latter idea is supported by the results of Regnault and co-authors (2019) who stated the analysis of the MDS-UPDRS-II, underscored the limitations, and failed to accurately capture patient-reported motor signs and the impact of PD.

It seems reasonable to exclude the total and motor score and rather seek for associations between more gait related (sub)scales, e.g., UPDRS-Gait5 (includes motor items related to falling, freezing of gait, walking, postural stability, and gait) which was correlated with average stride time (Weiss et al., 2011). Nonetheless, the use of the MDS-UPDRS in routine clinical practice is further limited due to time burden (AlMahadin et al., 2020).

Results of this study distinctly demonstrated that females with more advanced PD had lower fast walking gait speed, not depending on whether simple or motivational instruction was used, though when motivational instruction was used then the relationship was the strongest, and CWS was associated merely with the motor score of MDS-UPDRS. Furthermore, previous research has demonstrated that fast-paced gait speed in a laboratory setting is more strongly correlated with daily gait speed (Corrà et al., 2021). This suggests that physiotherapists should conduct a more comprehensive assessment of gait speed in individuals with PD as relying solely on conventional gait speed may not provide sufficient information.

The relative change in gait speed was significantly lower in female participants contributing likely to the differences in relationship between gait speed and disease severity. Besides the beforementioned possible contributing aspect of higher competitiveness of male participants, another possible explanation for the different relationships observed across genders could be a higher tendency of women to withdraw during performance compared to men. It was concluded in a study by Ennis et al. (2013) that older adults perceive cognitive efforts as relatively harder, leading to a higher level of withdrawal compared to younger participants. There is a possibility that this withdrawal at harder effort extends to physical effort and is not specific to age. In the context of present study, since men walked faster, the FWS testing may have been less challenging for them, and as a result, they may have exerted themselves to a greater extent. On the other hand, female participants might have been more likely to withdraw or hold back during the testing of the fast walking speed.

Nevertheless, even though the existing evidence regarding the influence of gender on the relationship between disease severity and functional performance in PD is inconclusive, it is still possible that the association between motor function and underlying neurological status may vary between men and women with PD, that is yet to be studied. Certain gender differences in PD have been reported – e.g., presence of rigidity and positive history of depression, as well as postural instability being more evident in women than in men (Baba et al., 2005). Vila et al. (2021) have suggested that the differences between men and women might depend on the stage of the disease – the results of their study on gait revealed, that women initially exhibit worse gait parameters compared to men in the early stage of the disease (stage I), however, as the disease progresses, gait parameters in (e.g. speed and cadence) women tends to stabilize, while in men it deteriorates. These findings highlight the significance of considering both the disease stage and gender differences during assessments of individuals with PD. Moreover, it is likely that such considerations should also be incorporated into interventions to ensure optimal effectiveness.

Nonetheless, besides standard functional performance assessment, the author of this study asserts that comprehending the current disease severity, e.g., HY scale stage of a patient with PD holds significance for physiotherapists. For instance, having knowledge about whether a patient experiences unilateral or bilateral involvement, or exhibits postural instability, provides a solid basis for physiotherapists to design their assessments, customize interventions, and treatment plans according to the unique needs and capabilities of each individual.

It must be noted that when considering a HY stage of a patient, physiotherapist must keep in mind that HY primarily emphasizes postural instability and may not adequately capture the full range of motor features, impairments, and disabilities associated with PD (Goetz et al., 2004). Further, it gives no information on non-motor problems nor about the difficulties patients encounter during their daily life and therefore, the aspect of daily functioning needs to be captured otherwise, e.g., by using ModPSFS. Molla-Cassanova et al., (2022) also found that as the PD progresses, challenges in maintaining postural control, difficulties in sitting down or standing up from a chair etc., becomes increasingly impaired. Nonetheless, regardless of what is the current disease severity of the patient, it is crucial for physiotherapists to adopt a rehabilitation model that places a high priority on prevention (Quinn and Morgan, 2017). It seems reasonable to dedicate some time of therapy sessions to each core area suggested by physiotherapy guidelines.

6.4. Limitations and strengths of the study and implications for future studies

This intervention study has several strengths that contributes to its significance. Firstly, it includes a control group for meaningful comparisons. The assessments used in this study cover both the functional performance aspects and include patient-reported outcome measures, ensuring reproducibility. Moreover, the

chosen assessments are applicable in a clinical setting, enhancing their practical value. Further, the instructions given to the patients were kept standardized. To mitigate potential bias among researchers, the study ensured consistency by assigning the same assessor to provide instructions and conduct assessments, such as range of motion (ROM) measurement, for each participant during both baseline assessment and final assessment. The study's novelty lies in its PD-specific intervention, targeting all the core areas recommended in the physiotherapy guideline in a clinically feasible format.

However, there are limitations to consider. The small sample size restricts the generalizability of the findings and caution should be exercised when applying the results to a larger population. The primary factor contributing to the small sample size was because of the limited availability of the facility where the sessions were conducted as it was situated within an in-patient ward. Since, the study participants were outpatients, the utilization of the therapy room was constrained. However, it is important to acknowledge that a similar therapy room could be situated in an outpatient setting as well, though it was so at the execution of the study.

It's important to note that the intervention provided in this study was suitable for individuals with mild-to-moderate PD, and its effectiveness in advanced stages would likely differ. Previous research has shown that the stage of the disease has a greater impact on functionality (Vila et al., 2021; Molla-Casanova et al., 2022), supporting the need for further research with patients of different stages.

Additionally, the participants in this study had not received any physiotherapy intervention in the previous year, which may have influenced their baseline functional status. This inclusion criterion was set to ensure that the potential improvements can be attributed to the intervention provided in current study. Nevertheless, even though this particular inclusion criterion was not prioritized as the primary criterion for potential participants, it did not lead to significant exclusions from the study, being indicative of low referral rates of PwP to physiotherapy in Estonia.

One limitation of this study may be the use of a previously unused assessment tool, the ModPSFS. The ModPSFS was specifically designed to address the need for a patient-centered care, and yet have comparable outcome measures to complement physiotherapeutic assessments. While other standardized assessments such as Nottingham Extended Activities of Daily Living (Clarke et al., 2016) and Patient specific index for PD (Nijkrake et al., 2009) exist, they have limitations in terms of comparability across individuals or groups. Nottingham Extended Activities of Daily Living includes activities that may not be applicable to all individuals, and Patient specific index for PD includes items that not all participants would perform. In contrast, the ModPSFS focuses on a specific list of activities that each participant regularly performs, allowing for valid comparisons. Comparable outcome data is crucial in research and clinical work, especially when assessing the impact of interventions on basic ADL. The ModPSFS ensures consistency by assessing the same specific activities for all participants. Previous standardized assessments like Nottingham Extended Activities of Daily Living and Patient

specific index for PD, although valuable from a patient's perspective, do not enable good comparisons across individuals or groups due to their limitations.

The health status check in the study was a single-item question in the Mod-PSFS, which aligns with evidence supporting the use of single-item assessments in clinical practice and long-term monitoring (Rosenzveig et al., 2014). Despite time constraints being a barrier to patient-centered care (West et al., 2005), it is important to prioritize asking patients to provide a one-item estimation of their health status both before and after interventions. The fact that nearly 60% of the control group perceived their health status to have deteriorated at the second assessment raises a question, whether it was indicative of a disease progression of small extent, future studies need to clarify this.

Gender is recognized as a significant factor influencing the execution of activities of daily living (ADL). Previous research has reported gender differences to be in instrumental ADL among individuals with PD (Foster, 2014). The current study has brought attention to the gender as a contributor to clinical physiotherapy assessments. While physiotherapy practice is generally considered to be unbiased in terms of gender, it is important to acknowledge that both the gender of the patient and the physiotherapist can have an impact on rehabilitation settings and clinical practice (Stenberg et al., 2021). There are indications in the literature that men and women may respond differently to interventions (Serrao et al., 2019), but further studies should investigate this aspect in greater detail. Gender is likely to play a significant role in the actual performance of activities and the outcomes of interventions in people with PD, and it is expected that future studies will give more attention to this aspect.

6.5. Practical recommendations/clinical implications

Regrettably, not in all countries PwP have access to physiotherapy services, especially with skilled therapists who specialize in providing PD-specific approaches (Nonnekes et al., 2015). This study increases the awareness of PD-specific physiotherapy,and provides practical applications for physiotherapists working in clinical setting. This study indicated that a group intervention program combining core areas specifically important for individuals with PD can be implemented successfully in clinical setting. The PD-specific core areas to be addressed in the intervention include balance, gait, transfers, physical capacity, and manual activities as recommended in EPDPG (Keus et al., 2014), with keeping in mind that use of external cueing to be superior to usual physical therapy care in PwP (Osborne et al., 2022)

A twice-per-week physiotherapeutic intervention with a duration of 8 weeks, was effective in increasing the speed of gait initiation, reducing self-reported FOG and functional activity limitations, and improving the ROM. The results of this study also suggest incorporation of comprehensive gait assessment that goes beyond assessment of merely customary gait speed. During gait performance assessment the impact of the instructions given to the patient must be kept in

mind. As instructions used contributes to the assessment results in PwP, keeping the instructions standardized is important. Furthermore, gait assessment should take into account the possible impact of the gender of the patient, especially when the gait speed is not adjusted with height. Also, Göttgens et al., (2020) have hinted the need for implementation of sex- or gender-sensitive approaches in PwP.

Considering the patient perspective is vital in evidence-based physiotherapy. By valuing patient input, utilizing patient-reported outcome measures, physiotherapists can provide patient-centered care that addresses individual needs and enhances treatment outcomes. Nonetheless, sustaining a comparability of how PD translates into everyday life can be challenging. A possible tool, ModPSFS was suggested in this study.

Overall, the present study approves that different evidence-based physiotherapy recommendations can be incorporated into PD-specific physiotherapy programme in a manner easily applicable in clinical settings, that has beneficial outcomes regarding the gait and ADL limitations in PwP, and hopefully results in higher willingness of the physicians to refer patients to physiotherapy.

7. CONCLUSIONS

1. An 8-week disease-specific group physiotherapy improves standing-to-walking gait speed and hip flexion range of motion of patients with Parkinson's disease, without significant improvements in sit-to-stand transfer.
2. An 8-week disease-specific group physiotherapy reduces self-reported freezing of gait and functional activity limitations in patients with Parkinson's disease, at the same time most experiencing improvement in overall health status at final assessment, while many controls report deterioration of overall health status.
3. The instructions used during gait assessment significantly affect the gait speed of both men and women with mild-to-moderate Parkinson's disease. Men with Parkinson's disease generally exhibit faster gait speeds compared to women across all instructions, except in height-adjusted customary walking speed. Additionally, there is a greater increase in walking speed from customary to fast in men with Parkinson's disease.
4. Gait speed, as measured using different instructions is associated with disease severity in women with Parkinson' s disease but not in men, whereas using the motivational instruction reveals the strongest associations.
5. To ensure a comprehensive assessment of functional performance of patients with Parkinson's disease, it is essential to consider multiple aspects including patient-reported functional activity limitations, patient's gender, height, and the importance of instructions provided during gait assessment.

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SUMMARY IN ESTONIAN

Haigus-spetsiifilise füsioteraapia mõju kerge ja mõõduka Parkinsoni tõvega patsientide funktsionaalsetele näitajatele

Parkinsoni tõve iseloomulikud motoorsed sümptomid on treemor, rigiidsus, bradükineesia, posturaalne ebastabiilsus (Balestrino & Schapira, 2020), painutatud kehahoiak ja tardumised (Jankovic, 2008), mis haiguse neurodegeneratiivse olemuse tõttu progresseeruvad (Poewe et al., 2017), mõjutades patsientide elukvaliteeti ja igapäevast toimetulekut. Haiguse kliinilised ilmingud on tingitud dopamiinergiliste neuronite degeneratsioonist (Cacabelos, 2017). Dopamiinergiliste ravimite kõrval kasutatakse Parkinsoni tõvega patsientide sümptomite kontrollimiseks toetava ravimeetodina ka füsioteraapiat ja kehalist treeningut (Bouça-Machado et al., 2019).

Füsioterapeutide rolliks Parkinsoni tõvega patsientide ravis on läbi erinevate füsioterapeutiliste sekkumiste kasutamise (Radder et al., 2020) kehalise aktiivsuse soodustamine, motoorsete sümptomite käsitlus ja sekundaarsete komplikatsioonide ennetamine (Pang, 2021). Teaduslikult on tõendatud aeroobse treeningu, jõuharjutuste ja tasakaaluharjutuste positiivne mõju (Pang, 2021), samuti on kinnitust leidnud väliste stiimulitega täiendatud kõnnitreeningu kasulikkus (Osborne et al., 2022). Vastavaid aspekte soovitavad teraapias kasutada ka erinevad ravijuhendid, muuhulgas Euroopa Parkinsoni Tõve Füsioteraapia Ravijuhend (*European Physiotherapy Guideline for Parkinson's Disease*, edaspidi EPGPD, Keus et al., 2014).

Siiski ei ole uuringutes tõhusaks osutunud sekkumised füsioterapeudi kliinilises töös sageli rakendatavad, tingituna aja- ja muudest piirangutest, ka on ainult ühele valdkonnale keskenduv sekkumine vastuolus üha olulisemaks muutuva patsiendikeskse füsioteraapia põhimõttega (Stevens et al., 2017). Ka EPGPD-s toodud suuniste kohaselt peaks Parkinsoni haigusele spetsiifiline füsioteraapia hõlmama viit valdkonda: füüsiline võimekus, siirdumised, käelised tegevused, tasakaal ja kõnd. Siiski napib uuringuid, kus oleks uuritud ravijuhendi soovitusi kombineeriva sekkumise mõju.

Füsioterapeutiline hindamine enne ja pärast sekkumist on ülioluline (Lahelle et al., 2018), sealjuures on Parkinsoni tõvega patsientide sekkumisuuringute tõhususe hindamiseks enamasti kasutatud kõnnikiiruse hindamist, sest kõnni aeglustumine on Parkinsoni tõve puhul tavaline (Hackney & Earhart, 2009; Pistacci et al., 2017). Kõnni kiirus on Parkinsoni tõvega patsientidel parandatav väliste stiimulite kasutamisega (Rubinstein et al., 2002), sh võivad ka füsioterapeudi poolsed juhised olla kõndi kiirendavaks stiimuliks (Lohnes ja Earhart, 2011).

Doktoritöö **eesmärk** oli uurida füsioteraapia ravijuhendi põhivaldkondi kombineeriva sekkumise mõju patsientide kõnnile, sealhulgas tardumiste esinemisele, ning enesehinnagulisele igapäevaelu toimetulekupiirangute tasemele. Lisaks analüüsiti doktoritöös füsioterapeudi poolsete instruktsioonide mõju Parkinsoni tõvega patsientide kõnnikiirusele.

Uuringu meetodid: Uuringusse sissearvamiskriteeriumid täitsid 28 Parkinsoni tõvega isikut, kellest neli loobus esmase hindamise järel uuringus osalemast. Uuritavad osalesid kümnenädalase vahega kahel hindamisel. See koosnes intervjuust, neuroloogilisest ja funktsionaalsest hindamisest. Intervjuu käigus selgitati enesehinnanguliste küsimustike abil väja tardumiste (FOG-küsimustik) ja igapäevaelu toimetulekupiirangute (ModPSFS) esinemine. Neuroloogilise hindamise käigus selgitati välja uuritava haiguse raskusaste Hoehn&Yahr skaala ja MDS-UPDRS skaala järgi. Funktsionaalne hindamine hõlmas mitmeid kliinilises prkatikas füsioterapeutide poolt kasutatavaid hindamismeetodeid: 10-m kõnnitest, 5× istest püsti tõusmise test, puusaliigese liigesliikuvus ja *Short Physical Performance Battery*.

Esmase hindamise järgselt jaotati uuritavad plokk-randomiseerimise alusel sekkumis- ja kontrollgruppi. Sekkumisgrupp jaotati omakorda 3-liikmelisteks rühmadeks ning nad osalesid kaheksa nädala vältel kaks korda nädalas tunniajalistel füsioteraapia sessioonidel, kokku 16 korral. Füsioteraapia toimus ambulatoorselt (osalusprotsent 100%) ja teraapia keskendus Parkinsoni tõve füsioteraapia ravijuhendis toodud põhivaldkondadele. Iga 60-minutiline sessioon oli jaotatud viide ossa: harjutused lamavas asendis, harjutused istuvas asendis, harjutused seistes, kõnnitreening ja käeliste tegevuste harjutamine. Teraapias kasutati ka erinevaid väliseid stiimuleid.

Doktoritöö tulemuste põhjal võib järeldada:

1. Kaheksa nädalane Parkisoni tõve spetsiifiline grupifüsioteraapia parandab patsientide kõnni alustamise kiirust ja proksimaalset liigesliikuvust, parandamata oluliselt istest püsti siirdumise kiirust.
2. Kaheksa nädalane Parkisoni tõve spetsiifiline grupifüsioteraapia vähendab patsientide enesehinnangulist tardumiste ja igapäevaelu toimetulekupiirangute taset ja enamik teraapias osalenuid raporteerib teraapiajärgselt ka üldise terviseseisundi paranemist. Samas kontrollgrupi liikmetest suurem osa raporteerib 10 nädalase perioodi jooksul terviseseisundi halvenemist
3. Nii Parkinsoni tõvega meestel kui ka naistel mõjutab testi eel antud juhis kõnni kiirust. Meespatsientide kõnnikiirused on suuremad kui naistel, välja arvatud kehapikkuse osas kohandatud tavakõnnikiiruse puhul. Parkinsoni tõvega mehed on suutelised oma kõnnikiirust enam suurendama, võrreldes naistega.
4. Parkinsoni tõvega naiste kõnnikiirus on seda madalam, mida enam väljendunud haigusega on tegu, sealjuures ilmnevad tugevaimad seosed motiveeriva instruktsiooniga tuvastatud kõnnikiiruse puhul.
5. Parkinsoni tõvega patsientide funktsionaalne hindamine peab olema põhjalik, sealjuures patsiendi enese toimetuleku ja sümptomaatika kohta raporteeritut arvestav. Parkinsoni tõvega patsientide kõnni hindamisel tuleb arvesse võtta ka patsiendi sugu, pikkust ning ka füsioterapeudi poolseid juhiseid.

Praktiline väärtus:

Doktoritöö suurendab teadlikkust Parkinsoni tõve spetsiifilise füsioteraapia olemusest ja omab praktilist väärtust füsioterapeutidele, kes töötavad Parkinsoni tõvega inimestega. See uuring näitas, et viies väikestes gruppides läbi füsioteraapia ravijuhendis (EPDPG, Keus et al., 2014) välja toodud põhivaldkondi kombineeriva füsioterapeutilise sekkumise, paraneb Parkinsoni tõvega patsientide kõnnifunktsioon ja liigesliikuvus, vähenevad tardumised ja enesetajutud igapäevaeluga toimetulekupiirangud. Tulemused viitavad ka Parkinsoni tõvega patsientide kõnni põhjalikuma hindamise olulisusele. Kuna instruktsioonid mõjutavad patsientide kõnnikiirust, on füsioterapeudil oluline jälgida, et hindamisinstruktsioonid oleksid ühtsed erinevatel hindamistel. Lisaks peaks kõnnikiiruse hindamisel arvesse võtma patsiendi sugu, eriti juhul, kui kõnnikiirust ei kohendata kehapikkuse suhtes.

Kokkuvõttes tõestab doktoritöö Parkinsoni tõvega patsientidele suunatud füsioteraapia efektiivsust, rõhutab olulisi aspekte Parkinsoni tõvega patsientide füsioterapeutilisest hindamisest ja loodetavasti suurendab Parkinsoni tõvega patsiente füsioteraapiasse suunamise taset.

ACKNOWLEDGEMENTS

The original work summarized in this study was possible because of the co-operation of many people. In particular, I wish to extend my sincere gratitude and appreciation to the following people:

– To all the patients for making this study possible.

– My supervisors Mati Pääsuke, Aet Lukmann and Pille Taba.

Mati, thank you for your continuous reassurance and mentorship. Your support and trust in my abilities has motivated me to pursue high standards in my research.

Aet, thank you for your confidence in this project and for granting me the opportunity to carry out an interventional study.

Pille, thank you for caring deeply about the Parkinson's disease community in Estonia. Your expertise and valuable insights have been instrumental in shaping the direction of my work. Your kindness, guidance and constructive feedback has been the structural force behind this study, particularly during the most challenging times. You are inspirational!

– Eve Unt for the careful revision and valuable advice.

– I would like to express my gratitude to the physiotherapists – Kristi Reimann, Mari Raudmann and Kristel Ao – and Mrs. Tiiu Paju, nurse, at the Department of Neurology of theTartu University Hospital, for their contribution in the data collection.

– I am thankful to my colleagues for all their encouragement.

– In closing, I want to thank my family, especially my husband Mikk, not only for his love and comprehension but also for insightful comments throughout this effort. I am fortunate to be a mother of our bright children, Helen, Egle and Heiko, who have provided support and understanding, despite of having had to sacrifise a great-deal of "mom-time". I also wish to thank my parents for the dedication they have provided to our family at all times.

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