Health-related quality of life in individuals with Parkinson's disease

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Abstract

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Motor impairment, cognitive decline and speech disruption are prevalent consequences of Parkinson's disease (PD) and have been shown to impact quality of life. However, the relative influence of each of these domains on quality of life is unknown. This study is designed to assess the determinants of health-related quality of life (HRQoL) in individuals with PD. Metrics examined participant's cognitive, motor and speech impairment, as well as their perception of how the deficits impacted their HRQoL. Results revealed meaningful, significant predictive relationships when considering severity of motor symptoms, and communication participation. Overall, these results indicate a combination of speech and motor deficits may be the best predictor of overall quality of life.

Parkinson's Disease (PD) is a chronic, progressive neurodegenerative disorder present in more than 8-million people globally (Kletzel, Hernandez, Miskiel, Mallinson, & Pape, 2017; Sapir, Ramig, & Fox, 2008a). PD most commonly affects individuals over the age of 60, but can impact those as young as 20 (Kostić, 2009). This movement disorder has been linked to deficits in dopamine production, which negatively impact basal ganglia function. Specifically, it has been tied to the degradation of the substantia nigra pars compacta of the basal ganglia (Bergman & Deuschl, 2002) though the overarching etiology remains unknown. Damage to the basal ganglia causes increased inhibition of movement, and results in a variety of motor and non-motor symptoms (Thenganatt & Jankovic, 2014).

PD is classified as a hypokinetic movement disorder, and characteristically presents with the following motor signs: tremor, rigidity, bradykinesia/akinesia, and postural instability (Wolters, 2008). Speech abnormalities are also common. The speech impairment most often associated with PD is hypokinetic dysarthria, which will develop in 70-90% of individuals with the disease (Sapir et al., 2008a). Both speech and limb/trunk motor symptoms are related to the progressive loss of dopaminergic neurons in the substantia nigra (Duffy, 2013).

PD is also associated with non-motor symptoms in the cognitive, neuropsychiatric, sleep, sensory, and autonomic domains (Marras & Chaudhuri, 2016), and is now recognized as a complex multidimensional disorder (Gopalakrishna & Alexander, 2015), as reflected in Table 1. These non-motor symptoms are believed to have a considerable impact on HRQoL, with noted occurrence in at least 50% of people with PD (Duncan et al., 2014a; Litvan et al., 2011a; Williams-Gray, Foltynie, Brayne, Robbins, & Barker, 2007). They may occur prior to the classical motor symptoms, and often remain under-diagnosed by clinicians, despite the significant influence on day-to-day functioning (Duncan et al., 2014b).

Table 1. Common characteristics of Parkinson's disease.

Parkinson's Disease Symptoms: Motor vs. Non-Motor		
Motor Symptoms		
Tremor Akinesia/bradykinesia Rigidity Postural Instability		Dysarthria Dysphagia
Non-Motor Symptoms		
<u>Cognitive</u> Executive Dysfunction Attention Impairment Memory Deficits Dementia	<u>Neuropsychiatric/Mood</u> Depression Anxiety Hallucinations/delusions Confusional episodes Panic Attacks	<u>Sensory</u> Pain Hyposmia (reduced smell) Visual Dysfunction Paraesthesia (abnormal tingling/prickling) Fluctuating Dyskinesia (involuntary muscle movement)
<u>Autonomic</u> Orthostatic Hypertension Sweating Sexual Dysfunction Bladder disturbances Frequency Urgency Nocturia (excessive urination at night)	<u>Gastrointestinal</u> Aguesia (reduced taste) Nausea/reflux/vomiting Sialorrhea (excessive salivation) Constipation Fecal incontinence Unsatisfactory voiding of bowel	<u>Sleep</u> Excessive Daytime Sleepiness Vivid Dreaming Insomnia Sleep Disordered Breathing REM Behavior Disorder Non-REM Sleep-Related Movement Disorders (e.g., Restless Leg Syndrome, Sleep Related Epilepsy) Sleep fragmentation (increased arousal during sleep cycles)

Note: Based on (Berardelli, Rothwell, Thompson, & Hallett, 2001b; Duffy, 2013; Gopalakrishna & Alexander, 2015; Jankovic, 2008a; Moustafa et al., 2016; Sapir, Ramig, & Fox, 2008b).

Research has shown that PD has a significant impact on Health-Related Quality of Life (HRQoL) (Duncan et al., 2014b; Gómez-Esteban et al., 2007; Maira Rozenfeld et al., 2016; Martinez-Martin et al., 2011). HRQoL is a multi-dimensional metric that includes various domains, such as physical, mental, emotional and social health. When compared to the more general term "quality of life," HRQoL encompasses measures beyond population health and life expectancy, and emphasizes the impact of health status. It is a valuable patient-reported metric frequently used to monitor the effects and changes associated with disease. The primary purpose of this study is to examine factors influencing health-related HRQoL from three primary

domains: motor impairment, cognitive functioning, and speech impairment. First, a review of the primary characteristics of PD will be provided, followed by a discussion of potential measurement options, and the current research regarding the impact of these domains on HRQoL.

Motor Characteristics

As mentioned, PD is typically diagnosed based on the presence of four primary motor characteristics: tremor, rigidity, akinesia/bradykinesia, and postural instability. Presentation of these characteristics may be bilateral or unilateral (Jankovic, 2008a; K. M. Yorkston, 2010).

Tremor

Tremor is involuntary and rhythmic movement, due to abnormal muscle contractions (Duffy, 2013). In PD, resting tremor is a readily identifiable characteristic, and usually occurs unilaterally in the relaxed muscles of the hands, legs, lips, chin, or jaw (Duffy, 2013; Duffy, Strand, & Josephs, 2013; Jankovic, 2008b). Hand tremors or "pill-rolling" are common, observed as rhythmic circular motion of the distal region of the thumb and first finger, which can transfer between hands (Jankovic, 2008b).The tremor associated with PD decreases or stops while the person is asleep, is actively using the body part, or is concentrating on the tremor. Conversely, as the person rests, the tremor will increase in persistence and intensity (Jankovic, 2008b).

Rigidity

Persons with PD often present with an increased resistance during passive movement, known as rigidity (Sapir, 2014). Rigidity can occur bilaterally or unilaterally in the limbs and trunk, and can be associated with pain (Jankovic, 2008b). Additionally, stiffness can lead to decreased

range of motion in affected regions, regardless of the direction or speed of movement (Duffy, 2013).

Akinesia/Bradykinesia

Cessation or slowness of movement often occurs in PD. Akinesia is commonly termed "freezing," and occurs during the initiation or transition between movements, often while walking, though does not occur in all patients with PD (Jankovic, 2008b; Sapir, 2014). This reduction in spontaneous movement may also occur in the face, resulting in a lack of facial expression and often termed "masked face" in people with PD (Berardelli, Rothwell, Thompson, & Hallett, 2001a). Bradykinesia presents as an overall slowness of movement that occurs while performing tasks, but is frequently used as an all-encompassing term for the motor impairments associated with PD (Berardelli et al., 2001a).

Postural Instability

Postural instability relates to decreased postural reflexes, and occurs during the later stages of PD (Jankovic, 2008b). Patients often present with poor posture response anticipation, abnormal postural sway and inadequate organization of automatic responses (Moustafa et al., 2016). This instability is frequently associated with falls that cause additional injuries, which may negatively affect HRQoL (Adkin, Frank, & Jog, 2003; Jankovic, 2008b). Bradykinesia can also influence instability in patients with PD, as well as sensory changes related to advancing age (Jankovic, 2008b).

Measurement of Motor Symptoms

The motor symptoms of PD are most often measured using the Hoehn and Yahr Rating Scale and the Unified Parkinson's Disease Rating Scale III (UPDRS-III) (Goetz et al., 2004; Ramaker, Marinus, Stiggelbout, & Van Hilten, 2002). The Hoehn and Yahr scale was designed as a

descriptive staging scale focusing on the clinical features of PD, designated by whole and half point increments on a five-point scale (Goetz et al., 2004; Hoehn & Yahr, 1967). The Hoehn and Yahr scale (see Table 2) is considered a quick and effective measurement of parkinsonian symptoms, and is a common reference standard in both clinical and research practices (Goetz et al., 2004).

Table 2. The Hoehn and Yahr Scale (Hoehn & Yahr, 1967)

Hoehn and Yahr Scale	
Score	*Description*
1.0	Unilateral involvement only
1.5	Unilateral and axial involvement
2.0	Bilateral involvement without 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 contrast to the Hoehn and Yahr Scale, the UPDRS was developed to incorporate the varying symptoms associated with PD, including both motor and non-motor characteristics. The UPDRS-III evaluates PD in the following four domains: Part I: Mentation, Behavior and Mood; Part II: Activities of Daily Living; Part III: Motor; Part IV: Complications. Motor symptoms are addressed in both Part II and Part III, quantifying motor disability and impairment. Characteristics are rated on a zero to four scale, with zero representing normal or no involvement, and four representing the most severe involvement. Overall, the UPDRS-III is considered an effective, valuable and accurate rating tool when measuring PD impairment across domains (Goetz et al., 2003).

Motor Symptoms and HRQoL

The physical manifestations of the motor impairment due to PD can have a negative impact on HRQoL. Tremor, rigidity, akinesia/bradykinesia and postural instability often lead to decreased physical mobility, which is the most commonly reported problem among people with PD (Karlsen, Larsen, Tandberg, & Mæland, 1999; Schrag, Jahanshahi, & Quinn, 2000). Additionally, motor impairments decrease individual's ability to complete ADLs, which adversely impacts HRQoL (Schrag et al., 2000). This inability to complete ADLs leads to a decreased level of independence, which has also been shown to negatively impact a patient's HRQoL (Karlsen et al., 1999).

While several studies have investigated the association between motor symptoms and HRQoL, a particularly relevant study by Gómez-Esteban et. al., (2007) addressed this relationship using the UPDRS and the Parkinson's Disease Questionnaire-39 (PDQ-39). This cross-sectional study included 110 patients with PD, and examined the correlation between HRQoL and individual's mental condition, daily life activities, motor condition and associated drug complications (Gómez-Esteban et al., 2007). The authors investigated the relationships between the individual measurement items on the PDQ-39 (e.g., mobility) and the UPDRS (e.g., gait) as well as the overall relationships between total scores on the assessments, in order to identify which characteristics had the greatest impact on HRQoL (Gómez-Esteban et al., 2007). The authors concluded that three variables have the greatest impact on HRQoL in people with PD: mental condition, complications of dopaminergic drugs, and physical mobility (Gómez-Esteban et al., 2007). Furthermore, researchers identified gait disturbance and postural instability as significant contributors to the decrease in physical mobility, negatively impacting overall HRQoL (Gómez-Esteban et al., 2007).

Speech Characteristics

Hypokinetic dysarthria is a motor speech disorder that commonly occurs in people with PD, causing impairments across the subsystems of speech, including phonation, respiration, articulation and resonance (Duffy, 2013). Most notable are the changes in voice, articulation and prosody (Aileen, Robert, Caterina, John, & Sandra, 1999; Duffy, 2013; Duffy et al., 2013), including the following characteristics: monopitch and monoloudness, reduced stress, harsh or breathy voice quality, imprecise consonants, short rushes of speech, repeated phonemes, inappropriate silences, low pitch and variable/increased rate (Duffy, 2013). Articulatory changes are influenced by hypokinesia causing challenges with rapidly alternating movements, like those of the tongue and lips during speech. Perceptually, the differences most keenly observed are reduced loudness, rapid rate, difficulty with initiation, and a sense of mumbling (Duffy, 2013; Duffy et al., 2013). These speech impairments can lead to a decreased motivation to communicate (Miller, Noble, Jones, Allcock, & Burn, 2008a) as well as a decreased conveyance of emotions via speech (Barnish et al., 2017).

The changes in voice, articulation and prosody in people with PD frequently leads to decreased speech intelligibility. Speech intelligibility can be defined as the extent to which a listener understands the speech by speakers with dysarthria, and is an overall measure that reflects the impact of the impairment as well as the compensatory strategies used by the speaker (K. M. Yorkston, 2010). More than 50% of people with PD will present with reduced speech intelligibility over the course of the disease (Miller et al., 2007), and this reduction has been shown to negatively impact communication participation (McAuliffe, Baylor, & Yorkston, 2017). While speech intelligibility disruption is only one facet of hypokinetic dysarthria, it is often used as a key metric of severity when measuring speech impairments in people with PD (Stipancic, Tjaden, & Wilding, 2016; Tjaden & Wilding, 2011b).

Measurement of Speech Intelligibility

Clinically, speech intelligibility is commonly used as a measurement of activity limitation for individuals with communication disorders, such as hypokinetic dysarthria (K. M. Yorkston, 1996). Speech intelligibility is often measured by having participants read words or sentences that are later transcribed by a naïve listener. Examples of such methods include the *Frenchay Dysarthria Assessment (Enderby, 1983),* the computer-based *Speech Intelligibility Test* (SIT) (K. M. Yorkston, 2010), and the overall accuracy of transcribed words, sentences, or passages by clinicians or blind listeners (Gurevich & Scamihorn, 2017; Miller et al., 2007).

Speech Intelligibility and HRQoL

Due to the communication changes associated with hypokinetic dysarthria, individuals with PD often demonstrate a significant decrease in their self-perceived communication skills and control of their communication during interpersonal interactions (Hartelius & Svensson, 1994; Miller et al., 2007; Miller, Noble, Jones, Allcock, & Burn, 2008b). The speech impairments associated with hypokinetic dysarthria (e.g., articulatory imprecision, prosodic flatness) have been linked with decreased communicative participation, which may have an adverse impact on HRQoL (McAuliffe et al., 2017; Miller, 2017; Sapir et al., 2008b).

Dysarthria is regarded as a substantial problem by people with PD, with one study identifying that 29% of participants regarded it as their greatest challenge (Hartelius & Svensson, 1994). In another study, Miller et. al. (2007) investigated the prevalence and pattern of intelligibility changes in people with PD, finding that of 125 participants, 51.2% of speakers were considered "difficult to understand" by listeners. In this study, individuals were recorded reading one of six minimally-matched lists, and these recordings were then judged by three unique listeners (Miller et al., 2007). Steps were taken to assure participant similarity (e.g.,

cognitive testing) and to avoid listener familiarity (99 different listeners were used) (Miller et al., 2007). In terms of patient perception, 38% of individuals rated challenges with speech as a major concern, and 10% identified speech challenges as their top concern, indicating that communication difficulties are viewed as a key problem among this population (Miller et al., 2007). However, when considering these results, it is important to remember that communicative participation is negatively affected by several factors. While intelligibility plays a key role, communicative participation is also impacted by an individual's emotional, cognitive and fatigue challenges (McAuliffe et al., 2017; Miller, 2017). These communicative characteristics taken as a whole have been shown to negatively impact social communication and HRQoL (Miller, 2017; Miller et al., 2008b; Sapir et al., 2008b). While PD's effect on HRQoL has been extensively investigated, few studies consider speech impairment as a key variable. Based on the limited research examining speech, this relationship and the importance of communication difficulties to individuals who have PD, additional research is needed to investigate the interactions between the changes to speech intelligibility, self-perception, cognition and motor challenges.

Communicative Participation

In order to fully capture the impact of the speech impairment associated with PD, communicative participation will be measured in order to supplement HRQoL measurements. The short form version of the *Communicative Participation Item Bank* (CPIB), a discipline-specific, patient-reported measure will be used to evaluate communicative participation, which is defined as "taking part in life situations in which knowledge, information, ideas or feelings are exchanged" (Baylor et al., 2013; Eadie et al., 2006) (see Appendix A). The CPIB evaluates how a condition, such as PD, interferes with a wide range of daily speech communication activities, using a four point scale (Baylor et al., 2013). Participants will be asked to consider how the PD produced

changes to their speech effects their day-to-day participation in communicative situations. A previous study involving the communication participation of people with total laryngectomy found that the CPIB short form moderately correlated with self-perceived acceptability of speech, indicating the CPIB short form is a valid metric of the self-perception of speech (Eadie et al., 2016).

Cognitive Characteristics

While PD occurs following the degeneration of dopaminergic neurons in the basal ganglia, additional deterioration is often observed in the prefrontal cortex, and supplementary and primary cortices (Moustafa et al., 2016). Impairment in these cortical areas, paired with basal ganglia dysfunction, leads to deficits in cognition in addition to the well-documented motor symptoms (Moustafa et al., 2016). Impaired cognition has been observed across the course of PD, with approximately 15%-25% of patients presenting with challenges in the early stages of the disease and 50-80% of people demonstrating Parkinson's Disease Dementia over the course of the disease (Kandiah et al., 2014; Rozenfeld, Annelise, Marcieli, Artur Francisco Schumacher, & Carlos Roberto Mello; Varalta et al., 2015). The characteristics of cognitive impairment vary by patient, level of education and age, but often include a decline in the one or several of the following domains:

Executive function

Executive functions are mental processes that direct cognitive, communicative and social behavior. Dysfunction in this area may occur early in the course of PD, and often includes challenges with inhibition, planning and the process of decision making, including during the formation and execution of goal-oriented behaviors (Dirnberger & Jahanshahi, 2013). A review of the available literature regarding executive dysfunction in PD was recently conducted and

indicated that people with PD present with executive function deficits across many executive aspects, including attention, working memory, visual processing, planning, initiation, awareness, and use of feedback to make real-time adjustments to behavior (Dirnberger & Jahanshahi, 2013; Vlagsma et al., 2015).

Attention

Attention is the focus and awareness of one's surrounds and the tasks at hand. It is considered one of the core areas of cognitive impairment in people with PD, though attentional deficits have been found to range in severity from minimal to moderate for less complex tasks, such as switching attention between two tasks (Kandiah et al., 2014; Muslimovic, Post, Speelman, & Schmand, 2005). Conversely, when performing more complex tasks, such as the Digit Symbol test, people with PD tend to demonstrate a more substantial impairment (Muslimovic et al., 2005). Additionally, as with other executive function abilities, attentional skills appear to decline over the course of PD (Maira Rozenfeld, Annelise, Marcieli, Artur Francisco Schumacher, & Carlos Roberto Mello, 2016). Overall, deficits in concentration and attention in PD have been estimated at 41%, even at early stages of the disease (Pfeiffer, Løkkegaard, Zoetmulder, Friberg, & Werdelin, 2014).

Memory

Several types of memory can be impacted by PD, including episodic memory (memory associated with specific events), working memory (memory that focuses on the immediate intake and manipulation of information), and immediate and delayed recall (Kandiah et al., 2014; Maira Rozenfeld et al., 2016; Rozenfeld et al.). In addition, spatial working memory has been identified to decline at a faster rate than other forms of working memory, and overall memory deficits

increase with duration of PD (Maira Rozenfeld et al., 2016) . Similar to attention impairments, deficits in memory have been estimated to occur in 41% of people with PD (Pfeiffer et al., 2014).

Visuospatial function

Visuospatial function is the visual perception of spatial relationships, and is often assessed during cognitive examinations. People with PD frequently present with deficits to their visuospatial function (Dirnberger & Jahanshahi, 2013; Maira Rozenfeld et al., 2016; Owen, Iddon, Hodges, Summers, & Robbins, 1997; Pfeiffer et al., 2014). Pfeiffer et. al. (2014) estimate that 34% present with this impairment, even at early stages of the disease. However, Muslimovic et. al. (2005) note that it is challenging to directly test these proficiencies without the influence of other cognitive and executive skills. They theorize that an independent deficit in visuospatial abilities is not present in people with PD, but rather is influenced by the other cognitive deficits that are associated in completing the task (Muslimovic et al., 2005). While this theory is of interest, it is not widely accepted, and more research is required to separate the independent role of visuospatial deficits in PD.

Additionally, a relationship between the cognitive symptoms of PD and high-level language function has been identified (Altmann & Troche, 2011), suggesting a consideration of the language abilities throughout the course of PD (McAuliffe et al., 2017). Similar to cognitive characteristics, language impairment may vary by individual. People with PD may display challenges with both production and comprehension at the complex sentence and discourse level, as well as increased difficulties with word retrieval, though it is challenging to discern these deficits from other cognitive impairments (Altmann & Troche, 2011; Miller et al., 2007; Moustafa et al., 2016). Furthermore, individuals with PD may not provide sufficient information

or content when conveying messages, which is often observed in conjunction with decreased verbal fluency (Altmann & Troche, 2011).

Measurement of Cognitive Characteristics

Cognitive changes in PD often fall across a broad spectrum, and are measured in a variety of ways, both informally (e.g., during discourse production, interview, per patient and caregiver report) and formally (e.g., standardized cognitive assessments such as the Repeatable Battery for the Assessment of Neuropsychological Status – RBANS). As PD is a unique, complex and multifaceted disease, several tools have been created and evaluated for their efficacy in assessing cognition in people with PD. In particular, The Parkinson's Disease Cognitive Rating Scale (PD-CRS) was designed to specifically address the spectrum of cognitive deficits that occur over the course of PD, including the changes associated with various cortical involvement (Pagonabarraga et al., 2008). Additionally, the Montreal Cognitive Assessment (MoCA) has been evaluated regarding its ability to accurately assess and predict the progression of cognitive impairment in people with PD (Brown et al., 2016; Hoops et al., 2009; Kandiah et al., 2014). When identifying such cognitive deficits associated with PD, fronto-subcortical involvement is addressed via examination of sustained attention, working memory, alternating and action verbal fluency, clock drawing and immediate and delayed free recall verbal memory, while posterior cortical deficits are identified via confrontation naming and clock copying (Pagonabarraga et al., 2008). Additionally, both the PD-CRS and MoCA, have been shown to be valid and reliable diagnostic tool for a heterogeneous population of cognitively impaired individuals, including those with PD (Brown et al., 2016; Kandiah et al., 2014; Pagonabarraga et al., 2008; Ruzafa-Valiente et al., 2016).

Cognition and HRQoL

The cognitive changes occurring in people with PD have a significant, negative impact on HRQoL (Altmann & Troche, 2011; Kandiah et al., 2014; Klepac, Trkulja, Relja, & Babić, 2008; Maira Rozenfeld, Annelise, Marcieli, Artur Francisco Schumacher, & Carlos Roberto Mello; Miller et al., 2006; Miller et al., 2008b). Increased cognitive abilities (e.g., attention, memory) have been associated with better self-perceived HRQoL, increased independence and communicative participation, as well as reduced levels of depression (Miller et al., 2008b). Across studies, the mixed and extensive cognitive changes associated with PD are consistently shown to have a negative impact on individual's HRQoL.

When considering specific aspects of cognition, enhanced self-perceived HRQoL has been associated with elevated skill in the domains of visual attention/memory, visuospatial function, and executive function (Klepac et al., 2008). Higher levels of executive function, such as the ability to plan, organize, self-regulate, and orient oneself, directly correlates with an individual's ability to independently complete activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (Cahn et al., 1998; Klepac et al., 2008; Lawrence, Gasson, Kane, Bucks, & Loftus, 2014). Deficits in executive functions lead to decreased capacity to complete IADLs, such as driving or cooking a meal, which have been shown to negatively impact HRQoL (Goverover, Chiaravalloti, Gaudino-Goering, Moore, & Deluca, 2009; Klepac et al., 2008). Additionally, impairment to self-awareness and self-regulation may impact the ability of people with PD to effectively administer their medications and handle personal finances (Cahn et al., 1998). Overall, this decreased ability to independently complete day to day activities has been shown to impair HRQoL (Cahn et al., 1998; Lawrence et al., 2014).

In addition to the negative impact to ADL and IADL completion, cognitive changes in PD impair attention, planning, and memory function (Duncan et al., 2014b; Maira Rozenfeld et

al., 2016; Miller et al., 2008b). Duncan and colleagues (2014) identified a negative relationship between the attention and memory deficits associated with PD and overall HRQoL. In this study, individuals experienced an average of eight non-motor symptoms, including those related to cognition, such as forgetfulness and concentration, and those relating to bodily function, such as constipation and hypersalivation (Duncan et al., 2014b). Additionally, as the disease advances, researchers found that cognitive and neuropsychiatric factors were the most predictive of HRQoL in people with PD (Duncan et al., 2014b). However, when interpreting these findings, it is important to note that symptoms such as "forgetfulness" were self-reported by participants, and the impact of medications on cognition (e.g., those prescribed for urinary urgency) is uncertain (Duncan et al., 2014b).

Health-Related Quality of Life

HRQoL, or the standard of health, comfort and happiness, is an important patient-reported metric often used for monitoring the effects and changes associated with degenerative disease. As research has shown, PD has a significant impact of overall HRQoL, and while several studies have investigated the effect, there is disagreement regarding which characteristics and which scales are the most apt predictors of HRQoL (Duncan et al., 2014b; Gómez-Esteban et al., 2007; Maira Rozenfeld et al., 2016; Martinez-Martin et al., 2011). Motor symptoms, non-motor symptoms, personal perception and family related factors have all been correlated with decreased HRQoL in people with PD (Duncan et al., 2014b; Kadastik-Eerme, Rosenthal, Paju, Muldmaa, & Taba, 2015; Spadaro, Bonanno, Di Lorenzo, Bramanti, & Marino, 2013; Visser et al., 2009). Specifically, depression, cognition, perceived autonomy and motor control have been shown to significantly impact the HRQoL and well-being in individuals with PD, though no single metric has been identified to be the strongest predictor (Gómez-Esteban et al., 2007; Kadastik-Eerme et

al., 2015; Maira Rozenfeld et al., 2016; Spadaro et al., 2013; Visser et al., 2009). While the relationship between HRQoL and many symptoms associated with PD have been researched, speech appears to seldom be considered. Hypokinetic dysarthria impacts individual's ability to efficiently communicate and negatively impacts HRQoL, yet the use of speech intelligibility as a predicting factor of HRQoL has yet to be investigated.

Measurement of HRQoL

While there are many measures designed to quantify overall HRQoL, a Movement Disorder Society Task Force was commissioned in 2011 to evaluate the various HRQoL scales and the associated psychometrics, pertaining to PD (Martinez-Martin et al., 2011). The task force assessed seventeen overall scales of HRQoL, identifying four generic scales (e.g., *EuroQoL*, *Health Related Quality of Life Questionnaire*) and five PD-specific measures (e.g., *Parkinson's Disease HRQoL-39*, *Parkinson's Disease Quality of Life Questionnaire)* that were recommended for use in people with PD (Martinez-Martin et al., 2011). Results indicated that all recommended scales demonstrated limitations of use, but that they were appropriate for administration to people with PD, were often used by researchers beyond the original developers, and had completed successful clinimetric testing (Martinez-Martin et al., 2011). Based on this information, the following PD HRQoL measures were considered for the present study: the *Parkinson's Disease Questionaire-39 (PDQ-39)* and the *Parkinson's Disease Questionnaire-8* (PDQ-8) (See Appendix B).

The PDQ-39 measures eight dimensions of ill-health, and contains 39 questions that produce a score ranging from zero (good health) to 100 (poor health) (C. Jenkinson, R. Fitzpatrick, V. Peto, R. Greenhall, & N. Hyman, 1997). It was designed to measure overall health related well-being in people with PD, as well as to determine the effect of treatment

regimens upon particular aspects of HRQoL (C. Jenkinson et al., 1997). The PDQ-8 was developed as a shorter version of the PDQ-39 in order to provide a more rapid assessment of HRQoL in PD (Crispin Jenkinson, Ray Fitzpatrick, Viv Peto, Richard Greenhall, & Nigel Hyman, 1997). Each of the eight questions on the PDQ-8 correlate with an overall domain represented on the PDQ-39 (e.g., mobility, cognition), and the short-form has been confirmed as a reliable and valid measure (Crispin Jenkinson et al., 1997; Martinez-Martin et al., 2011).

The present study is a subset of the larger Brown and Spencer (2018) investigation, where the PDQ-8 is being used as a measure of health-related HRQoL. The use of the PDQ-8 is well justified for the current study to provide insight into participant's perceived HRQoL associated with mobility, ADLs, emotional well-being, stigma, social support, cognition, communication and bodily discomfort (Crispin Jenkinson et al., 1997).

In sum, motor impairment, cognitive decline and speech impairment are prevalent consequences of PD and have been shown to impact QoL. In consideration of this evidence, the question becomes which domain exerts the most influence on self-perceived well-being. Consequently, this study addresses the following research questions:

1. **What is the determinant ability of four sets of variables – demographic/clinical, motor impairment, cognitive functioning, and speech impairment – over the primary domain of health-related quality of life in individuals with PD?**
2. **What is the determinant ability of these variables on the secondary domain of communication participation?**

It is important to understand this question when educating people with PD and developing treatment plans to support individuals with PD and their caregivers. It is predicted that speech intelligibility (as measured by monologue intelligibility and the SIT) will most significantly

predict of self-perceived HRQoL, as measured by the PDQ-8. Additionally, it is predicted that speech intelligibility, when considered with cognitive function will have the largest impact on communicative participation, as measured by the CPIB. These predictions are based on previous data suggesting that losses in communication ability in addition to motor impairment may be related to increased levels of frustration and depression, and overall decreases to HRQoL and communicative participation.

METHODS

The study was approved by the Institutional Review Board at the University of Washington. Following informed consent, participants completed background demographic and disease-related questions. Additionally, screenings regarding exclusionary criteria and cognitive status were conducted, followed by an assessment of overall motor function. A speech sample was also collected from each participant.

Participants

To be included in this study, participants needed an established diagnosis of PD with no other neurological complications (e.g., stroke, traumatic brain injury). Individuals needed to be >50 years old, and could not be diagnosed with PD previous to this age. Inclusion criteria for visual acuity was the ability to read line 20/30 at 2.3 feet from the Snellen chart. Criteria for adequate hearing thresholds were < 50 dB at 500, 1000, and 2000 Hz in at least one ear. Participants were also screened for depression using the Beck Depression Inventory II, with a score ≤ 29 required for participation. Additional participant information and disease history were collected via a guided interview (Appendix C).

A total of 27 individuals participated in this study. The age of participants ranged between 60 and 80 years (mean age 71.11 years), with more males (n=18) than females. Duration

of disease varied from 1 year to 20 years, with a mean duration of 9.06 years. Additional demographic information can be found in Table 3.

Table 3: Selected Demographic Characteristics

Characteristic	*Mean*	*Median*	*SD*	*Range*
Age (yr)	71.11	71	5.78	60-81
Disease Duration (yr)	9.06	8	4.82	1-20
Education (yr)	17.07	17	1.92	13-22

Procedure

The following procedure is a subset of a larger study conducted by Brown and Spencer (in progress).

Motor Functioning

Following guidelines of The International Parkinson and Movement Disorder Society (MDS), two researchers were trained in the use of the MDS-Unified Parkinson's Disease Rating Scale (UPDRS), Motor Examination (Part III). This exam entails a "rate what you see" assessment of the motor signs of PD, and includes 18 questions with five response options (ranging from 0-4), with higher scores indicating greater impact of PD symptoms. These data points were collected via observation of and conversation with individuals. The subsets of rating scale can be found in Appendix D.

Motor symptoms were characterized using the most recent version of the UPDRS (Goetz et al., 2007) that includes 13 Motor Examination scores and 3 self-report scores from Part II, Motor Aspects of Experiences of Daily Living. Total motor score was calculated as the mean of the following 16 sections: 2.10 tremor; 3.15. postural tremor, right hand; 3.15. postural tremor, left hand; 3.16. kinetic tremor, right hand; 3.16. kinetic tremor, left hand; 3.17. rest tremor, right upper extremity; 3.17. rest tremor, left upper extremity; 3.17. rest tremor, right lower extremity;

3.17. rest tremor, left lower extremity; 3.17. rest tremor, lip/jaw; 3.18. constancy of rest tremor; 2.12. walking and balance; 2.13. freezing; 3.10 gait; 3.11. freezing of gait; 3.12 postural stability. Overall motor functioning was also assessed using the conventional Hoehn and Yahr scale Appendix E.

Speech Sample

Speech was recorded using a high-quality, head-mounted microphone (AKG C520) with a constant mouth-to-microphone distance of two inches. The microphone was connected to a portable digital speech recorder (Zoom H6, GU-ZOOMH6). All speech samples were recorded in a quiet environment with low ambient noise.

Two tasks were used to elicit speech samples. To determine a quantifiable index of the speaker's sentence-level intelligibility, the computerized version of the Speech Intelligibility Test (K. M. Yorkston, 1996) was administered. This task includes 11 randomized and computer-generated sentences of varied length. The SIT was scored following the Yorkston (1996) protocol, and provided a percent intelligibility for each participant.

In addition, a monologue was elicited during a description task, where participants were asked to talk about their job, their family or a memorable vacation for approximately 60 seconds. Samples were segmented into speech runs, which are operationally defined as a stretch of speech bounded by a silent period or pause between words of at least 200 milliseconds (Tjaden & Wilding, 2011a). Each monologue was transcribed by the researcher in order to facilitate the identification of the first 100-word speech run that does not contain proper nouns, formulaic phrases or specialty vocabulary (Sidtis, Cameron, Bonura, & Sidtis, 2011). Silent and filled (e.g., 'ah,' or 'um') pauses were used to determine speech run boundaries and partial words were given a 0.5-word value when determining word counts (Goldman-Eisler, 1961; Litvan et al., 2011b;

Tjaden & Wilding, 2011a). This transcribed, 100-word sample was used for the second intelligibility rating, which was conducted by naïve listeners (detailed below). To ensure reliability, an independent judge reassessed 15% of the monologues, to determine if criteria for speech runs were applied consistently with the initial coding.

The intelligibility of the 100-word speech runs for each personal narrative was then scored via transcription by three different listeners, to provide a mean intelligibility rating. Intelligibility scores were determined by counting the number of correctly identified words and dividing by the total 100 words. Misspellings and homonyms were considered correct; however, synonyms or morphological variations were considered incorrect (Bunton & Keintz, 2008).

Listeners were recruited from the broader community at the University of Washington and were native English speakers without hearing loss. Listeners were provided with an orthographic transcription of each monologue sample, which was scored against the individual rubric. All speech samples were transcribed in a quiet environment with low ambient noise.

Cognitive Functioning

In order to address the differing cognitive profiles associated with PD, researchers administered the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005). The MoCA has shown good specificity in identifying the specific cognitive deficits in PD, with cut-off scores ranging between 25 and 26 (Brown et al., 2016; Hoops et al., 2009; Kandiah et al., 2014). The MoCA provided an overall score, as well as measures specific to memory, attention and visuospatial skills. The following MoCA scores align with various cognitive profiles: cognitive impairment (overall score of ≤21), mild cognitive impairment (overall score of <26), and normal cognitive function (overall score ≥26) (Nasreddine et al., 2005).

Health Related Quality of Life

HRQoL was measured using two participant-completed questionnaires. The *Parkinson's Disease Questionnaire-8 (PDQ-8)* is a disease-specific measure that was used to identify each individual's overall health-related quality of life (HRQoL) (Crispin Jenkinson et al., 1997). The PDQ-8 is short-form version of the PDQ-39 and has been identified as a reliable and valid measure of HRQoL in PD (Crispin Jenkinson et al., 1997). Additionally, the *Communicative Participation Item Bank (CPIB)* was used to describe the interference of PD with individual's expressive communicative abilities and their impact on QoL in a wide range of speaking situations (Baylor et al., 2013).

Proposed Analyses

Single and multiple linear regression models were used to determine the role of motor function, speech intelligibility and cognitive performance as a predictor of HRQoL and communicative participation. An alpha level of 0.05 was used. Correlations (Pearsons r: two-tailed) were used to assess the degree of relationship between each potential determinant –demographic/clinical, cognitive, motor and speech variables with health-related HRQoL and communication participation.

RESULTS

Reliability

To ensure reliability, an independent judge reassessed 15% of the monologues, to determine if criteria for speech runs were applied consistently with the initial coding. Five of the 27 samples were randomly selected using the random number generator function of Excel, and independently transcribed by a second trained researcher. Transcriptions were scored for accuracy, revealing a 97.8% inter-rater reliability.

Motor, Speech, and Cognitive Measures

Measures of motor function, speech intelligibility and cognitive abilities, averaged across participants, are shown in Table 4. There was a broad range of motor severity as measured by the UPDRS and Hoehn & Yahr scales, with participants ranging from mild, unilateral motor signs to marked, bilateral motor signs. Average speech intelligibility was high for both the SIT (mean 96%) and monologue (mean 94%); however, the monologue captured a broader range of intelligibility. Cognitive function, as measured by the MoCA, was distributed across severity levels, ranging from normal functioning (score of 30) to cognitive impairment (score of 16). Average performance fell in range of mild cognitive impairment.

Table 4: Measures of motor function, speech intelligibility and cognitive performance

Variables	Mean	Median	SD	Range
Motor Function				
UPDRS Score (max 32)	12.89	12.00	6.99	3-32
Hoehn & Yahr Scale (max 5)	2.67	3.00	0.77	1-4
Speech Intelligibility				
SIT (%)	95.96	96.36	2.49	89.09-100
Monologue (%)	93.59	95.00	4.78	81.33-100
Cognitive Function				
MoCA (max 30)	24.70	26.00	4.18	16-30

Note. UPDRS = Unified Parkinson's Disease Rating Scale; SIT = Sentence Intelligibility Test; MoCA = Montreal Cognitive Assessment

Predicting Health Related Quality of Life (HRQoL)

Linear regression analyses were conducted to investigate the relationship between health-related quality of life (per the PDQ-8) and motor functioning, speech functioning and cognitive functioning. Regression models were run with and without control of the demographic/clinical variables of age, sex, years of education, disease duration, and depression scores (BDI-II). Three linear regression models were significant; two of the three models suggest that motor functioning

is most predictive of HRQoL of the variables considered. A complete list of regression results can be found in Appendix F.

Motor Symptoms and HRQoL

Both measures of motor performance, the UPDRS and Hoehn and Yahr scale, were found to be predictive of performance on the measure of HRQoL (PDQ-8), but only when the demographic/clinical variables noted above were not factored into the model. The UPDRS was a significant predictor of PDQ-8 performance ($F(1,25) = 13.34$, $p < .01$), with an R^2 of 0.32. A significant regression equation was also found using the Hoehn and Yahr scale as a predictor of PDQ-8 ($F(1,25) = 7.04$, $p < .05$), with an R^2 of 0.19. Regression results can be found in Table 5. A Pearson product-moment correlation coefficient was computed to assess the nature of the relationship between the PDQ-8 and the two motor scales (see Table 6). There was a significant negative correlation between performance on the UPDRS ($r = -.590$, $p < .01$) and the Hoehn and Yahr scale ($r = -.469$, $p < .05$). Thus, scores on the PDQ-8 suggesting worse HRQoL were significantly associated with more impaired motor presentation on both the UPDRS and Hoehn and Yahr measures. A scatterplot of the correlations can be found in Appendix G.

Table 5: Motor function as a predictor of Health-Related Quality of Life

Measure	*Variable(s)*	*p-value*	*Adjusted R^2*
PDQ-8	UPDRS + Clinical/Demographics	0.068	0.241
	H&Y + Clinical/Demographics	0.174	0.139
	UPDRS	0.001*	0.322
	H&Y	0.014*	0.189

** $p < .05$*

Note. PDQ-8 = Parkinson's Disease Questionnaire- Short Form; UPDRS = Unified Parkinson's Disease Rating Scale; H&Y = Hoehn and Yahr scale

Table 6. Pearson correlation coefficients for predictor and response variables.

	Response Variables	
Predictor Variables	**PDQ-8**	**CPIB**
UPDRS	-.590**	-.338
H&Y	-.469*	-.072
MoCA	-.314	-.092
SIT	.010	.056
Monologue	.205	.609**
Age	-.336	-.214
Education	-.153	-.113
Disease Duration	-.154	-.210
BDI-II	-.123	-.146

*correlation is significant at the 0.05 level (two-tailed)
**correlation is significant at the 0.01 level (two-tailed)

Speech Intelligibility and HRQoL

The role of speech intelligibility (measured by the SIT and monologue intelligibility) as a predictor of HRQoL, with and without control of demographic/clinical variables, are shown in Table 7. Linear regression analyses revealed no significant relationships between HRQoL and speech intelligibility measures. Pearson correlations between intelligibility measures and HRQoL were not significant (see Table 6).

Table 7: Speech intelligibility as a predictor of Health-related Quality of Life

Measure	*Variable(s)*	*p-value*	*Adjusted R^2*
PDQ-8	SIT + Clinical/Demographics	0.480	-0.011
	Monologue + Clinical/Demographics	0.390	0.025
	SIT	0.961	-0.040
	Monologue	0.306	0.003

** $p < 0.05$*
Note. PDQ-8 = Parkinson's Disease Questionnaire- Short Form; SIT = Sentence Intelligibility Test

Cognition and HRQoL
A significant regression equation was found ($F(6,20) = 2.72$, $p < .05$), with an adjusted R^2 of 0.28. However, the MoCA was only a significant predictor of PDQ-8 performance when combined with the demographic/clinical variables (see Table 8). In that model, both the MoCA ($p = .009$) and age ($p = .004$) uniquely accounted for variance in the PDQ-8. The MoCA by itself, without the demographic variables, was not a significant predictor ($p = 0.11$). Pearson correlations between the MoCA and HRQoL were not significant (see Table 6).

Table 8: Cognitive function as a predictor of Health-Related Quality of Life

Measure	*Cognitive Measure*	*p-value*	*Adjusted R^2*
PDQ-8	MoCA + Clinical/Demographics	0.043*	0.284
	MoCA	0.111	0.062

** $p < 0.05$*
Note. PDQ-8 = Parkinson's Disease Questionnaire- Short Form; MoCA = Montreal Cognitive Assessment

Predicting Communication Participation
Linear regression analyses were conducted to investigate the relationship between communicative participation (per the CPIB) and motor functioning, speech functioning and cognitive functioning. Regression models were run with and without control of the

demographic/clinical variables of age, sex, years of education, disease duration, and depression scores (BDI-II). Only the linear regression model with the monologue was significant; suggesting that speech intelligibility measured at the conversation level is most predictive of communicative participation of the variables considered. A complete list of regression results can be found in Appendix D.

Motor Symptoms and Communicative Participation

The role of motor symptoms (as measured by the UPDRS and Hoehn and Yahr Scale) as a predictor of communicative participation, with and without control of the demographic/clinical variables, are shown in Table 9. Linear regression analyses revealed no significant relationships between communicative participation and motor performance measures. Pearson correlations between motor measures and communication participation were not significant (see Table 6).

Table 9: Motor function as a predictor of communicative participation

Measure	*Variable(s)*	*p-value*	*Adjusted R^2*
CPIB	UPDRS + Clinical/Demographics	0.377	0.031
	H&Y + Clinical/Demographics	0.475	-0.009
	UPDRS	0.085	0.079
	H&Y	0.720	-0.035

** $p < .05$*

Note. CPIB = Communicative Participation Item Bank; UPDRS = Unified Parkinson's Disease Rating Scale; H&Y = Hoehn and Yahr scale

Speech Intelligibility and Communicative Participation

Analysis of speech intelligibility (measured by the SIT and monologue intelligibility) as a predictor of communicative participation is shown in Table 10. Monologue intelligibility was found to be predictive of performance on the measure of communicative participation (CPIB), both with and without control of demographic/clinical variables. When clinical/demographic variables were factored into the regression equation, the monologue was a significant predictor

of the CPIB ($F(1,25) = 3.91, p < 0.001$) with an R^2 of 0.40. It was also a significant predictor of CPIB performance when considered in the more parsimonious model without the demographic/clinical variables ($F(1,25) = 14.73, p < 0.001$), with an R^2 of 0.35. A Pearson product-moment correlation coefficient was computed to assess the nature of the relationship between the CPIB and the two measures of speech intelligibility (see Table 6). There was a significant negative correlation between monologue intelligibility and the CPIB ($r = 0.609, p < 0.001$). Thus, scores on the CPIB suggesting worse communicative participation were significantly associated with decreased monologue speech intelligibility. A scatterplot of the correlation can be found in Appendix G. The correlation between the CPIB and SIT was not significant.

Table 10: Speech intelligibility as a predictor of communicative participation

Measure	*Variable(s)*	*p-value*	*Adjusted R^2*
CPIB	SIT & Clinical Demographics	0.441	0.005
	Monologue & Clinical Demographics	0.010*	0.402
	SIT	0.782	-0.040
	Monologue	0.001**	0.346

** $p < 0.05$*
*** $p < .01$*
Note. CPIB = Communicative Participation Item Bank; SIT = Speech Intelligibility Test

Cognition and Communicative Participation

The role of cognition (measured by the MoCA) as a predictor of communicative participation, with and without control of the demographic/clinical variables, is shown in Table 11. Linear regression analyses revealed no determinant ability of communicative participation by the MoCA. Pearson correlations between the cognitive measure and communicative participation were not significant (see Table 6).

Table 11: Speech intelligibility as a predictor of communicative participation

Measure	*Cognitive Measure*	*p-value*	*Adjusted R^2*
CPIB	MoCA & Clinical Demographics	0.450	0.001
	MoCA	0.647	-0.032

** $p < 0.05$*
Note. CPIB = Communicative Participation Item Bank; MoCA = Montreal Cognitive Assessment

DISCUSSION

The goal of the present study was to evaluate factors influencing health-related HRQoL in people with PD from three primary domains: motor impairment, cognitive functioning, and speech impairment. Clinical measures of severity across these domains were considered as predictors of HRQoL and communication participation for individuals with PD. It was predicted that speech intelligibility (as measured by monologue intelligibility and the SIT) would be the most significant predictor of self-perceived HRQoL, as measured by the PDQ-8. Additionally, it was predicted that speech intelligibility combined with cognitive function will have the largest impact on communicative participation, as measured by the CPIB.

Predicting HRQoL

Findings from this study revealed several predictive relationships when considering HRQoL as measured by the PDQ-8. Based on our sample, HRQoL was significantly predicted by the severity of motor symptoms and, to a lesser extent, cognitive functioning. Speech intelligibility was not found to be predictive of HRQoL.

The PDQ-8 measures HRQoL across eight domains of health and illness, including mobility, cognition, emotional well-being, communication and bodily discomfort. The results of this study indicate that severity of motor symptoms most strongly predicts self-perceived HRQoL, across two measures of motor functioning—the UPDRS and the Hoehn and Yahr scale.

An elevated severity score on the UPDRS, suggesting an increase in tremor, slowness, rigidity, etc., was associated with reduced health-related quality of life. Similarly, higher scores on the Hoehn and Yahr scale, associated with more distributed and severe symptoms of PD, were also associated with reduced health-related quality of life.

These results are consistent with previous research, indicating that physical manifestations of the motor impairment in people with PD (tremor, rigidity, akinesia/bradykinesia and postural instability) negatively impact HRQoL (Karlsen et al., 1999; Schrag et al., 2000). In particular, the predictive relationship between motor impairment and the PDQ-8 is congruent with research performed by Gómez-Esteban et. al. (2007), which identified a similar relationship using the UPDRS and the Parkinson's Disease Questionnaire-39. The authors looked both globally at motor impairment (total severity of motor symptoms) as well as individual symptoms, and identified that gait disturbance and postural instability negatively impact mobility which decreases overall HRQoL (Gómez-Esteban et al., 2007).

The results of the present study, in tandem with previous research, indicate that motor severity measures may be used clinically to predict HRQoL. By extension, medications and compensations for motor impairment may have the greatest potential to improve quality of life. Overall, based on the predictive relationship observed between severity of motor symptoms and results of self-perceived quality of life, motor symptoms appear to have a stronger influence on perception of HRQoL than cognitive and speech impairment.

In addition to measures of motor functioning, the MoCA was found to be a significant predictor of HRQoL, but only with the influence of the confounding variable of age. However, the MoCA did not significantly predict performance on the PDQ-8 when measured alone, indicating that a predictive relationship does not exist between the two without the influence of

other factors. The relationship between cognition and HRQoL only surfaced with the influence of age; the MoCA is known to have pronounced age effects, particularly when considered with an individual's level of education (Freitas, Simões, Alves, & Santana, 2012).

Our hypothesis that changes to speech intelligibility, considered in tandem with cognitive differences, would best predict HRQoL was based on literature suggesting individuals with PD often demonstrate a significant self-perceived decrease communication skills and that speech challenges are of major concern (Hartelius & Svensson, 1994; Miller et al., 2007; Miller et al., 2008b). However, based on the present sample, speech intelligibility was not predictive of HRQoL.

Predicting Communicative Participation

Findings from this study revealed several predictive relationships when considering determinants of communicative participation as measured by the CPIB. Monologue intelligibility was observed to significantly predict performance on the CPIB, both with and without controlling for demographic/clinical variables. Motor severity measures, the SIT, and cognitive variables were not found to be predictive of communicative participation as measured by the CPIB.

The results of this study indicate that monologue intelligibility most strongly predicts self-perceived communicative participation as measured by the CPIB. Specifically, decreased conversational intelligibility negatively impacts communicative participation, both when measured alone and with the influence of demographic/clinical variables. Interestingly, while monologue intelligibility was a strong predictor of communicative participation, the additional measure of intelligibility, the SIT, had no relationship with the CPIB. It is possible that the SIT inflated the participants' intelligibility, due to the improved understandability and naturalness that often occurs when individuals with PD are externally cued by a reading task (Sidtis et al.,

2011; Weir-Mayta, Spencer, K. A., Eadie, T. L., Yorkston, K., Savaglio, S., & Woollcott, C., 2017).

The predictive relationship between monologue intelligibility and communicative participation illustrates the marked impact of the dysarthria on engagement in life activities. It is well documented that the communication changes associated with hypokinetic dysarthria cause individuals with PD to demonstrate a pronounced decrease in their self-perceived communication skills (Hartelius & Svensson, 1994; Miller et al., 2007; Miller et al., 2008b), but the specific relationship between intelligibility and communicative participation has not been sufficiently studied (McAuliffe et al., 2017; Miller, 2017; K. Yorkston, Baylor, & Mach, 2017). The clinical implications of this relationship are considerable. While monologue intelligibility was a strong determinant of communication participation, sentence-level intelligibility elicited via reading was not. Therefore, clinicians (and researchers) should consider measurement of intelligibility via monologue whenever possible, as it appears to be the more sensitive clinical tool, particularly when attempting to anticipate impact to communication participation.

It is perhaps surprising that the MoCA was not predictive of communication participation as cognition is inherent to communication. That said, the MoCA may not have been sufficiently sensitive or comprehensive to fully assess the cognitive abilities of persons in this study (Kletzel et al., 2017; Nasreddine et al., 2005). Previous research has noted that increasing the difficulty of certain items on the MoCA (e.g., orientation information) may increase its sensitivity for this population (Kletzel et al., 2017).

The significant relationship between monologue intelligibility and communicative participation aligns with the predictions made in this study, though it was expected to be observed with both monologue intelligibility and the SIT. Additionally, it was proposed that

cognition would play a significant role in communicative participation. However, the absence of a relationship between the CPIB and cognitive influence does not support the hypothesis.

Future Research

While this study sheds light on the role of speech intelligibility as a predictor of communicative participation, additional research should focus on investigating the overall role of communication as a predictor of HRQoL. One potential avenue would be to look more comprehensively at the role of communication, as mediated by cognitive ability, as a predictor of HRQoL. This study used the MoCA as a cognitive screener, though an in-depth assessment cognitive abilities may provide better insight regarding cognition as a predictor of HRQoL.

An additional area that may be of interest would be to consider how HRQoL in people with PD and the communicative abilities can be monitored throughout assessment and treatment, and then used as a predictive metric. Ideally, these measures would be used early on in the disease process. Furthermore, as PD is a complex multidimensional disorder (Gopalakrishna & Alexander, 2015), it may be of interest to consider the influence of other symptoms (e.g., sleep disorder, autonomic dysfunction) in relation to changes in speech intelligibility, and how the combination affects overall HRQoL.

Finally, future studies would benefit from a larger and more diverse participant pool, across a wide spectrum of severity, allowing for the possibility to generalize to the greater population.

Limitations

These conclusions should be viewed as preliminary. One limitation is sample size, as only 27 persons with PD participated in this study, which reduces the ability of these results to be generalized to the greater population of people with PD. Another limitation is the demographics

of the participant population, as it is not necessarily representative of the greater population in terms of gender and education level. As noted previously, this study may have been limited by the use of a cognitive screening tool as opposed to an in-depth assessment of cognitive skills.

Conclusion

The goal of this study was to examine factors influencing HRQoL and communicative participation according to three primary domains: motor impairment, cognitive functioning, and speech impairment. Results revealed meaningful, significant predictive relationships when considering these metrics. Specifically, HRQoL (as measured by the PDQ-8) was predicted by the severity of motor symptoms, and communication participation (as measured by the CPIB) was predicted by monologue intelligibility. Overall, these results indicate a combination of speech and motor deficits may be the best predictor of overall quality of life. Improved awareness and understanding of the relationship between changes to communicative participation and HRQoL will encourage a more complete and comprehensive approach to patient care. Future studies in this area should focus on the comprehensive communication of people with PD, including the increased role of cognition, as a predictor of HRQoL with a larger and more diverse participant pool.

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Appendices

Appendix A. Communication Participation Item Bank (Baylor et al., 2013)

The Communicative Participation Item Bank – General Short Form

Instructions:
The following questions describe a variety of situations in which you might need to speak to others. For each question, please mark how much your condition interferes with your participation in that situation. By "condition" we mean ALL issues that may affect how you communicate in these situations including speech conditions, any other health conditions, or features of the environment. If your speech varies, think about an AVERAGE day for your speech – not your best or your worst days.

	Not at all (3)	A little (2)	Quite a bit (1)	Very much (0)
1. Does your condition interfere with... **...talking with people you know?**	○	○	○	○
2. Does your condition interfere with... **...communicating when you need to say something quickly?**	○	○	○	○
3. Does your condition interfere with... **...talking with people you do NOT know?**	○	○	○	○
4. Does your condition interfere with... **...communicating when you are out in your community (e.g. errands; appointments)?**	○	○	○	○
5. Does your condition interfere with... **...asking questions in a conversation?**	○	○	○	○
6. Does your condition interfere with... **...communicating in a small group of people?**	○	○	○	○
7. Does your condition interfere with... **...having a long conversation with someone you know about a book, movie, show or sports event?**	○	○	○	○
8. Does your condition interfere with... **... giving someone DETAILED information?**	○	○	○	○
9. Does your condition interfere with... **...getting your turn in a fast-moving conversation?**	○	○	○	○
10. Does your condition interfere with... **...trying to persuade a friend or family member to see a different point of view?**	○	○	○	○

Appendix B. Parkinson's Disease Questionnaire – Short Form (Crispin Jenkinson et al., 1997)

Many people with Parkinson's Disease report problems from time to time. We are interested in how you have been in your general health over the last four weeks.

Please complete this form by placing a tick or check mark in one box on each line.

Over the past four weeks have you, because of your Parkinson's Disease...	Never	Occasionally	Sometimes	Often	Always or cannot do at all
(7)...had difficulty getting around in public places?	☐	☐	☐	☐	☐
(12)...had difficulty dressing yourself?	☐	☐	☐	☐	☐
(17)...felt depressed?	☐	☐	☐	☐	☐
(27)...had problems with close relationships?	☐	☐	☐	☐	☐
(31)...had problems with concentration?	☐	☐	☐	☐	☐
(35)...felt unable to communicate properly?	☐	☐	☐	☐	☐
(37)...had painful muscle cramps and pains?	☐	☐	☐	☐	☐
(25) Over the **past four weeks** have you felt embarrassed by having Parkinson's Disease?	☐	☐	☐	☐	☐

Appendix C. Interview Questionnaire

1. Is English your first language?
2. When were you officially diagnosed with PD?
3. What were your initial motor symptoms? When did they begin? Were the symptoms more obvious on one side versus the other?
4. Do you have/have you ever had deep brain stimulation?
5. Have you ever had a stroke, a traumatic brain injury, or any other neurologic disease or condition beyond PD?
6. Did you have any speech difficulty before you were diagnosed with PD? Did you stutter?
7. Have you noticed any changes in your speech related to the Parkinson's disease? Please describe.
8. Have you noticed any changes to your thinking or memory since your diagnosis?
9. Are you currently receiving cognitive or speech therapy?
10. Are you experiencing difficulty managing the use of alcohol or drugs? ([If yes] May I give you information about the local AA/NA group for help?)
11. Other changes you're experiencing from PD that we haven't covered?
12. Please list the medications you are currently taking

Appendix D. Relevant sections of the MDS-Unified Parkinson's Disease Rating Scale III (Goetz, 2007).

2.10 TREMOR Over the past week, have you usually had shaking or tremor? 0: Normal: Not at all. I have no shaking or tremor. 1: Slight: Shaking or tremor occurs but does not cause problems with any activities. 2: Mild: Shaking or tremor causes problems with only a few activities. 3: Moderate: Shaking or tremor causes problems with many of my daily activities. 4: Severe: Shaking or tremor causes problems with most or all activities.	☐

	SCORE
2.12 WALKING AND BALANCE Over the past week, have you usually had problems with balance and walking? 0: Normal: Not at all (no problems). 1: Slight: I am slightly slow or may drag a leg. I never use a walking aid. 2: Mild: I occasionally use a walking aid, but I do not need any help from another person. 3: Moderate: I usually use a walking aid (cane, walker) to walk safely without falling. However, I do not usually need the support of another person. 4: Severe: I usually use the support of another person to walk safely without falling.	☐
2.13 FREEZING Over the past week, on your usual day when walking, do you suddenly stop or freeze as if your feet are stuck to the floor. 0: Normal: Not at all (no problems). 1: Slight: I briefly freeze but I can easily start walking again. I do not need help from someone else or a walking aid (cane or walker) because of freezing. 2: Mild: I freeze and have trouble starting to walk again, but I do not need someone's help or a walking aid (cane or walker) because of freezing. 3: Moderate: When I freeze I have a lot of trouble starting to walk again and, because of freezing, I sometimes need to use a walking aid or need someone else's help. 4: Severe: Because of freezing, most or all of the time, I need to use a walking aid or someone's help.	☐

3.10 GAIT

Instructions to examiner: Testing gait is best performed by having the patient walking away from and towards the examiner so that both right and left sides of the body can be easily observed simultaneously. The patient should walk at least 10 meters (30 feet), then turn around and return to the examiner. This item measures multiple behaviors: stride amplitude, stride speed, height of foot lift, heel strike during walking, turning, and arm swing, but not freezing. Assess also for "freezing of gait" (next item 3.11) while patient is walking. Observe posture for item 3.13.

0: Normal:	No problems.
1: Slight:	Independent walking with minor gait impairment.
2: Mild:	Independent walking but with substantial gait impairment.
3: Moderate:	Requires an assistance device for safe walking (walking stick, walker) but not a person.
4: Severe:	Cannot walk at all or only with another person's assistance.

☐

3.11 FREEZING OF GAIT — **SCORE**

Instructions to examiner: While assessing gait, also assess for the presence of any gait freezing episodes. Observe for start hesitation and stuttering movements especially when turning and reaching the end of the task. To the extent that safety permits, patients may NOT use sensory tricks during the assessment.

0: Normal:	No freezing.
1: Slight:	Freezes on starting, turning or walking through doorway with a single halt during any of these events, but then continues smoothly without freezing during straight walking.
2: Mild:	Freezes on starting, turning or walking through doorway with more than one halt during any of these activities, but continues smoothly without freezing during straight walking.
3: Moderate:	Freezes once during straight walking.
4: Severe:	Freezes multiple times during straight walking.

☐

3.12 POSTURAL STABILITY

Instructions to examiner: The test examines the response to sudden body displacement produced by a quick, forceful pull on the shoulders while the patient is standing erect with eyes open and feet comfortably apart and parallel to each other. Test retropulsion. Stand behind the patient and instruct the patient on what is about to happen. Explain that s/he is allowed to take a step backwards to avoid falling. There should be a solid wall behind the examiner, at least 1-2 meters away to allow for the observation of the number of retropulsive steps. The first pull is an instructional demonstration and is purposely milder and not rated. The second time the shoulders are pulled briskly and forcefully towards the examiner with enough force to displace the center of gravity so that patient MUST take a step backwards. The examiner needs to be ready to catch the patient, but must stand sufficiently back so as to allow enough room for the patient to take several steps to recover independently. Do not allow the patient to flex the body abnormally forward in anticipation of the pull. Observe for the number of steps backwards or falling. Up to and including two steps for recovery is considered normal, so abnormal ratings begin with three steps. If the patient fails to understand the test, the examiner can repeat the test so that the rating is based on an assessment that the examiner feels reflects the patient's limitations rather than misunderstanding or lack of preparedness. Observe standing posture for item 3.13

0: Normal:	No problems: Recovers with one or two steps.
1: Slight:	3-5 steps, but subject recovers unaided.
2: Mild:	More than 5 steps, but subject recovers unaided.
3: Moderate:	Stands safely, but with absence of postural response; falls if not caught by examiner.
4: Severe:	Very unstable, tends to lose balance spontaneously or with just a gentle pull on the shoulders.

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3.15 POSTURAL TREMOR OF THE HANDS

Instructions to examiner: All tremor, including re-emergent rest tremor, that is present in this posture is to be included in this rating. Rate each hand separately. Rate the highest amplitude seen. Instruct the patient to stretch the arms out in front of the body with palms down. The wrist should be straight and the fingers comfortably separated so that they do not touch each other. Observe this posture for 10 seconds.

0: Normal:	No tremor.
1: Slight:	Tremor is present but less than 1 cm in amplitude.
2: Mild:	Tremor is at least 1 but less than 3 cm in amplitude.
3: Moderate:	Tremor is at least 3 but less than 10 cm in amplitude.
4: Severe:	Tremor is at least 10 cm in amplitude.

☐ R

☐ L

3.16 KINETIC TREMOR OF THE HANDS

SCORE

Instructions to examiner: This is tested by the finger-to-nose maneuver. With the arm starting from the outstretched position, have the patient perform at least three finger-to-nose maneuvers with each hand reaching as far as possible to touch the examiner's finger. The finger-to-nose maneuver should be performed slowly enough not to hide any tremor that could occur with very fast arm movements. Repeat with the other hand, rating each hand separately. The tremor can be present throughout the movement or as the tremor reaches either target (nose or finger). Rate the highest amplitude seen.

0: Normal:	No tremor.
1: Slight:	Tremor is present but less than 1 cm in amplitude.
2: Mild:	Tremor is at least 1 but less than 3 cm in amplitude.
3: Moderate:	Tremor is at least 3 but less than 10 cm in amplitude.
4: Severe:	Tremor is at least 10 cm in amplitude.

☐ R

☐ L

3.17 REST TREMOR AMPLITUDE

Instructions to examiner: This and the next item have been placed purposefully at the end of the examination to allow the rater to gather observations on rest tremor that may appear at any time during the exam, including when quietly sitting, during walking and during activities when some body parts are moving but others are at rest. Score the maximum amplitude that is seen at any time as the final score. Rate only the amplitude and not the persistence or the intermittency of the tremor.
As part of this rating, the patient should sit quietly in a chair with the hands placed on the arms of the chair (not in the lap) and the feet comfortably supported on the floor for 10 seconds with no other directives. Rest tremor is assessed separately for all four limbs and also for the lip/jaw. Rate only the maximum amplitude that is seen at any time as the final rating.

Extremity ratings

0: Normal:	No tremor.
1: Slight:	≤ 1 cm in maximal amplitude.
2: Mild:	> 1 cm but < 3 cm in maximal amplitude.
3: Moderate:	3 - 10 cm in maximal amplitude.
4: Severe:	> 10 cm in maximal amplitude.

☐ RUE

☐ LUE

☐ RLE

☐ LLE

Lip/Jaw ratings

0: Normal:	No tremor.
1: Slight:	≤ 1 cm in maximal amplitude.
2: Mild:	> 1 cm but ≤ 2 cm in maximal amplitude.
3: Moderate:	> 2 cm but ≤ 3 cm in maximal amplitude.
4: Severe:	> 3 cm in maximal amplitude.

☐ Lip/Jaw

3.18 CONSTANCY OF REST TREMOR	SCORE
Instructions to examiner: This item receives one rating for all rest tremor and focuses on the constancy of rest tremor during the examination period when different body parts are variously at rest. It is rated purposefully at the end of the examination so that several minutes of information can be coalesced into the rating. 0: Normal: No tremor. 1: Slight: Tremor at rest is present ≤ 25% of the entire examination period. 2: Mild: Tremor at rest is present 26-50% of the entire examination period. 3: Moderate: Tremor at rest is present 51-75% of the entire examination period. 4: Severe: Tremor at rest is present > 75% of the entire examination period.	☐

Appendix E. Hoehn and Yahr (2004) Stages

HOEHN AND YAHR STAGE	
0: Asymptomatic. 1: Unilateral involvement only. 2: Bilateral involvement without impairment of balance. 3: Mild to moderate involvement; some postural instability but physically independent; needs assistance to recover from pull test. 4: Severe disability; still able to walk or stand unassisted. 5: Wheelchair bound or bedridden unless aided.	☐

Appendix F. Complete results of statistical analysis

Linear regression between CPIB and MoCA + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	67.1224	26.1404	2.568	0.0184*
MoCA	-0.2245	0.4482	-0.501	0.6219
Age	-0.3891	0.2929	-1.328	0.1991
Sex	-5.6029	3.5151	-1.594	0.1266
Years of Ed	-0.4020	1.0010	-0.402	0.6922
Disease Duration	-0.1092	0.3078	-0.355	0.7265
BDI-2	-0.6361	0.4619	-1.377	0.1837
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-12.5298	-4.2094	0.8104	3.3562	12.8029
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
7.003 on 20df	0.2315	0.0009092	1.004 on 6df & 20df	0.4501

Linear regression between CPIB and UPDRS + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	53.69538	25.68550	2.090	0.0495*
UPDRS	-0.20607	0.22076	-0.933	0.3617
Age	-0.22804	0.27798	-0.820	0.4217
Sex	-5.47571	3.39450	-1.613	0.1224
Years of Ed	-0.49904	0.80716	-0.618	0.5434
Disease Duration	-0.07843	0.30534	-0.257	0.7999
BDI-2	-0.58944	0.45071	-1.308	0.2058
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-13.3098	-3.8828	0.9163	3.4749	12.5684
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
6.898 on 20df	0.2543	0.03061	1.137 on 6df & 20df	0.3774

Linear regression between CPIB and Hahn & Yahr + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	64.0762	25.4890	2.514	0.0206*
Hahn & Yahr	0.5063	2.0947	0.242	0.8115
Age	-0.3588	0.3008	-1.193	0.2469
Sex	-6.1757	3.4205	-1.806	0.0861
Years of Ed	-0.7573	0.8109	-0.934	0.3615
Disease Duration	-0.1027	0.3122	-0.329	0.7456
BDI-2	-0.5880	0.4640	-1.267	0.2196
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-11.566	-4.783	1.109	4.183	12.674
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
7.036 on 20df	0.2241	-0.008681	0.9627 on 6df & 20df	0.4747

Linear regression between CPIB and SIT + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	29.5760	62.2571	0.475	0.6399
SIT	0.3553	0.6219	0.571	0.5741
Age	-0.2995	0.2652	-1.129	0.2723
Sex	-6.0291	3.3774	-1.785	0.0894
Years of Ed	-0.8590	0.8252	-1.041	0.3103
Disease Duration	-0.1217	0.3074	-0.396	0.6964
BDI-2	-0.6691	0.4707	-1.422	0.1705
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-12.4068	-5.0483	0.8432	4.3451	11.8778
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
6.989 on 20df	0.2343	-0.004619	1.02 on 6df & 20df	0.4407

Linear regression between CPIB and Monologue + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	-19.5045	28.9541	-0.674	0.50825
Monologue	0.8526	0.2293	3.719	0.00136**
Age	-0.3014	0.2030	-1.484	0.15329
Sex	-3.9357	2.6797	-1.469	0.15747
Years of Ed	-0.8988	0.6100	-1.473	0.15620
Disease Duration	-0.1592	0.2383	-0.668	0.51179
BDI-2	-0.2794	0.4644	-0.767	0.45213
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-9.422	-3.327	-0.877	2.685	9.266
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
5.418 on 20df	0.54	0.402	3.913 on 6df & 20df	0.009521

Linear regression between PDQ and MoCA + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	73.62426	14.31976	5.141	4.97 e-05***
MoCA	-0.70736	0.24554	-2.881	0.00924**
Age	-0.52579	0.16046	-3.277	0.00377**
Sex	-1.35668	1.92558	-0.705	0.48921
Years of Ed	0.49323	0.54834	0.899	0.37909
Disease Duration	0.04158	0.16860	0.247	0.80771
BDI-2	-0.43112	0.25303	-1.704	0.10390
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-6.2388	-1.8488	0.0484	1.3921	6.9907
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
8.836 on 20df	0.449	0.2836	2.716 on 6df & 20df	0.04279

Linear regression between PDQ and UPDRS + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	44.82426	14.70866	3.047	0.00636**
UPDRS	-0.32699	0.12642	-2.587	0.01763*
Age	-0.16815	0.15918	-1.056	0.30340
Sex	-1.90422	1.94384	-0.980	0.33898
Years of Ed	-0.14640	0.46221	-0.317	0.75473
Disease Duration	0.08393	0.17485	0.480	0.63645
BDI-2	-0.30626	0.25810	-1.187	0.24929
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-8.6960	-2.5899	-0.1104	2.9310	5.3371
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
3.95 on 20df	0.4157	0.2405	2.372 on 6df & 20df	0.06796

Linear regression between PDQ and Hahn & Yahr + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	50.4017	15.2381	3.308	0.00351**
Hahn & Yahr	-2.3545	1.2523	-1.880	0.07473
Age	-0.1570	0.1799	-0.873	0.39305
Sex	-2.4324	2.0449	-1.190	0.24817
Years of Ed	-0.2775	0.4848	-0.572	0.57348
Disease Duration	-0.0203	0.1866	-0.109	0.91445
BDI-2	-0.4008	0.2774	-1.445	0.16799
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-9.9693	-2.4310	0.1297	2.6926	6.5882
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.206 on 20df	0.3374	0.1386	1.697 on 6df & 20df	0.1735

Linear regression between PDQ and SIT + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	49.79720	40.58846	1.227	0.2341
SIT	0.9468	0.40544	0.234	0.8177
Age	-0.31357	0.17293	-0.813	0.0848
Sex	-2.85261	2.20187	-1.296	0.2099
Years of Ed	-0.52427	0.53796	-0.975	0.3414
Disease Duration	0.02643	0.20044	0.132	0.8964
BDI-2	-0.34612	0.30686	-1.128	0.2727
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-9.1685	-3.0807	0.9702	2.6062	6.6264
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.557 on 20df	0.2224	-0.01086	0.9534 on 6df & 20df	0.4804

Linear regression between PDQ and Monologue + Demographics				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	42.27457	23.91335	1.768	0.0923
Monologue	0.16832	0.18934	0.894	0.3818
Age	-0.31560	0.16768	-1.882	0.0744
Sex	-2.44051	2.21319	-1.103	0.2832
Years of Ed	-0.52224	0.50382	-1.037	0.3123
Disease Duration	0.01955	0.19685	0.099	0.9219
BDI-2	-0.26428	0.30094	-0.878	0.3903
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-8.2838	-2.9566	0.5998	2.5583	6.1019
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.474 on 20df	0.2503	0.02535	1.113 on 6df & 20df	0.3898

Linear regression between CPIB and MoCA				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	20.9313	8.2074	2.550	0.0173*
MoCA	-0.1516	0.3276	-0.463	0.6474
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-13.747	-5.989	1.315	4.405	12.618
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
7.114 on 25df	0.008499	-0.03116	0.2143 on 6df & 20df	0.6474

Linear regression between CPIB and UPDRS				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	21.464	2.713	7.910	2.89e-08***
UPDRS	-0.332	0.185	-1.794	0.0849
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-15.8042	-5.1503	0.5238	4.1877	12.1837
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
6.725 on 25df	0.1141	0.07863	3.219 on 1df & 25df	0.0849

Linear regression between CPIB and Hahn & Yahr				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	18.9074	4.9445	3.824	0.000778***
H&Y	-0.6458	1.7814	-0.363	0.719998
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-13.616	-6.293	1.384	4.707	11.384
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
7.126 on 25df	0.00523	-0.03456	0.1314 on 1df & 25df	0.72

Linear regression between CPIB and SIT				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	2.3985	52.9311	0.045	0.964
SIT	0.1541	0.5514	0.279	0.782
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-13.387	-5.407	1.613	4.192	11.593
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
7.133 on 25df	0.003114	-0.03676	0.07809 on 1df & 25df	0.7822

Linear regression between CPIB and Monologue				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	-64.7420	21.3753	-3.079	0.005634**
Monologue	0.8754	0.2281	3.838	0.000751***
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-8.0033	-4.9154	-0.2922	2.1213	13.0479
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
5.667 on 25df	0.3707	0.3456	14.73 on 1df & 25df	0.0007506

Linear regression between PDQ and MoCA				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	31.4359	5.0629	6.209	1.71q-06***
MoCA	-0.3340	0.2021	-1.653	0.111
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-8.4202	-2.9183	-0.4138	3.4138	7.5837
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.388 on 25df	0.09851	0.06245	2.732	0.1109

Linear regression between PDQ and UPDRS				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	28.0204	1.5059	18.606	3.69e-16***
UPDRS	-0.3751	0.1027	-3.653	0.0012**
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-6.1435	-2.3938	-0.1447	3.2305	6.9819
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
3.732 on 25df	0.348	0.3219	13.34 on 1 and 25df	0.001201

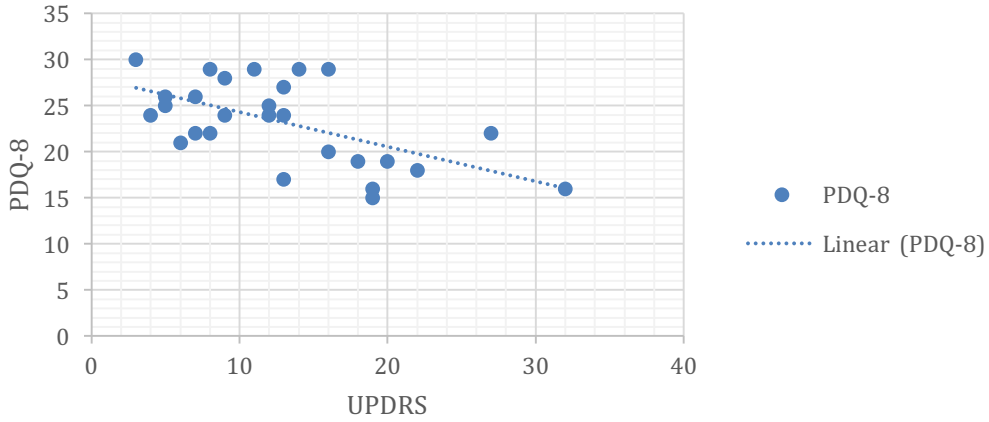
Linear regression between PDQ and Hahn & Yahr				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	30.407	2.833	10.733	7.54e-11***
H&Y	-2.708	1.021	-2.653	0.0136*
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-7.9907	-2.6366	-0.2824	3.8634	6.7176
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.083 on 25df	0.2197	0.1885	7.041 on 1 and 25df	0.01365

Linear regression between PDQ and SIT				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	21.47218	34.29486	0.626	0.537
SIT	0.01785	0.35727	0.050	0.961
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-8.160	-3.692	0.840	3.316	6.840
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.622 on 25df	9.985e-05	-0.0399	0.002497 on 1 and 25df	0.9605

Linear regression between PDQ and Monologue				
Coefficients				
Variable	*Estimate*	*Standard Error*	*T value*	*Pr(>|t|)*
(Intercept)	5.3829	17.0639	0.315	0.755
Monologue	0.1902	0.1821	1.045	0.306
Residuals				
Minimum	*1st Quartile*	*Median*	*3rd Quartile*	*Maximum*
-7.8960	-3.3508	0.6746	3.6884	8.3865
Additional Data				
Residual Standard Error	*Multiple R-squared*	*Adjusted R-squared*	*F-statistic*	*P-value*
4.545 on 25df	0.04182	0.003497	1.091 on 1 and 25df	0.3062

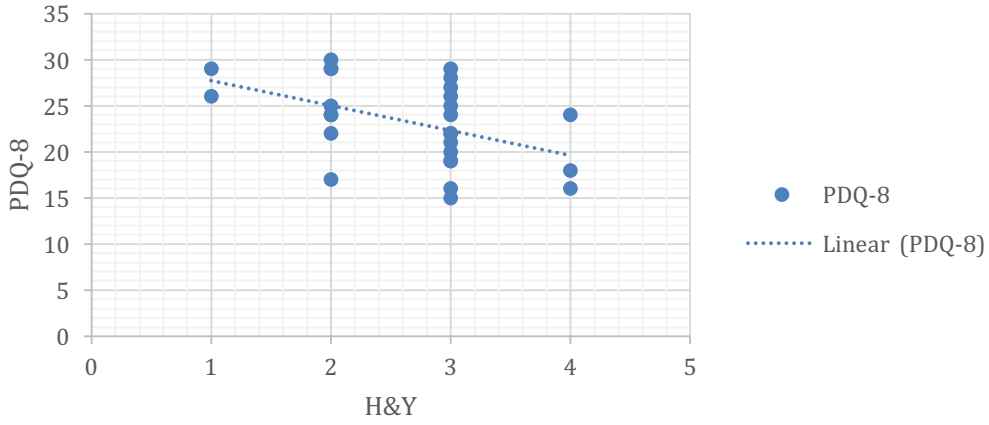
Appendix G. Scatterplots of significant determinants of health-related quality of life and communication participation.

Figure 1: Correlation between motor severity measure and Health-Related Quality of Life



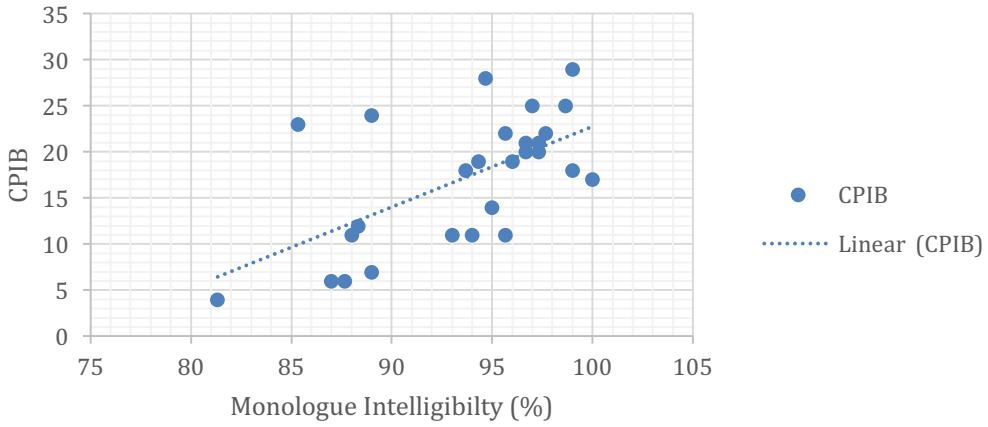
r = -0.590; p = 0.001
Note. PDQ-8 = Parkinson's Disease Questionnaire- Short Form; UPDRS = Unified Parkinson's Disease Rating Scale

Figure 2: Correlation between motor severity measure and Health-Related Quality of Life



r = -0.469; p=0.014
Note. PDQ-8 = Parkinson's Disease Questionnaire- Short Form; UPDRS = Unified Parkinson's Disease Rating Scale; H&Y = Hoehn and Yahr scale

Figure 3: Correlation between monologue intelligibility and communicative participation



r = 0.609; p = 0.001
Note. CPIB = Communicative Participation Item Bank

References

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