EARLY-STAGE PARKINSON'S DISEASE INFLUENCES THE COORDINATION OF TRANSITIONAL AND NON-TRANSITIONAL OVERGROUND AMBULATION

by

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Non-steady-state locomotion involving complex ambulation tasks, such as changing directions, walking over an obstacle, or moving from one terrain to another, are frequently presented in everyday life. These motor tasks that occur at home and within the community are often difficult to execute for individuals with neuromuscular conditions, where reduced dexterity and cognition hinder task planning and performance. Parkinson's disease is characterized by restrictive gait patterns, such as tremors, increased limb stiffness, and impaired balance, which typically are exacerbated when completing complex tasks. Early diagnosis is critical for individuals with Parkinson's disease to begin exercise programs and other therapies that can assist with slowing the progression of the disease. Optical gait analysis is a research tool that can be used to quantify kinematic differences within 1 mm of precision of those with motor impairments compared to healthy individuals. It also has the potential to be used in clinical settings to assist with the diagnosis of Parkinson's disease for people still in the early stages of the disease when symptoms are not yet outwardly perceptible. My research analyzed the joint angles and joint ranges of motion of the hips, knees, and ankles of individuals with early-stage Parkinson's disease

compared to a healthy control group as they walked continuously on a terrain circuit that integrated a level ground walkway, staircase, turn, and ramp. It was hypothesized that since individuals with Parkinson’s disease are challenged by internal regulation of their mechanics, these complex tasks and corresponding analysis would reveal inherent kinematic differences during specific terrains or transitions. Additionally, we hypothesized that of the events analyzed, transitional events (i.e., moving from one terrain to another) would be more prone to cause deviations from control subjects due to the higher neuromechanical demand required. One stride was analyzed during each transitional or non-transitional event, identifying the joint angles and total joint ranges of motion (ROM). Four of the twelve events had a statistically significant difference ($\alpha = 0.05$) between groups. Individuals with Parkinson’s disease displayed greater hip ROM during ramp ascent, less knee ROM during ramp ascent to the turn transitions and stair ascent to the turn transitions, and less hip ROM during ramp descent to level-walking transitions. Reduced knee flexion also revealed decreased stride length when approaching the turn and was associated with a higher number of steps taken to complete the transition. Differences in hip ROM, when ascending and transitioning off of the ramp, suggested that the unconstrained manner of ramp ambulation (relative to the stairs) presents individuals with Parkinson’s disease a greater challenge, perhaps due to an increased motor redundancy for task planning. Collectively, our analyses show that these common types of complex lower-limb tasks can be distinguished even at the early stages of Parkinson’s disease, and could assist in slowing its progression.

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EARLY-STAGE PARKINSON'S DISEASE INFLUENCES THE COORDINATION OF TRANSITIONAL AND NON-TRANSITIONAL OVERGROUND AMBULATION

1.1 INTRODUCTION

1.1.1 Complex Task Planning

Daily movement is commonly presented with complex motor tasks that require a quick cognitive response to the environment. These tasks might involve unexpected starting or stopping, changing directions, walking over an obstacle, or moving from one terrain to another, all of which require higher motor dexterity and cognition compared to standard steady-state ambulation [1]. These complex tasks interfere with neuromuscular task planning, demanding additional muscle coordination to adapt to external stimuli successfully. Studies have frequently performed experiments to understand kinematic patterns during unobstructed, steady-state walking tasks; however, neuromuscular response to complex tasks is not well-understood [2, 3]. Healthy individuals can often overcome shifts in their typical gait patterns, but those with motor impairments, such as individuals with Parkinson's disease (PD), often have difficulty planning and executing complex tasks [4].

1.1.2 Parkinson's Disease

PD is a neurodegenerative disorder, typically diagnosed in older individuals, that progressively weakens motor function, causing symptoms such as tremors, increased limb stiffness, and impaired balance. PD is characterized by restrictive gait patterns, such as shuffling, freezing gait, decreased stride length, slowed movement (bradykinesia), reduced movement (hypokinesia), or no movement (akinesia) [5, 6]. Greater than 85% of those with PD develop gait complications within 3 years of diagnosis, with most of the problems not being visibly noticeable in the early stages of the disease [7]. However, these gait deficiencies are often exaggerated during complex walking tasks [8]. Little is known about the ability of PD individuals to alter task planning and if they perform those tasks with different underlying kinematics compared to healthy individuals. Analyzing the neuromuscular demand required to complete complex tasks could be an effective method for studying motor and cognitive function at the early stages of PD, and might reveal associated kinematic insufficiencies that develop.

PD individual's decline in motor function and altered performance of complex events affect their capacity to complete normal daily activities. Approximately 60% of PD individuals have stated experiencing at least one fall, which often results in further impairment and a subsequent reduction in physical activity [9]. Research has shown that individuals with PD that have enrolled in exercise programs have displayed a reduced rate of falls [10]. Furthermore, exercise and other therapeutic treatments have shown to slow the progression of the disease and improve motor function. Starting and maintaining exercise interventions benefit the physical abilities of individuals with PD, allowing them to improve their quality of life and continue to live independently [11]. However, in order to start such treatments, early detection of the disease is essential. Neurologists diagnose PD based on a person's medical history and through an examination of their symptoms, but there is no quantitative test to identify if an individual has PD [12].

1.1.3 Optical Gait Analysis

One useful tool to quantify the motor capabilities of individuals with PD is to perform a gait analysis using an optical motion capture system. These systems provide a high-resolution method to analyze joint and body segments to calculate body kinematics within 1 mm of precision of those with motor deficiencies. Recent technological advancements of these systems allow it to not only be employed in engineering research settings but also has created opportunities for uses in clinical laboratory testing. They can be utilized for studying the state of disease due to their ability to determine the main contributors to a particular motor impairment [13]. Even though this may not be considered a medical diagnosis, it assists in prescribing treatments and evaluating the outcomes of therapies [13].

1.1.4 Non-Steady-State Locomotion and Parkinson's Disease

Detecting changes in gait kinematics in individuals with little to no outward sign of PD relative to control subjects would provide insights into early signs of the disease and may promote earlier detection. PD interferes with a person's ability to perform and control complex ambulation tasks, but most research has only investigated gait kinematics during straight-line walking tasks [6]. The following study analyzed the kinematic joint ranges of motion for the hips, knees, and ankles in individuals with early-stage PD compared to healthy control subjects, in order to identify gait impairments through the use of a variety of complex walking tasks. The goal of the study was to identify biomarkers in early-stage PD gait when they are faced with a continuously changing terrain circuit that integrated a level ground walkway, staircase, turn, and ramp. This non-steady-state circuit presented participants with a variety of complex terrains and transitions between those terrains. This study hypothesized that since individuals with PD are challenged by self-regulation of their mechanics, when presented with complex terrains, a gait analysis would reveal underlying kinematic differences for a particular task or transition. Furthermore, transitional events on the circuit might be more prone to diverge from the healthy subjects, since those with PD tend to be challenged by dual-task performance and struggle to overcome gait disturbances [8, 14].

1.2 MATERIALS AND METHODS

1.2.1 Experimental Data Collection

This study recruited a total of ten subjects that consisted of five subjects with PD and five healthy subjects. Both groups provided written informed consent to participate in the experiment that is outlined in a protocol approved by the Institutional Review Board at The University of Texas Southwestern Medical Center. The healthy individuals acted as the controls and comprised of four males and one female with a mean age of 25.2 (2.5) years, a mean height of 1.75 (0.11) meters, and a mean mass of 66.8 (12.2) kilograms. All PD participants were in the early stages of the disease (Table 1) with a Hoehn and Yahr stage (H & Y) of 1 or 2, which was determined previously by Staci M. Shearin, Ph.D., PT, NCS [15].

All subjects were using their prescribed dosage of medication during testing, and none of them had an implanted deep-brain stimulator. Additionally, as early-stage PD individuals, subjects did not experience freezing gait or any other observable indicators of the disease. Each subject was equipped with 66 retroreflective markers attached to 12 significant body segments on the arms, legs, and trunk. A ten-camera optical motion capture system (Vicon, 100 Hz) was utilized to track the markers outfitted on the participants. Gait kinematic data was collected for the subjects as they walked comfortably through the terrain circuit. (Figure 1).

Table 1. Characteristics of study participants with Parkinson's disease.

H & Y Stage	Age	Years with PD	Falls	Exercise/ Week (min)	Gender	Height (m)	Mass (kg)	Dominant Hand	Side Affected
2	57	8	1	840	M	1.72	94.8	R	R
1	62	5	0	240	F	1.72	54.4	R	R
1	66	1.5	0	80	F	1.72	82.6	L	R
2	67	3	0	600	M	1.80	92.5	R	L
2	62	6	0	480	F	1.72	63.5	R	L

The terrain circuit consisted of a 2.5-meter ramp with a 10-degree incline, a four-step staircase with a step height of 0.15 meters, and a step depth of 0.30 meters. There was also an additional step between the ramp and staircase with the same step height and depth. PD participants performed a total of ten trials beginning with their left leg, five trials moving from ramp ascent to stair descent, and the other five trials moving from stair ascent to ramp descent. PD individuals were instructed to use handrails when necessary in order to complete the terrain events safely. The healthy controls performed the same number of trials without handrails, also beginning with their left leg.

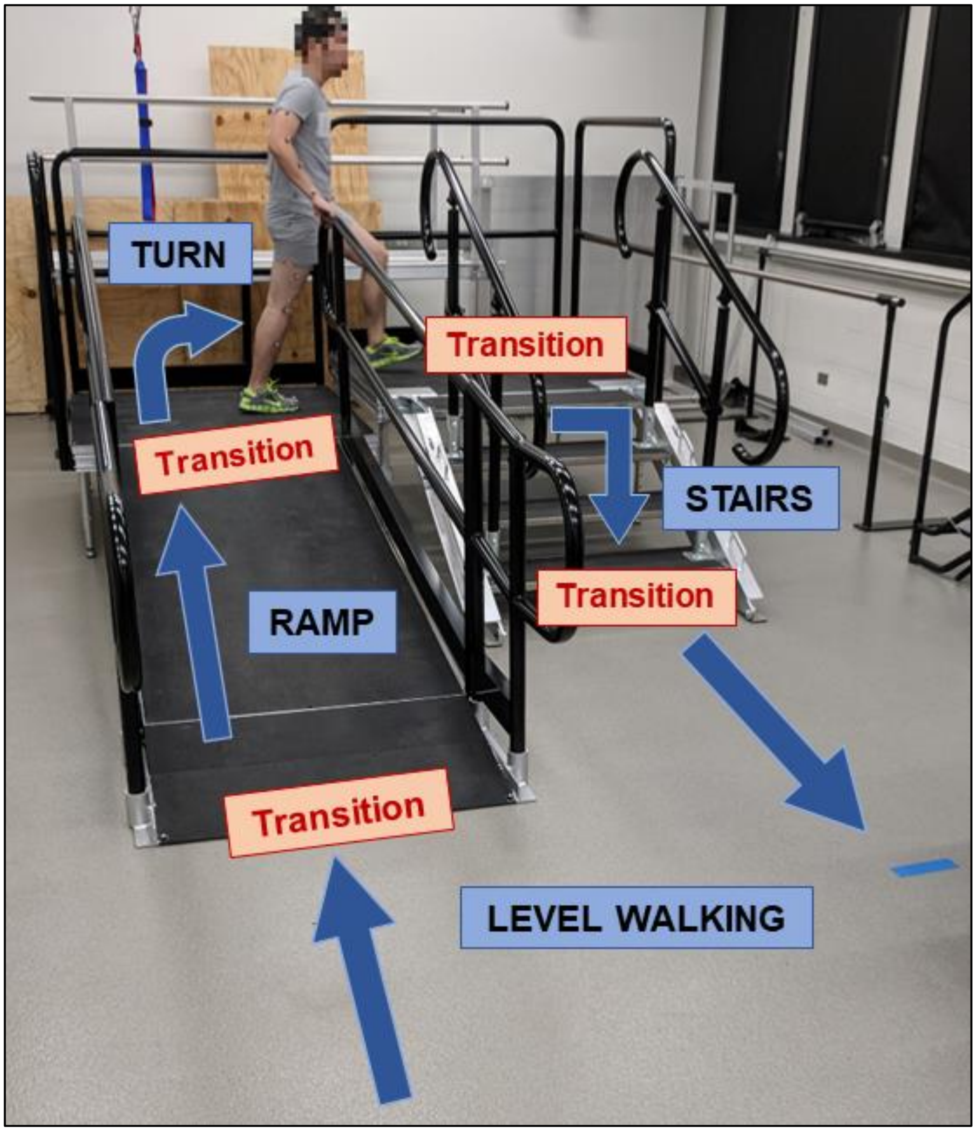

Figure 1. Terrain circuit completed by all study participants.

1.2.2 Data Processing

All captured motion files were imported into Visual3D (C-Motion), where dynamic models were created for each subject. These models were produced using a static calibration recording, where segment masses were calculated as a percentage of total body mass [16, 17]. Model-based computations were performed for each trial completed by subjects, ascertaining the joint angles for the ankles, knees, and hips. The unprocessed joint angle trajectories for a full trial were smoothed using a low-pass Butterworth filter with a cutoff frequency of 6 Hz. All trials contained the three joint angle trajectories for the entire terrain circuit, which were exported to be further analyzed using MATLAB (MathWorks).

1.2.3 Non-Transitional Terrain Events

Force plates were not employed on the terrain circuit to identify the phases of the gait cycle; heel-strike and toe-off for both feet were determined in Visual3D through the addition of labels to all recordings of each subject. Since participants were required to complete several complex tasks on the terrain circuit, each region of the circuit was defined as an explicit terrain event. Non-transitional terrain events analyzed were ramp ascent (RA), stair descent (SD), stair ascent (SA), and ramp descent (RD). Due to the differences in step length from subject to subject, each event was defined as a single gait cycle that started at the initial heel-strike of either leg on the studied terrain (Figure 2). Frame numbers for each trial were documented using the heel-strike labels previously created in Visual3D, which defined the interval of the event for a particular subject's trial on the circuit. These intervals were utilized in MATLAB to determine the joint angles for the ankles, knees, and hips. Joint angles during an event were evaluated for only the leading leg of the gait cycle, which was designated as the leg that began the terrain event.

Ranges of motion (ROM) were also evaluated for each non-transitional terrain event. The range of motion was calculated as the difference between the maximum joint angle and the minimum joint angle of a participant's gait cycle within a terrain event (Figure 3). The range of motion for each subject was averaged over all their trials. Then, an overall group average was taken for individuals with PD and healthy controls.

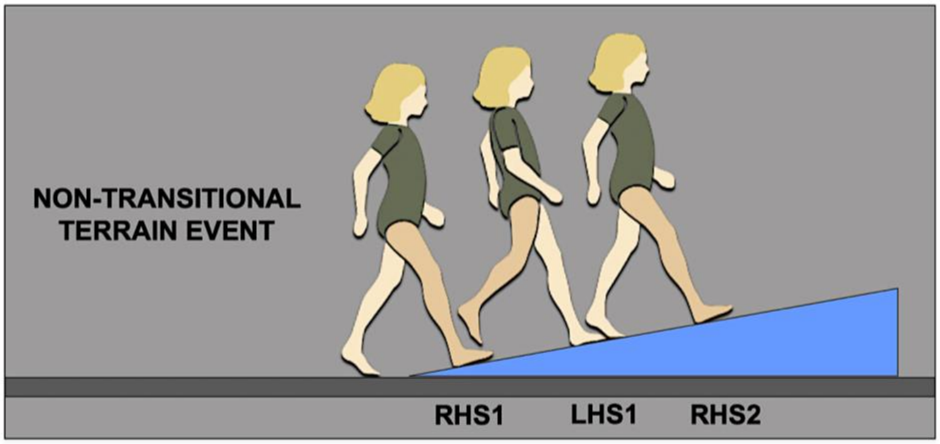

Figure 2. Gait cycle description for non-transitional terrain events.

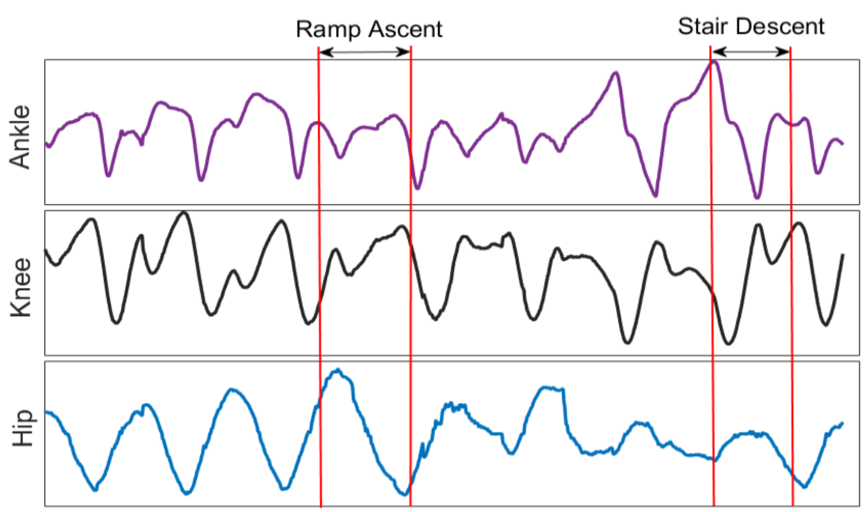

Figure 3. Range of motion analysis for a single trial for ramp ascent and stair descent.

1.2.4 Transitional Terrain Events

Transitional events were defined as when subjects were required to move from one non-transitional event to the next. Analysis included the following eight transitional events: level-walking to ramp ascent (LW/RA), ramp ascent to turn (RA/T), turn to stair descent (T/SD), stair descent to level-walking (SD/LW), level-walking to stair ascent (LW/SA), stair ascent to turn (SA/T), turn to ramp descent (T/RD), and ramp descent to level-walking (RD/LW). Each of these events was defined as one gait cycle that ended during the first heel-strike of either leg on the next terrain (Figure 4). Similar to the analysis of non-transitional events, ranges of motion were determined from joint angle profiles for all subjects on each event.

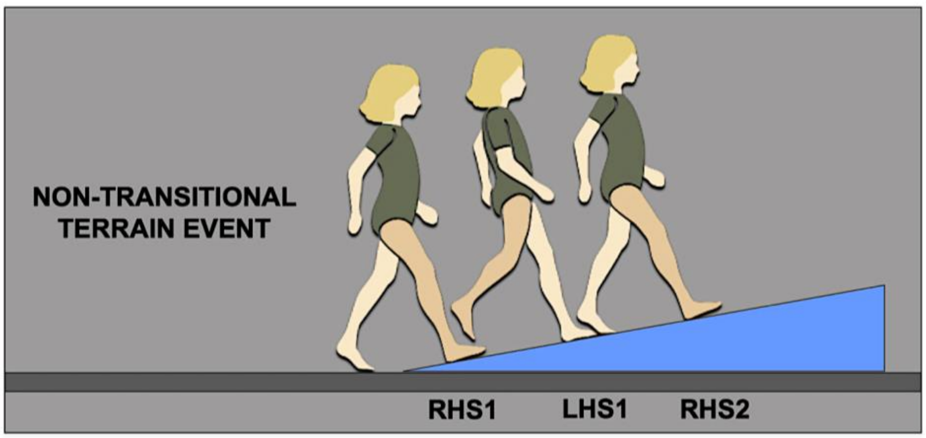

Figure 4. Gait cycle description for transitional terrain events.

1.2.5 Statistical Analysis for Ranges of Motion

Statistical analysis for ranges of motion was performed separately for the non-transitional and transitional terrain events. The between-group differences for ranges of motion in the ankles, knees, and hips were investigated to determine any significant differences expressed in the PD participants compared to the healthy controls for a terrain event. Unpaired, two-sample t-tests were used, assessing PD trials against control trials. This analysis defined that a result from a terrain event was considered significantly different if it had a p-value of less than 5% ($\alpha = 0.05$).

1.3 RESULTS

MATLAB figures were generated for non-transitional and transitional terrain events to determine the total range of motion in each joint during one gait cycle. Joint angle profiles for each terrain are reported below as three associated figures for the ankle, knee, and hip (Figures 5 – 16). These profiles are displayed in the sagittal plane as subjects moved from ramp ascent to stair descent and from stair ascent to ramp descent. For each terrain event, joint angle profiles report the average for each of the five PD subjects' and five control subjects' trials along with an overall average for both groups. Stars (∗) denotes terrain events that demonstrated a statistically significant difference in ranges of motion between PD and control subjects.

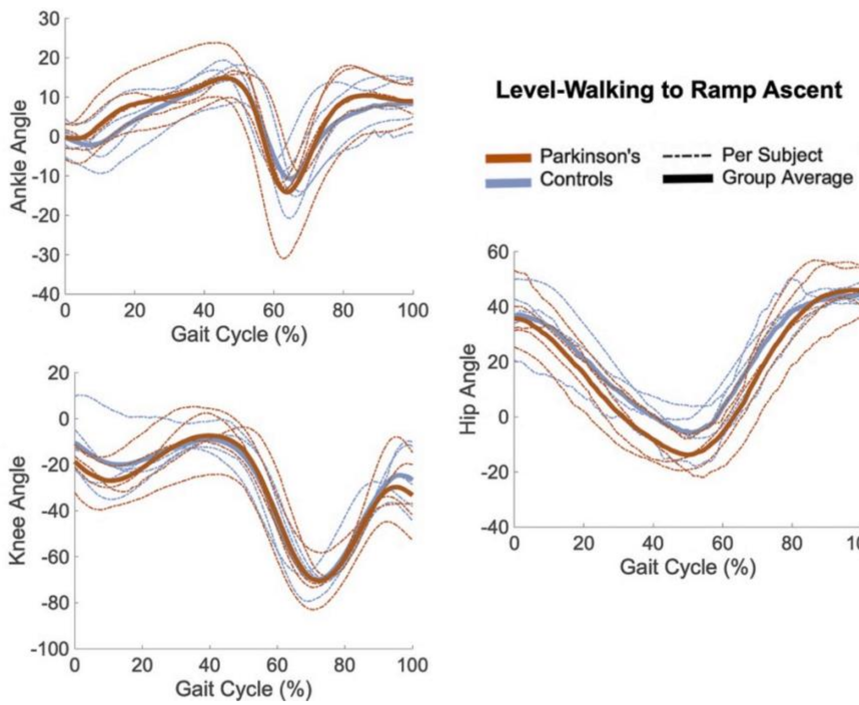

Figure 5. Joint angles for level-walking to ramp ascent (LW/RA).

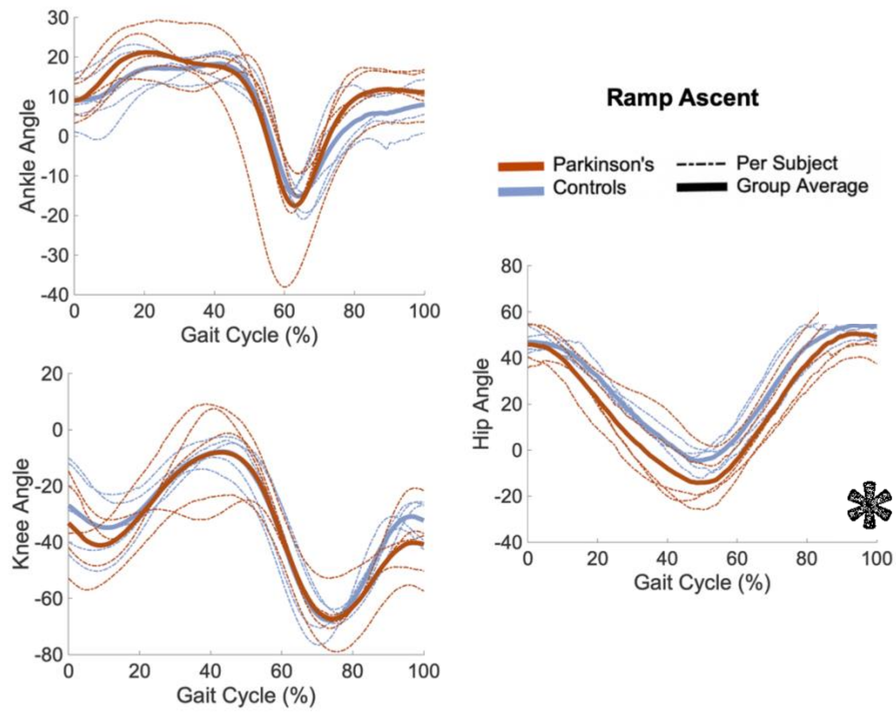

Figure 6. Joint angles for ramp ascent (RA).

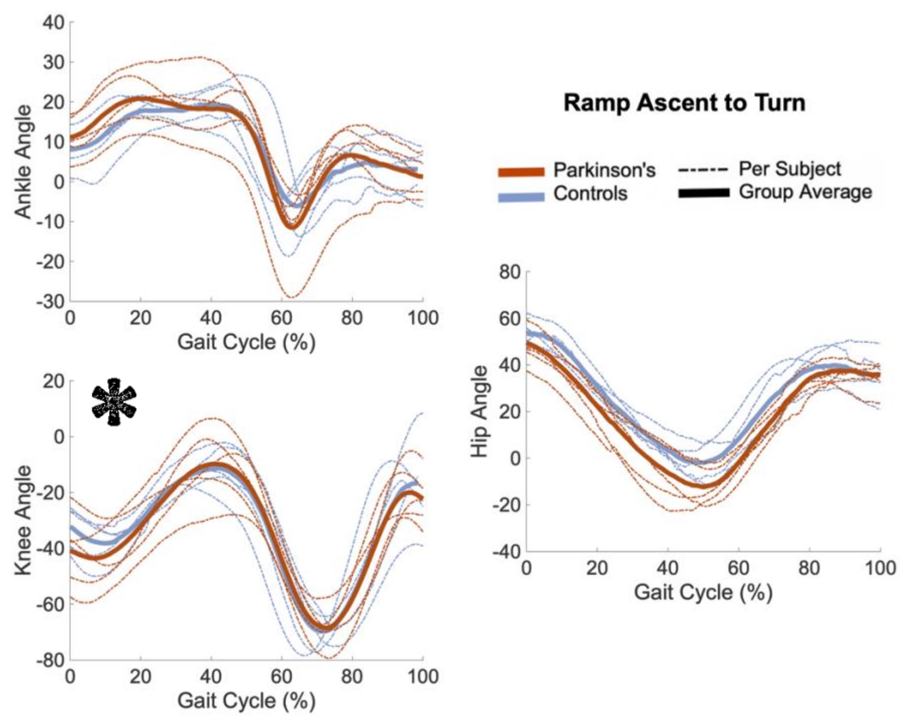

Figure 7. Joint angles for ramp ascent to turn (RA/T).

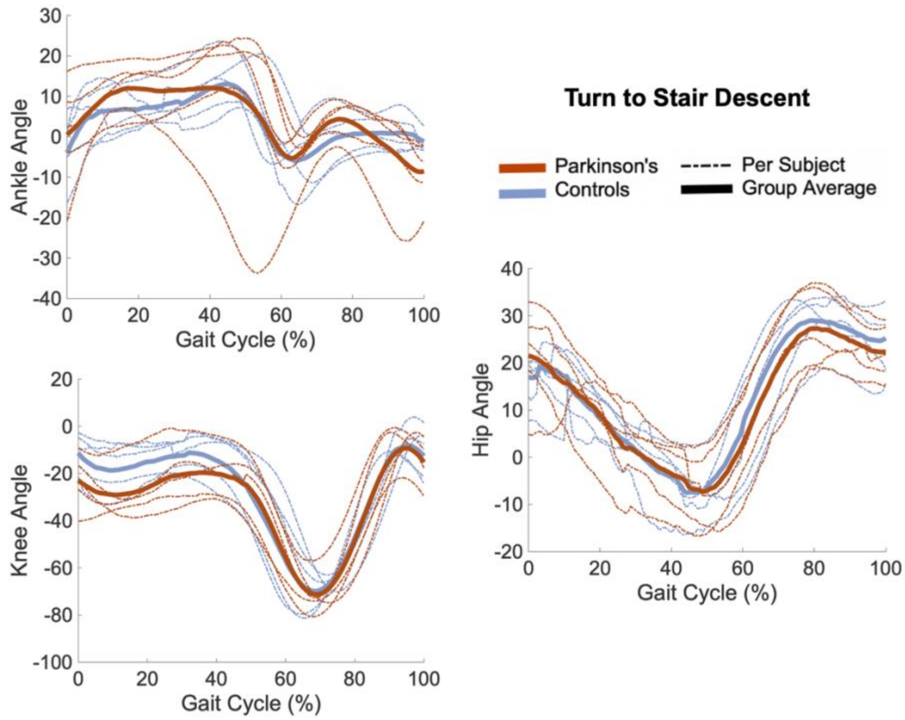

Figure 8. Joint angles for the turn to stair descent (T/SD).

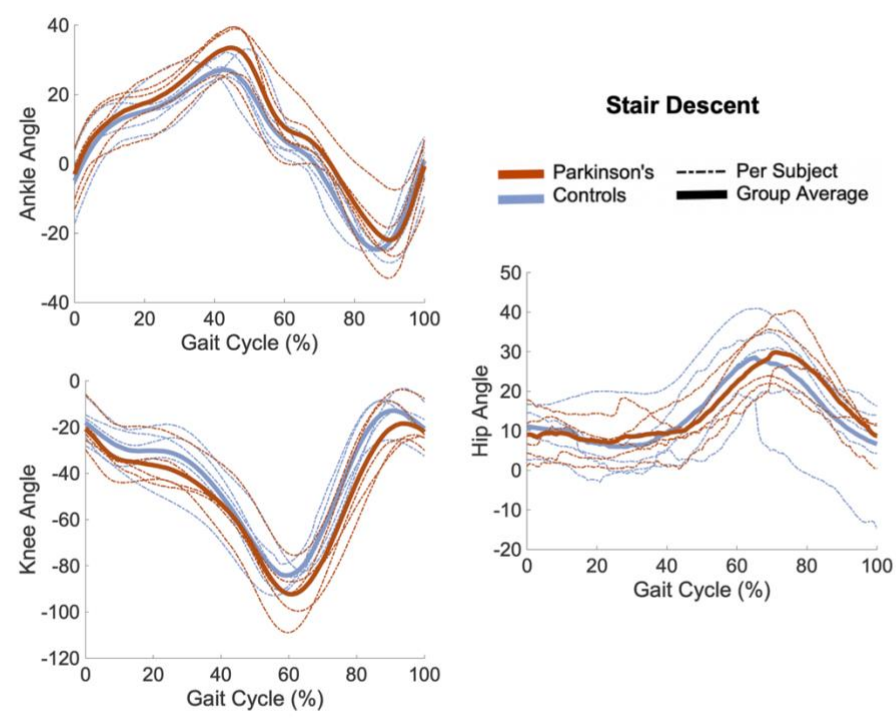

Figure 9. Joint angles for stair descent (SD).

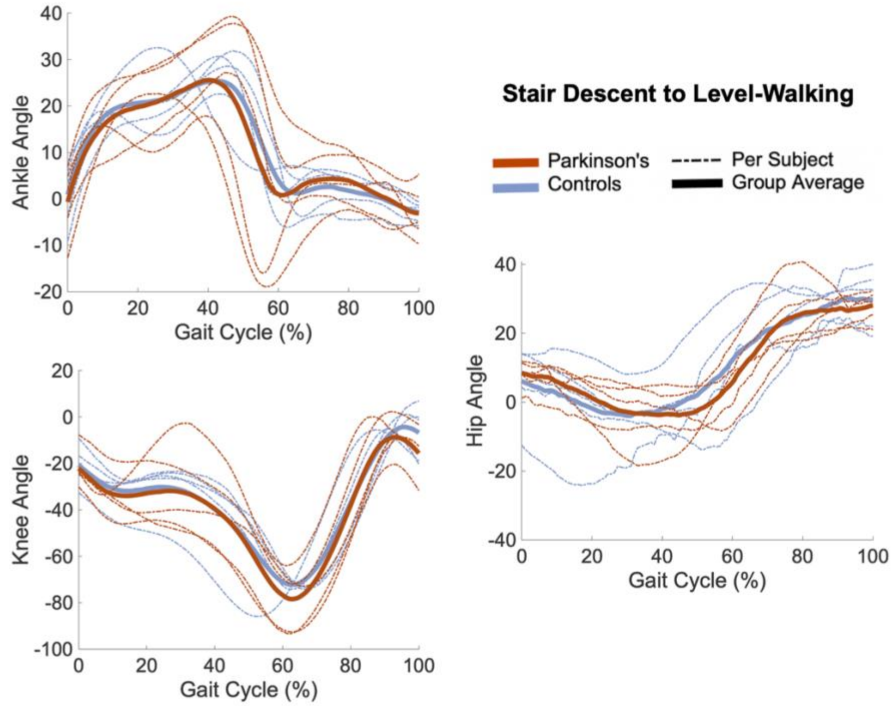

Figure 10. Joint angles for stair descent to level-walking (SD/LW).

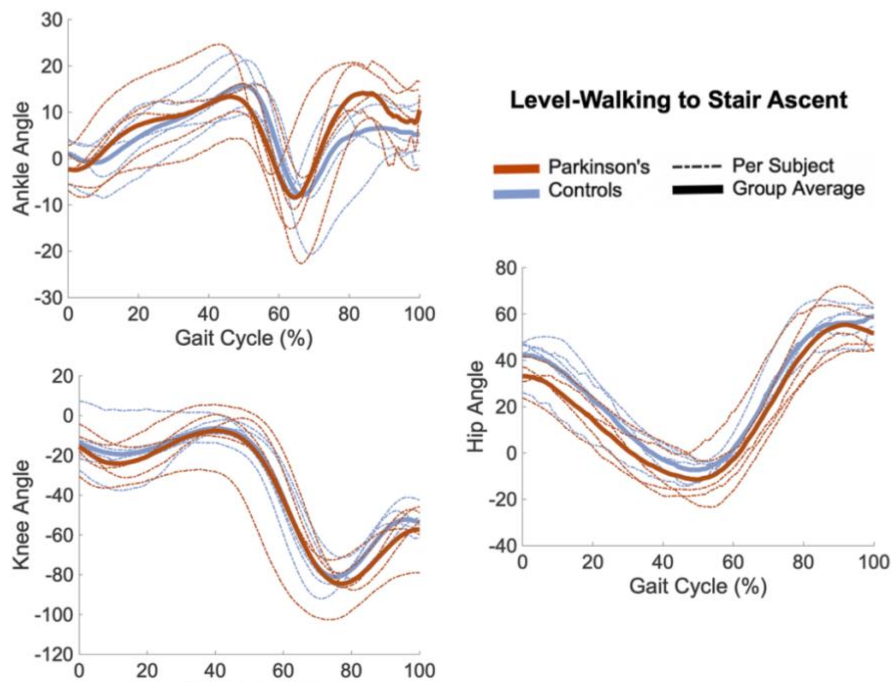

Figure 11. Joint angles for level-walking to stair ascent (LW/SA).

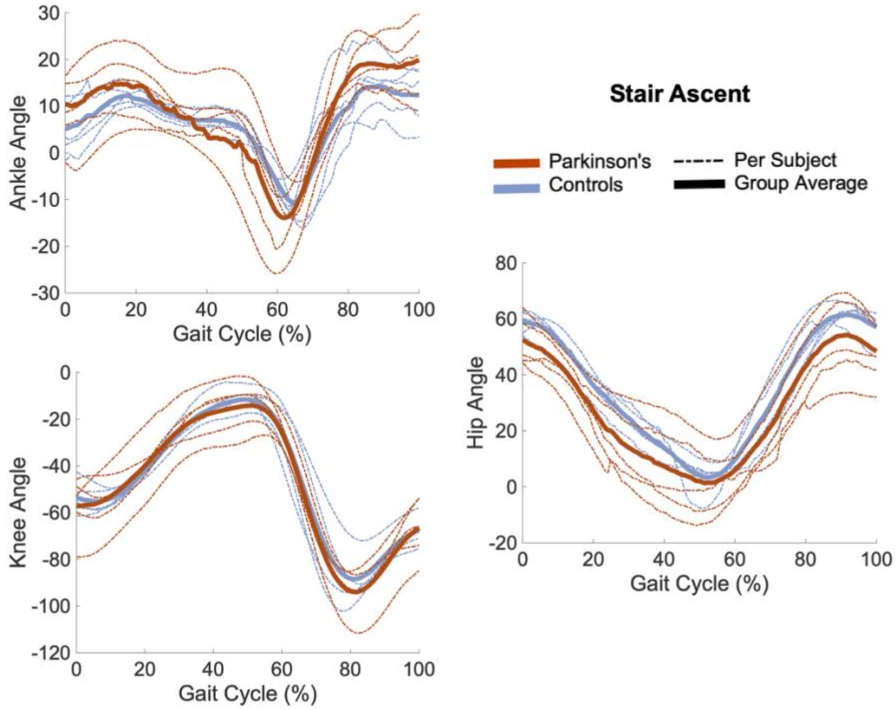

Figure 12. Joint angles for stair ascent (SA).

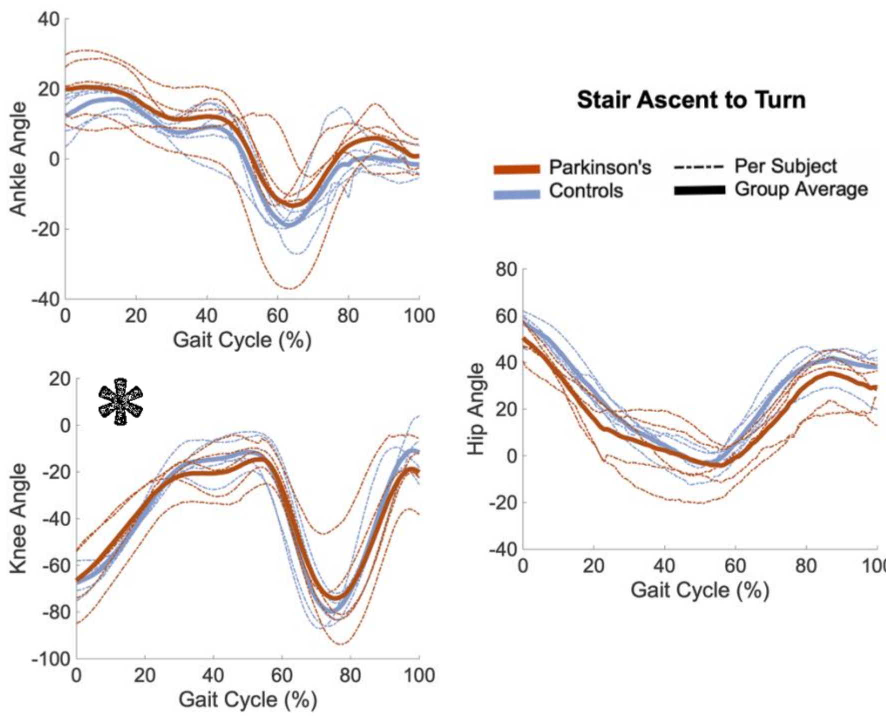

Figure 13. Joint angles for stair ascent to turn (SA/T).

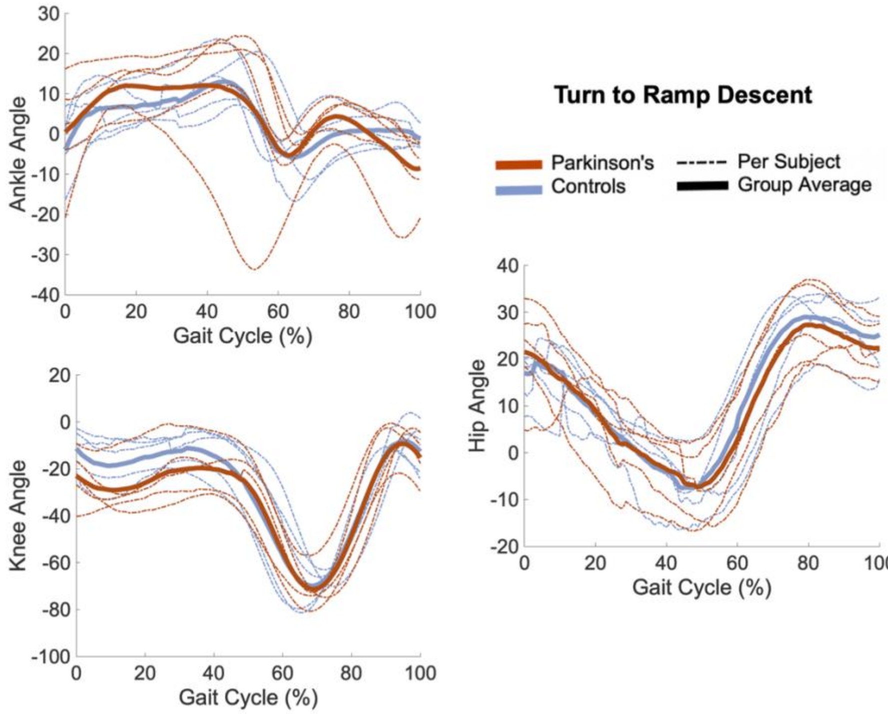

Figure 14. Joint angles for the turn to ramp descent (T/RD).

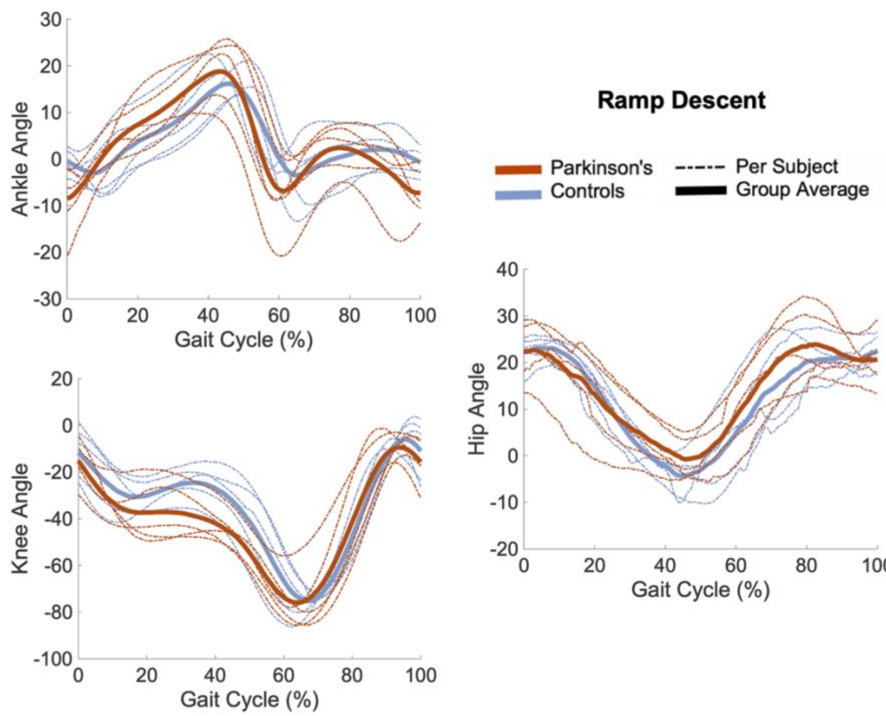

Figure 15. Joint angles for ramp descent (RD).

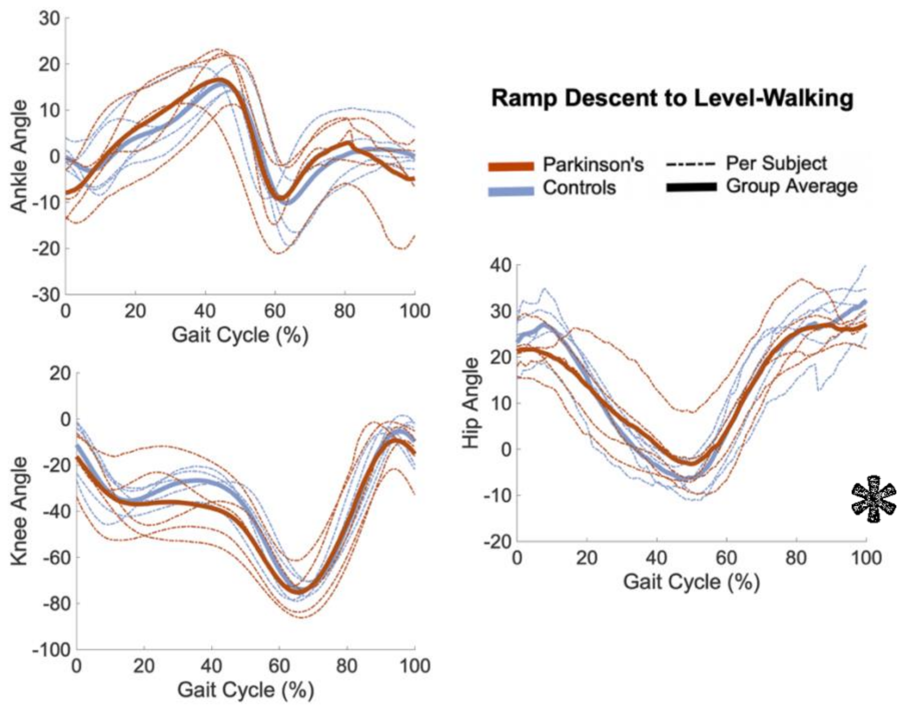

Figure 16. Joint angles for ramp descent to level-walking (RD/LW).

Statistical analysis revealed four total terrain events that demonstrated a significant difference between groups, which included three transitional terrain events and one non-transitional terrain event. Assessment of non-transitional terrain events displayed a greater range of motion in the hips during ramp ascent (RA) for individuals with PD, where ramp ascent was the only significantly different non-transitional event with a calculated p-value of 1.81% (Figure 6). The second, most substantial difference for non-transitional events was during ramp descent with PD individuals displaying a larger range of motion in their hips; however, this event was not considered statistically significant.

Analysis of transitional terrain events concluded that individuals with PD had less range of motion for three of the eight transitions. The terrain transitions evaluated displayed that individuals with PD demonstrated less motion in their hips for ramp descent to level-walking

(RD/LW) with a p-value of 0.08% (Figure 16). Furthermore, ranges of motion outcomes were significantly less for PD participants in their knees when approaching the turn. Knee flexion decreased as they moved from ramp ascent to the turn (RA/T) (Figure 7) and from stair ascent to the turn (SA/T) (Figure 13), demonstrating calculated p-values of 1.91% and 0.06%, respectively. The ranges of motion for all four of the terrain events that showed significant differences are summarized below with their corresponding p-values (Table 2). Overall, knee ROM from stair ascent to the turn and hip ROM from ramp descent to level-walking showed the greatest statistically significant differences for PD individuals against controls, followed by hip ROM during ramp ascent and knee ROM from ramp ascent to the turn. A few modest significant differences were also seen for the PD subjects, in which they showed greater hip ROM during ramp descent and smaller knee ROM from the turn to stair descent. These terrain events exhibited p-values less than or equal to 10%; however, they did not meet the predefined criteria of less than 5% that determined if a terrain event demonstrated a statistically significant difference.

Table 2. Terrain events with significantly different ROM for PD and control subjects.

Terrain Event	PD ROM	Control ROM	p-value
Knee – RA/T	64.06 (6.48)	68.47 (5.91)	1.91%
Knee – SA/T	66.92 (6.69)	76.37 (9.91)	0.06%
Hip – RA	65.64 (5.74)	58.14 (13.86)	1.81%
Hip – RD/LW	34.32 (5.81)	42.21 (8.94)	0.08%

Evaluation of individuals with PD as they approached the turn revealed that they tended to take additional steps compared to the healthy control subjects resulting in a decrease in stride length and reduced knee flexion. When walking on the ramp, PD study participants were presented with a less constrained terrain compared to the stairs, making the terrain events associated with the ramp more prone to inducing abnormal gait patterns. The analysis showed that three of the four terrain events considered significantly different, occurred when walking on the ramp or transitioning off the ramp. Furthermore, an examination of transitional compared to non-transitional terrain events showed that ramp ascent had an opposite direction of significance compared to the three transitional events.

1.4 DISCUSSION

Ranges of motion were evaluated for the PD group when walking on and transitioning to a ramp and staircase. The comparative analysis for this study performed computations to quantify any existing kinematic differences in the joint angles of the early-stage PD group compared to the healthy control group. The two main findings of this research revealed significant kinematic deviations in the hips when ascending or transitioning off of the ramp, and in the knees while approaching the turn. These dissimilarities highlight the neuromotor underpinnings associated with PD and provide a better understanding of the underlying approach used for planning and executing complex, non-steady-state walking tasks.

The first finding suggested that a ramp presents a spatially unconstrained terrain that manifests a more arbitrary method during task planning and task completion. The restricted manner of the stairs offers a recurring terrain for individuals with PD, providing a more consistent routine for task execution. Moreover, the stairs have a designated height on each step that gives PD subjects a clearer idea of what their step height needs to be to permit forward movement. Since the ramp is unable to provide a well-defined area like the stairs, subjects have a higher chance of perturbation. This idea is supported by the increase in range of motion seen in the hip joint during ramp ascent and ramp descent, and the decrease when transitioning back to level-walking. This higher variability associated with a less constrained terrain results in exacerbated motor impairments in PD individuals, and also makes overcoming these non-level-walking gait disturbances more challenging.

Another finding of this research was the notable decrease in knee range of motion when transitioning to the turn. When moving from stair ascent to the turn and from ramp ascent to the turn, individuals with PD exhibited less range of motion, indicating shorter strides. Reduced stride length is a common element of PD and corresponds to gait hypokinesia, which is a symptom known to continue to worsen with time [18]. Morris et al. completed research on reduced movement in gait and concluded that PD individuals have greater "difficulty with internal regulation of stride length" and are unable to activate the correct step response to a given condition initially. Even though this work did see improvement in stride length through the use of visual cues, they only tested PD subjects when performing steady-state walking tasks. Another study by Kelly et al. aimed to improve dual-task performance through instruction to PD subjects for both simple and complex walking tasks [7]. Their results were consistent with Morris's study, showing that PD subjects were able to adapt in response to auditory cues during simple, straight-line walking tasks. However, when required to perform more complex walking tasks, PD subjects were unable to modify walking through the use of only their focused concentration.

Overall, these past studies support that gait insufficiencies appear in PD individuals when completing complex walking tasks, and that they cannot be improved simply by paying closer attention to their approach during task performance. This decline in PD individuals' ability to self-regulate their mechanics makes it difficult for them to complete these tasks without error. This research further emphasized that there is a decrease in internal regulation in PD and uncovered what significant kinematic differences exist in the early stages of the disease when subjects are completing complex tasks. Level-walking does not induce the same motor and cognitive errors in PD individuals compared to what is seen when increasing the complexity of tasks. Previous research has shown that 92% of PD subjects have motor complications with balance when completing complex tasks that involve multi-tasking [19]. During the performance of complex tasks, deviations from normal gait can also occur in healthy controls, but individuals with PD have a much higher chance of error. Clinical examination of PD using a terrain circuit with a ramp and a turn would be more informative than an evaluation that consisted of only level-walking. Gait analysis for these types of tasks could contribute to current diagnosis techniques and assist with early detection of the disease.

A few limitations of this research should also be considered. Unlike previous research that only tested PD individuals with steady-state walking tasks, this study took additional measures to have a more accurate representation of the full range of complex conditions seen during daily living. However, since the terrain circuit was used to fit the experimental protocol, it may not be an ideal representation of the naturally occurring complex tasks and may limit the generalizations made from the study's findings. Secondly, the difference between the mean age of the healthy control subjects and PD subjects should be noted. The PD group was an average

age of 62.8 years old, whereas the control group averaged at 25.2 years old. This age gap could have influenced our results, in that, the control group may not have reflected the gait of healthy individuals that were around the same age of the PD group. Lastly, another limitation of this study was that it only examined five PD subjects. This smaller subject size was beneficial for manual gait analysis required due to differences in stride length on the different terrain events but might have affected the interpretation of the results.

1.5 CONCLUSION

This study completed a gait analysis between a PD group and a healthy control group, concluding that there were four distinct kinematic changes in the ranges of motion for subjects previously diagnosed with early-stage PD. Increased hip ROM when ascending the ramp and decreased hip ROM when transitioning off of the ramp indicated that this terrain event was more susceptible to deviate from healthy gait patterns due to the less constrained structure of the ramp. Additionally, reduced knee flexion when approaching the turn suggested an overarching decrease in stride length due to PD individual's tendency to take frequent and smaller steps, consistent with a festinating gait pattern. PD gait during simple walking tasks can be improved when focusing on either visual or auditory cues, however these approaches have an unresponsive effect on gait when trying to improve abnormal gait patterns that arise during complex tasks.

The significance of this research is to provide a better understanding of the underlying approach used for task completion in PD to promote earlier detection of the disease. The study showed that utilizing a non-steady-state circuit that consists of multiple, complex motor tasks may be a better approach to use when trying to diagnose PD through optical gait analysis in clinical settings. Steady-state walking tasks, such as straight-line, level-walking does not provide the same information needed to diagnose individuals who may be in the early stages of PD.

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BIOGRAPHICAL SKETCH

Emma Neuendorff was born in Houston, Texas in 1995. She is a sixth-generation Texan and grew up on her family's century ranch outside of Fayetteville, Texas. She graduated from La Grange High School in 2013, and then started her Bachelor of Science in Mechanical Engineering at The University of Texas at Austin. During her undergraduate degree, Emma was a research assistant in the Rehabilitation with Insight from Robotics and Engineering (REWIRE) Lab under the guidance of Dr. James Sulzer and Dr. Tunc Akbas. In 2017, she completed an extended internship located in San Angelo, Texas at Ethicon, Inc., a subsidiary of Johnson & Johnson, where she worked as a Facilities Engineer. Emma is now completing a Master of Science in Biomedical Engineering at The University of Texas at Dallas. She completed a second internship in 2019 with KCI, an Acelity company, working in product development of wound care devices as a Mechanical Engineer. Additionally, throughout her undergraduate and graduate education, she has worked for Girlstart, who promote STEM careers and education to young women. She taught an after-school program at various elementary schools, managing hands-on engineering activities. She is currently a part of the Systems for Augmenting Human Mechanics Lab under Dr. Nicholas Fey. Her research focuses on the examining joint mechanics for complex ambulation tasks in individuals with Parkinson's disease through the use of an optical motion capture system and biomarker analysis.

CURRICULUM VITAE

SUMMARY

Self-motivated, graduate biomechanical engineer with experience in research and product development of medical devices. Passionate about being involved in challenging projects that make a positive impact on people's lives.

EDUCATION

Master of Science, Biomedical Engineering May 2020

The University of Texas at Dallas, *GPA: 4.00/4.00*

Bachelor of Science, Mechanical Engineering May 2018

The University of Texas at Austin, *GPA: 3.46/4.00*
Business Foundations Certificate, *High Distinction*

Related Courses:

Biomaterials & Medical Devices, Modeling & Simulation, Soft Tissue Mechanics, Biostatistics, Neural Engineering, Polymers for Biomedical Applications, Immunology, Biomedical Microdevices, Anatomy & Physiology, Medical Device Design & Manufacturing, Finance, Accounting, Marketing, Biomechanics of Human Movement

EXPERIENCE

Systems for Augmenting Human Mechanics Lab September 2018 – May 2020
Graduate Research Engineer
Dallas, Texas

- Analyzed kinematic data collected on a stair/ramp terrain circuit using Visual3D
- Utilized MATLAB to evaluate joint angles and ranges of motion of individuals with Parkinson's disease compared to healthy controls
- Exhibited a poster at the 2019 Biomedical Engineering Society Conference

KCI – Acelity May 2019 – August 2019
Mechanical Engineering Intern
San Antonio, Texas

- Supported bench tests evaluating substantial equivalence for FDA 510(k) submission
- Designed SolidWorks wound models for dressing tests
- Engaged Key Opinion Leaders (KOLs) during product demonstration with clinical advisory board

Rehabilitation with Insight from Robotics & Engineering Lab September 2015 – May 2018
Undergraduate Research Engineer
Austin, Texas

- Collected and analyzed data from stroke patients using optical motion capture system
- Evaluated accuracy of assistive device for shoulder rehabilitation after spinal cord injury
- Facilitated human subject experiments to study various conditions in stroke

Ethicon – Johnson & Johnson January 2017 – July 2017

Facilities Engineering Co-Op Intern
San Angelo, Texas

- Managed projects in a controlled manufacturing setting
- Communicated with contractors and vendors
- Implemented a shredder to destroy unsaleable product

Girlstart September 2015 – May 2020

After-School STEM Education Intern
Dallas/Austin, Texas

- Organized group discussions during STEM demonstrations and emphasized comprehension through hands-on activities
- Maintained discipline in a classroom of 25-30 girls

ACADEMIC PROJECTS

Waste Dewatering System for Underserved Communities January 2018 – May 2018

Project Lead

- Worked with the International Federation of Red Cross (IFRC) to design a system to dewater human waste in refugee camps in order to reduce risk of disease
- Created SolidWorks models and used FEA to verify the structural integrity of the system

Fire Search & Rescue Vehicle August 2017 – December 2017

Project Lead

- Developed a prototype of a vehicle that aids firefighters in the search and rescue of pets
- Designed FEA models to predict the internal temperature of the electronics housing unit using different factors

Fetal Heart Monitor Attachment Project August 2016 – December 2016

- Collaborated with a practicing OB-GYN physician specializing in high risk pregnancies
- Developed a prototype for an improved attachment of a fetal heart monitor
- Addressed design risks by incorporating higher elasticity and greater mobility

CERTIFICATIONS & SKILLS

Certified SolidWorks Associate (CSWA) August 2016

Technical Skills: MATLAB, SolidWorks, Microsoft Office Suite, Visual3D, LabVIEW
Soft Skills: Leadership, Communication, Problem Solving, Public Speaking, Time Management