RESEARCH ARTICLE

The Effects of Heel Lifts on Dynamic Measures of Gait and Static Posture in Individuals with Parkinson's disease

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Abstract

This study expands upon the Hastings *et al* (2018) study on the use of heel lifts to change static postural alignment in persons with Parkinson's Disease (PD) and further explores whether the use of heel lifts provide improvements in dynamic gait parameters, Timed Up and Go (TUG) scores, and balance confidence. Outcome measures were taken with and without the heel lifts in place, at two data collection dates. Photographs were analyzed for postural alignment measures using ImageJ software and video was analyzed for gait and turning parameters utilizing the Dite and Temple scale. The Activities-specific Balance Confidence (ABC) scale was collected at baseline and after two weeks of heel lift use, otherwise outcome measures were performed in the reverse order on the first and second session to account for ordering, practice, and fatigue effects. Statistical analysis included paired t-tests for outcome measures and Pearson product correlation between the degree of plantarflexion contracture and ABC scale and overall balance confidence and fall history. We found that head tilt angle and turn time significantly improved (p = .037) (p = .002) with use of heel lifts. Turn time correlated to overall balance confidence (r = -.802, p = .000) and overall balance confidence correlated to fall history (r = -.501, p = .041). This study showed that accommodating a lack of ankle dorsiflexion range of motion with heel lifts significantly improves head tilt angle and decreases turn time as compared to without heel lifts, but has no significant effect on step length, gait speed, or overall TUG score in individuals with PD. Because our work shows that limited range of motion at the ankle contributes to real and perceived balance difficulties healthcare providers working with any population of patients exhibiting balance problems should include this measurement in their assessment and consider intervention with a heel lift when limitations are found.

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Keywords

Parkinson's disease; posture; turn; contracture; plantarflexion

Introduction

As healthy individuals advance in age, they often take more steps that are decreased in length.[1] This is normal to the aging process. However, for those with Parkinson's Disease (PD), these changes are experienced to a significantly greater extent, increasing falls risk in this population.[1] The gait pattern exhibited by those with PD is often characterized by short, stiff shuffling steps, decreased reciprocal arm swing, freezing, festination, slowness of movement, and difficulty with turning.[2] Turning proves to be especially challenging for persons with PD due to the increased time and increased number of steps it takes to turn.[3,4] Corresponding research suggests that persons with PD are two to three times more likely to fall than their healthy counterparts.[5] This unfortunate reality can have a profound

impact on the lives of persons with PD both physically and psychologically; leading to an increased fear of future falls, loss of independence, admittance to nursing facilities, and reduced mobility.[5]

Rigidity and a "stooped posture" are other cardinal signs of PD. Such a postural malalignment increases fall risk in this population. A "stooped posture" places one's center of gravity outside of their base of support. Hastings *et al* (2018) addressed this malalignment with the use of a heel lift to accommodate plantarflexion (PF) contracture in closed kinematic chain; hypothesizing that a lack of dorsiflexion (DF) range of motion can exacerbate postural alignment up the kinetic chain resulting in a "stooped posture".[6] Using a heel lift as their intervention, they found significant improvements in head tilt angle, trunk angle, and a more anterior placement of the pelvis; effectively shifting one's center of gravity over their base of support. As a result, they found that their participants not only looked more balanced, but their participants reported a greater sense of perceived stability with the heel lifts in. Most importantly, they found that the degree of PF contracture (or how much DF one lacked) correlated to the self-reported concern of falling that their participants felt in various environmental contexts as described by the Falls Efficacy Scale (FES). Their findings were also consistent with existing literature on the utilization of heel lifts to improve postural alignment during gait in both children and adults with cerebral palsy; a neurological condition characterized by similar motor deficits that include a lack of dorsiflexion range of motion. These studies agree that by establishing a normal alignment of the tibia, the body's center of mass (COM) is able to shift back over its base of support creating a greater sense of balance and stability. [7–9]

There are many challenges related to balance and motor activity in walking that the individual with PD must face, therefore, if a simple intervention addressing the patho-biomechanics of alignment can improve perceived stability, it is worth investigating if this intervention also has a positive impact on gait. The purpose of this study was to expand upon the Hastings et al (2018) study by repeating their work on static postural alignment and further exploring whether the use of heel lifts provides improvements in the dynamic gait parameters of step length, gait speed, Timed Up and Go (TUG) scores, and balance confidence as compared to when they are not used in individuals with PD.

Material and Methods

This was longitudinal, repeated measures, and within-subject study design; where the participants were their own controls. A convenience sample of 18 individuals diagnosed with PD were recruited using flyers posted at medical centers, community centers, and at PD support groups .Participants were included if they could independently ambulate 30 feet as well as move from sit to stand in a chair with or without an assistive device: one participant utilized a four wheel walker.

Participants were excluded if they were unable to understand English or suffered from a medical comorbidity that might impact their postural stability. Demographic information for the participants is detailed in Table 1.

Table 1. Participant Demographics

	Average	**Range**
Age	70	46 … 82
Years Since Diagnosis	5	1 … 16
H&Y Scale Score	1	0…….5
DF ROM	0.86	-8 … 18
Falls / Week	0.3	0 …. 2
Freezing Episodes / Month	12.3	0 …180
Days HL worn between sessions	13.4	10 … 15
Participation in Regular Exercise	100% of participants	
Participation in Regular Stretching	70.6% of participants	

The study received Institutional Review Board approval. Informed consent was obtained from all participants prior to their participation. Participants completed two one-hour sessions scheduled two weeks apart. The sequence of test protocol and procedure is provided in Figure 1. Data from one individual was excluded due to improper use of the heel lift. Analysis was performed on the remaining participants (*n*=17, 14 male and 3 female). No adverse events occurred during this study.

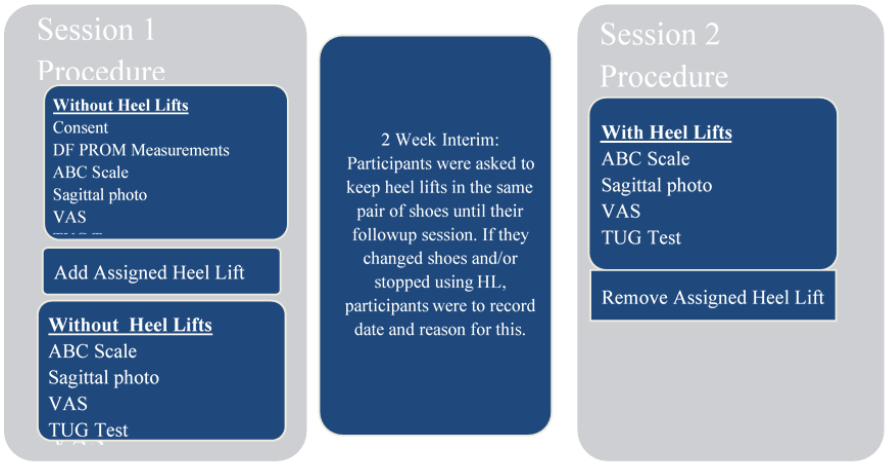

Figure 1. Study Flow Diagram.

Instruments/Outcome measures

Activities-specific Balance Confidence Scale: The Activities-specific Balance Confidence (ABC) Scale is a self-report outcome measure that is a reliable and valid test to use in persons with PD to predict falls risk.[10,11] This outcome measure was chosen because it asks questions concerning balance as it pertains to performing various activities of daily living. Questions in this outcome measure included activities that were both static and dynamic across level and uneven terrain as well as in unpredictable environmental conditions. Some participants reported that they were unable to rate certain activities as it were not happening in real time. To this, investigators asked the participant to predict how much confidence they would feel in their ability to maintain balance if they were in that situation.

Talocrural DF ROM and Heel Lift Assignment: Passive ankle range of motion into DF was measured with a standard goniometer by a single researcher. Participants were supine and measurements were taken with the moving arm aligned to the calcaneus and the knee positioned in full extension. Standard goniometric measurement has moderate to good intra-rater reliability.[12] The deficit in DF was then used to assign heel lift heights that ranged from 0.5 cm to 1.3 cm as detailed in Table 2. The largest DF deficit was used on determine the heel lift size that would be applied for both shoes utilizing the Warwick Enterprises Adjust-a-Lift heel lifts.

Table 2. Heel lift height (cm) used for DF limit

Dorsiflexion PROM	Height of Heel Lift
Positive to -4 °	0.5
-5° to -9°	0.9
-10 ° +	1.3

Static Postural Alignment: To measure static postural alignment a sagittal view photograph was taken. The camera position was standardized for distance, height, angles and settings: all photographs included the floor and clear space above the participants head. The participants were instructed to place their toes on a blue line taped to the floor and to stand “up nice and straight” while looking at a fixed picture from a standardized distance. The photographs were analyzed for head tilt angle, trunk flexion angle, and vertical height using ImageJ. ImageJ is a scientific image processing digital tool developed by the National

Institute of Health which is frequently updated. It has been shown to be a valid and reliable tool for the processing of image contact angle measurement.[13] A single researcher performed the digital analysis for all photographic measurements and the unit of measurement was standardized to one foot.

Perceived Stability: After the sagittal photo was taken, and prior to moving to the next station, the participant was asked to rate their perceived stability using a verbal numeric rating scale. The same researcher would ask, "How stable do you feel on a scale of 1 to 10, with ten being completely stable and one being convinced that you will fall without support."

Timed Up and Go: This test is a valid and reliable test for geriatric persons with PD. This outcome measure includes standing from sitting, walking, turning and sitting down. Instructions provided by the Center for Disease Control and Prevention were used and the participants were instructed as follows: "When I say go, I want you to stand up from the chair, walk to the blue line on the floor at a normal pace, turn, walk back to the chair at your normal pace, and sit down again."[14] A single researcher provided these instructions along with a demonstration of this for each participant. The same researcher then guarded the participant while the test was performed for safety. A different researcher used a stopwatch to time each participant to the nearest hundredth of a second. Participants were videotaped during this activity for later video analysis.

Video Analysis: The video footage for each participants' TUG test was used for analysis of turn behavior. Two researchers separately analyzed the video recordings of each participant to qualitatively and quantitatively rate their performance based upon the clinical measure tool for turning behavior in community-dwelling older adults by Dite & Temple (2002). Quantitative items included turn time and turn steps as well as total turn score. Interrater discrepancies were resolved by taking the mean scores of these quantitative items. Qualitative analysis included a dichotomous rating of 'yes' or 'no' on (Item 1) if the participant moved fluently without hesitance from walking into turn initiation, (Item 2) if there were any noticeable pauses during the turn, (Item 3) if their arms were held stiffly or out to provide balance, (Item 4) if the participant attempted to increase the size of their base of support or staggered during the turn, (Item 5) appears steady throughout the turn, and lastly, (Item 9) if they deviated from their desired direction when exiting the turn. This time, discrepancies in dichotomous decision making were resolved by coding 'yes' as '1' and 'no' as '0', then the mean score was taken of the two. Dite and Temple (2002) found that turn time and turn steps, demonstrated a good correlation to the Berg Balance Scale and the 360-degree turn and that the tool overall was a valid and reliable clinical measure for turning while walking in older adults. This tool is shown to have moderate interrater and retest reliability and was found to be highly sensitive for distinguishing multiple fallers (falls = 2+ over past two months) from non-multiple fallers (falls = 0 over past two months).

Hoehn and Yahr Staging Scale: The Hoehn and Yahr Staging Scale was used to categorize the participants into their clinically applicable PD stage. This scale is widely used in research settings as it is found to highly correlate to motor impairment, disability, and quality of life in individuals with PD.[15] This tool is time efficient, as it is based solely on observation, and was chosen over other outcome measures as it determines the stage of PD based on gross motor ability rather than cognitive function. Again, staging was rated separately, by two different researchers and the average of their stages were used, rounding to the nearest whole number for relevance.

Statistical analysis: SPSS version 26 software was used for the statistical analysis of our data. Descriptive statistics were used to define the participants. All outcome measures were analyzed using a paired t-test comparing heel lift to without heel lift. Pearson product was used for the correlations. Alpha was set a 0.05.

Results

No significant difference was found for total TUG time, Perceived stability or ABC scale score with and without heel lifts. There was no correlation between the DF deficit and the ABC scale score. One of our postural measures, head tilt angle, did show significant difference (Figures 2 and 3) and we also found a significant improvement in turn time with the use of heel lifts (Table 3). Additionally, all participants requested to keep the heel lifts due to perceived benefits.

Table 3. Significant Results with alpha = .05

	Significance	Mean	Std Dev	Correlation
Head tilt angle	p = .037	1.36	3.65	
Turn time	p = .002	.110	.192	
Overall balance confidence to fall history	p = .041			r = 0.501
Turn time to overall balance confidence	p = .000			r = -.802

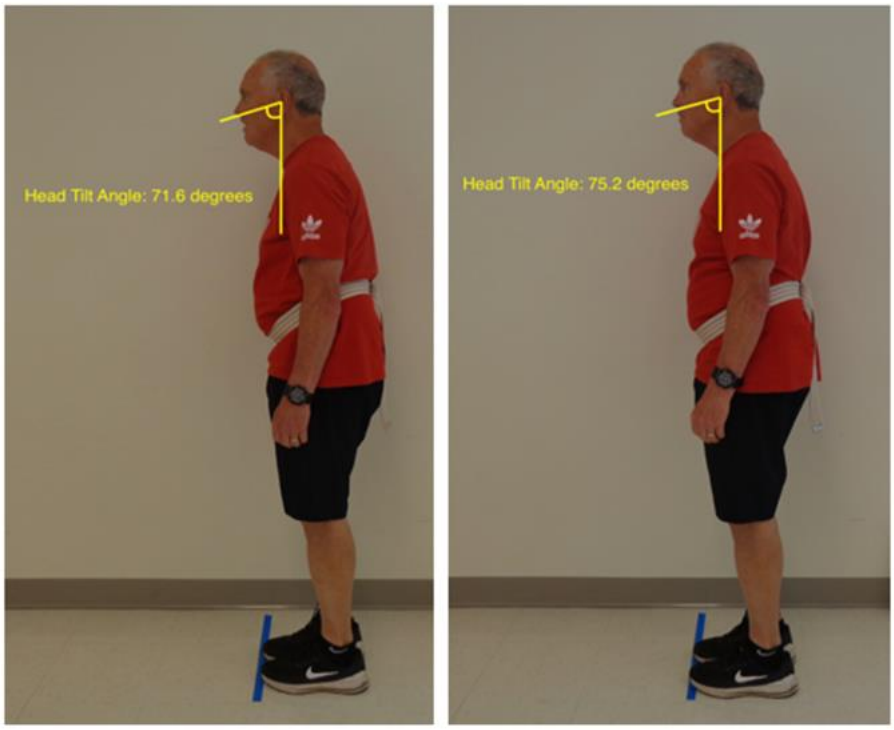

Figure 2&3. Figures illustrate a significant increase in head tilt angle (*p*=.037) in participant using the insertable heel lifts (right figure) as compared to without (left figure).

Discussion

Limitations to this study include the small sample size which was also homogeneous. The community near our institution is predominantly white and higher socio-economic level. This may have affected our samples' access to healthcare and thus the severity of the signs of their Parkinson's Disease.

Like the findings of Hastings *et al* (2018), we found a significant improvement in head tilt angle with the use of accommodating heel lifts, but not in the measures of trunk angle or vertical height. The difference in findings may be due to a difference in the verbal instructions provided during test administration. Participants were instructed to "stand up nice and straight," which may have altered their normal postural alignment. Fatigue is also a realistic concern in persons with PD. In the Hastings *et al* (2018) study the protocol required less exertion of the participants. Johanson *et al* looked at heel lifts in subjects with limited dorsiflexion and found that the impact was confined to the joints distal to the knee, however their subjects were without neurologic dysfunction and with a mean age of 25 years.[16] Other authors have utilized heel lifts on free ankles to effect plantar flexion and have seen improvement in gait performance; while this is the opposite of our intervention to accommodate plantarflexion, it does show that in a sample with neurologic dysfunction a heel lift intervention can have more extensive impact.[17]

Also, in the Hastings *et al* (2018) study, a significant correlation between the FES and PF contracture severity was found, however, we did not find a similar correlation between the ABC scale and PF contracture severity. This may be attributed to the fact that our participants were more functionally able due to our inclusion requirement for ambulation. While none of our participants had a normal DF range of 20 degrees, the deficits they presented with were minimal. It may have been the case that no one presented with enough DF severity to impact their sense of balance confidence. It is also possible that the difference lies in the two outcome measures. The FES asks how "concerned you are about the possibility of falling" while the ABC asks: "indicate your level of confidence in doing the activity without losing your balance".[18,10] The two outcome measures may be measuring different constructs.

Even without a measurable change in balance confidence we did see behavioral changes that relate to balance. We found that our participants not only quantitatively performed their turns faster, qualitatively, they looked more balanced as they were less inclined to hold their arms out straight to maintain their balance. rather, they were able to perform reciprocal arm swing, maintaining the natural flow of gait. Such observations indicated by Item 3 on the Dite and Temple (2002) clinic measure tool for turning trended towards significance when our participants used the heel lifts.

The improvement in head tilt angle with the use of the heel lifts is important because this change in postural alignment redirects the individual's gaze from the ground to their intended destination. In doing so, it is possible that heel lifts improve balance confidence with turning during walking by increasing visual input into the system. Lastly, Nakamura *et al* (2019) found that a loss of lumbar lordosis negatively affects TUG time in patients with PD and theorizes this may be due to one's center of gravity falling outside their base of support when the natural curve of the spine is lost with a stooped posture. As a result, energy consumption during activity is increased; compromising a person's ability to maintain balance when walking or standing.[9] This is consistent with our concept of improving upright alignment and moving the COM more directly over the feet to improve stability.

Whether a primary or secondary impairment, loss of DF range of motion will negatively impact postural alignment and balance. Passive range of motion of the ankle should always be assessed and prevention of the loss of range of motion should be a focus for patients with PD. When present, a lack of DF range of motion should be accommodated and a simple means of doing so is to use a in shoe heel lift.

Conclusion

From this study, we show that accommodating PF contractures with heel lifts significantly improves postural head tilt angle and decreases turn time as compared to without heel lifts, but has no significant effect on step length, gait speed, or overall TUG score in individuals with PD.

References

1. Bayle N, Patel AS, Crisan D, et al. Contribution of Step Length to Increase Walking and Turning Speed as a Marker of Parkinson's Disease Progression. *PloS one*. 2016; 11(4):e0152469.

2. Goodman CC. *Pathology for the Physical Therapist Assistant*. 4th ed. St. Louis, MO: Elsevier; 2017.

3. Weiss A, Herman T, Mirelman A, et al. The transition between turning and sitting in patients with Parkinson's disease: A wearable device detects an unexpected sequence of events. *Gait Posture*. 2019; 67:224–229.

4. Dite W, Temple VA. Development of a clinical measure of turning for older adults. *Am J Phys Med Rehabil.* 2002; 81(11): 857–866;

5. Plotnik M, Giladi N, Dagan Y, Hausdorff JM. Postural instability and fall risk in Parkinson's disease: impaired dual tasking, pacing, and bilateral coordination of gait during the "ON" medication state. *Exp Brain Res.* 2011; 210(3-4): 529–538.

6. Hastings J, Brown C, McNabb M, Repasky C. The Effect of Heel Lifts on Postural Stability in Individuals with Parkinson's Disease. *Phys Med Rehabil.* 2018, 1: 6.

7. Bartonek A, Lidbeck CM, Pettersson R, et al. Influence of heel lifts during standing in children with motor disorders. *Gait Posture.* 2011; 34(3): 426–431.

8. Wright E, DiBello SA. Principles of Ankle-Foot Orthosis Prescription in Ambulatory Bilateral Cerebral Palsy. *Phys Med Rehabil Clin N Am*. 2020; 31(1): 69–89.

9. Nakamura Y, Machida Y, Hanawa H, et al. Analysis of Relationships between Spinal Deformity and Walking Ability in Parkinson's Disease Patients. *Spine Surg Relat Res*. 2019; 3(4):348–353.

10. Activities-Specific Balance Confidence Scale. *Shirley Ryan AbilityLab*. Retrieved from: https://www.sralab.org/rehabilitation-measures/activities-specific-balance-confidence-scale.

11. Bloem BR, Marinus J, Almeida Q, et al. Measurement instruments to assess posture, gait, and balance in Parkinson's disease: Critique and recommendations. *Mov Disord.* 2016; 31(9):1342–1355.

12. Jung I-G, Yu I-Y, Kim S-Y, Lee D-K, Oh J-S. Reliability of ankle dorsiflexion passive range of motion measurements obtained using a hand-held goniometer and Biodex dynamometer in stroke patients. *J Phys Ther Sci*. 2015; 27(6): 1899–1901.

13. Lee JJ, You J. Movement measurement validity and reliability of the image j program for kinematic analysis: Semantic Scholar. *World Scientific.* 2016 16(8): 285.

14. Timed Up & Go (TUG). Center for Disease Control and Prevention. Retrieved from: https://www.cdc.gov/steadi/pdf/TUG_Test-print.pdf

15. Goetz CG, Poewe W, Rascol O, et al. Movement Disorder Society Task Force report on the Hoehn and Yahr staging scale: status and recommendations. *Mov Disord.* 2004; 19(9):1020–1028.

16. Johanson MA, Cooksey A, Hillier C, Kobbeman H, Stambaugh A. Heel lifts and Stance Phase of Gait in Subjects with Limited Ankle Dorsiflexion. *J Athl Train.* 2006; 41: 159–165.

17. Kurien AJ, Senthilvelkumar T, George J, Kumar V, Rebekah G. Heel Lift Improves Walking Ability of Persons with Traumatic Cauda Equina Syndrome—a pilot experimental study. Spinal Cord Ser Cases. 2020; 6(1):16.

18. Falls Efficacy Scale (FES). *Shirley Ryan AbilityLab.* Retrieved from: https://www.sralab.org/sites/default/files/2018-08/Falls-Efficacy-Scale.pdf