Original Article

American Journal of Men's Health
May-June 2019: 1–10
© The Author(s) 2019
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/1557988319839879
journals.sagepub.com/home/jmh
SAGE

Functional Balance and Gait Characteristics in Men With Lower Urinary Tract Symptoms Secondary to Benign Prostatic Hyperplasia

Emad Al-Yahya[1,2], Maha T. Mohammad[1], Jennifer Muhaidat[1], Saddam Al Demour[3], Dania Qutishat[1], Lara Al-Khlaifat[1], Rasha Okasheh[1], Sophie Lawrie[2], Patrick Esser[2], and Helen Dawes[2,4]

Abstract

The purpose of this cross-sectional study was to compare gait characteristics and functional balance Babilities in men with LUTS secondary to benign prostatic hyperplasia (BPH) to those of community-dwelling older adults under different conditions of increasing difficulties, and to aid health-care providers to identify those patients with decreased level of activity and increased risk of falls. We recruited a group of 43 men diagnosed with symptomatic BPH and a control group of 38 older men. Participants performed the timed up and go and 10-m walking tests under different conditions—namely, single task, dual-task motor, and dual-task cognitive. Time to complete the tests and spatial and temporal gait parameters were compared between groups and conditions via mixed-design ANOVA. Under dual-task conditions, individuals in both groups performed significantly worse compared to the single functional balance and walking tasks. As the complexity of the walking task increased—from dual-task motor to dual-task cognitive—significant differences between groups emerged. In particular, men with BPH performed worse than older adults in tasks demanding increased attentional control. Results suggest that dual-task decrements in functional balance and gait might explain decreased level of physical activity and increased risk of falls reported in men with LUTS. Health-care providers for men with LUTS due to BPH should assess for abnormal gait and remain vigilant for balance problems that may lead to decreased mobility and falls. The dual-task approach seems a feasible method to distinguish gait and balance impairments in men with BPH.

Keywords

BPH, LUTS, older adults, gait, dual task, physical activity

Received January 30, 2019; revised February 28, 2019; accepted March 3, 2019

Benign prostatic hyperplasia (BPH) is one of the most common and devastating diseases in men worldwide. Up to 50% of men exhibit evidence of BPH by the age of 50 years, and by the eighth decade of life this number surpasses 80% (Chughtai et al., 2016). Given the aging population worldwide, an overall increase in the rates of BPH is inevitable (Vuichoud & Loughlin, 2015); therefore health-care providers must be able to recognize and manage BPH and its complications accordingly.

BPH is characterized by benign proliferation of the epithelial and stromal components of the prostate (Chughtai et al., 2016). This benign overgrowth pushes against the urethra and the bladder, causing increased bladder outlet resistance (Kim, Larson, & Andriole, 2016; Sarma & Wei, 2012), and consequently the development

[1]School of Rehabilitation Sciences, The University of Jordan, Amman, Jordan
[2]Centre for Movement, Occupation and Rehabilitation Sciences, Faculty of Health and Life Sciences, Oxford Brookes University, UK
[3]Urology Devision, Department of Special Surgery, School of Medicine, The University of Jordan, Amman, Jordan
[4]Department of Clinical Neurology, University of Oxford, UK

Corresponding Author:
Emad Al-Yahya, PhD, School of Rehabilitation Sciences, The University of Jordan, Amman 11942, Jordan.
Email: e.alyahya@ju.edu.jo

of lower urinary tract symptoms (LUTS; Parsons, Sarma, McVary, & Wei, 2013). Therefore, BPH and LUTS become inextricable in managing older men with urinary symptoms (Kim et al., 2016).

While the exact mechanism for the development of BPH remains obscure (Kim et al., 2016), LUTS associated with BPH can be attributed to at least two mechanisms (Chughtai et al., 2016; Kim et al., 2016; Sarma & Wei, 2012). The first component is due to a static urethral obstruction caused by the increased epithelial tissue. The second is a dynamic component due to increased smooth muscle tone and resistance, which are determined by autonomic nervous system activity. Essentially, several lines of basic and clinical evidence point to the role of autonomic nervous system over activation in LUTS secondary to BPH (Choi, Lee, & Kim, 2010; Kim et al., 2016; McVary, Rademaker, Lloyd, & Gann, 2005; Platz et al., 1998).

BPH and associated LUTS have been linked to an increased risk of falls, decreased quality of life, impaired activity of daily living, and depression and sadness (Kim et al., 2016; Parsons et al., 2013; Sarma & Wei, 2012). Accumulating evidence suggests that modifiable metabolic and lifestyle factors are important in the etiology of BPH and LUTS including obesity, diabetes, diet and physical activity (Mongiu & McVary, 2009; Parsons et al., 2013; Raheem & Parsons, 2014). Physical activity of various intensities, including walking, has been reported not only to reduce BPH risk (Parsons & Kashefi, 2008; Platz et al., 1998), but also to delay its diagnosis and improve LUTS management (Park, Park, Chang, & Ryu, 2018; Wolin et al., 2015), presumably by decreasing autonomic nervous system over activation (Platz et al., 1998) and/or improving cardiovascular health (Parsons & Kashefi, 2008).

Walking is the most commonly reported mode of physical activity among the general population (Ham, Kruger, & Tudor-Locke, 2009). However, a large proportion of falls among older adults occurs during walking (Robinovitch et al., 2013; Stevens, Mahoney, & Ehrenreich, 2014). Therefore, it is important to consider gait and balance concerns when making treatment recommendations for older adults with BPH and LUTS. Physicians and health-care providers need to be aware of, and remain vigilant for, increasing falls risk and mobility impairment that may emerge from treatments including medications, bed rest, and occasional catheterization (Hsieh, Fleegle, & Arenson, 2014).

In line with this premise, gait and walking speed reflect health, well-being, and morbidity (Juen, Cheng, Prieto-Centurion, Krishnan, & Schatz, 2014; Studenski et al., 2011), with gait characteristics having been reported to predict fall (van Schooten et al., 2015; Weiss et al., 2013) and differentiate fallers from non-fallers (Howcroft, Kofman, & Lemaire, 2013; Rispens et al., 2015; Toebes, Hoozemans, Furrer, Dekker, & van Dieen, 2012). For example, gait has been increasingly used to monitor individuals with various disorders affecting neurological, cardiovascular, metabolic, and musculoskeletal systems (Cimolin et al., 2011; Esser et al., 2018; Juen et al., 2014; Kuate-Tegueu et al., 2017; Michael, Allen, & Macko, 2005; Valkanova et al., 2018; Zago et al., 2018). In community-dwelling men, LUTS have been suggested to be a potential risk factor for falls (Soliman, Meyer, & Baum, 2016). This notion is supported by indirect evidence associating urgency, frequency, nocturia, and incontinence with increased likelihood of falls in the elderly (de Rekeneire et al., 2003; Soliman et al., 2016; Tromp et al., 2001) To date, no study has investigated gait characteristics in men with BPH and LUTS.

An increasingly utilized approach to measure gait and balance within a clinical context is the dual-task methodology (Belghali, Chastan, Cignetti, Davenne, & Decker, 2017; Fino et al., 2018). That is to assess gait or balance while performing an additional motor or cognitive task, where associated performance deficits are termed dual-task interference. The rationale behind this relatively simple approach is two-fold (Al-Yahya et al., 2011): balance and gait are not pure automatic motor activities; rather they require cognitive resources, and purposeful everyday balance and gait activities commonly involve cognitive components such as remembering a shopping list or attending to a conversation. In fact, experimental studies have consistently reported that dual-task related balance and gait deficits increase with age (Al-Yahya et al., 2011), and poor dual-task performance can predict falls (Beauchet et al., 2008, 2009). These deficits have been associated with the walking task, complexity of the additional task, and individual's age and balance capability (Al-Yahya et al., 2011; Shumway-Cook & Woolacott, 2000). The main purpose of this study was to explore functional balance and gait characteristics in men with LUTS secondary to BPH while performing under conditions of different complexities. This would aid health-care providers in identifying those patients with decreased level of activity and increased risk of falls. The first research hypothesis was that an additional motor or cognitive task would compromise motor performance in functional balance and walking activities in older males with or without BPH. Considering the observation that increased autonomic nervous system activity has been linked to performance deficits during challenging walking tasks (Clark, Rose, Ring, & Porges, 2014), which also corresponds to individual's functioning level (Chatterjee et al., 2018), it was hypothesized second that men with BPH and LUTS would exhibit marked functional balance and gait deviations when compared to community-dwelling older adults, and these deviations become more prominent under more challenging conditions.

Subjects and Methods

In this cross-sectional experimental study, gait characteristics and functional balance in men diagnosed with BPH were compared to those in community-dwelling older men. In total, 81 men participated in this study from August 2015 to June 2017 in Amman, Jordan. The study conforms to the ethical principles of the Declaration of Helsinki and the institutional review board of the Jordan University Hospital reviewed and approved the protocol (10/2015/1186). All participants gave written informed consent prior to participation.

Participants

Forty-three men diagnosed with BPH and 38 community-dwelling older men participated in this study. Participants with BPH were recruited from the outpatient urology clinic of the Jordan University hospital. Inclusion criteria for the BPH group were (a) adult males diagnosed with moderate to severe LUTS secondary to BPH as confirmed by a senior urologist; (b) able to give informed consent; (c) able to walk independently for at least 5 min with or without a walking aid; and (d) with no cognitive, sensory, or psychological impairments precluding full engagement with experimental paradigm. LUTS secondary to BPH diagnosis was based on relevant medical history, physical examination including digital rectal exam, assessment of symptoms severity via the Arabic version of the International Prostate Symptom Score (IPSS; Hammad & Kaya, 2010), and urodynamics including uroflowmetry and post-void residuals (Abrams, Chapple, Khoury, Roehrborn, & de la Rosette, 2009), as well as prostate size via ultrasonography.

Community-dwelling older men were recruited from shopping malls, local community centers, and personal contact. Older adults (a) were 60 or more years old and able to give informed consent; (b) able to walk independently for at least 5 min with or without an aid; (c) did not report a history of neurological and/or psychiatric illness; and (d) showed no cognitive, sensory, or psychological impairments precluding full engagement with experimental paradigm.

Procedure

Demographic data of age, weight, height, as well as level of education for all participants were obtained and recorded. The Arabic version of the SF-36 health survey (Sabbah, Drouby, Sabbah, Retel-Rude, & Mercier, 2003) was utilized to assess participants' health-related quality of life. Because the experimental procedures involved a cognitive component, participants' global cognitive function was also assessed using the Arabic version of the Mini-Mental State Examination (MMSE; Al-Rajeh, Ogunniyi, Awada, Daif, & Zaidan, 1999).

Then different gait parameters were assessed by a modified version of the 10-m walk test (Graham, Ostir, Fisher, & Ottenbacher, 2008; Wade, Wood, Heller, Maggs, & Langton Hewer, 1987) for both groups. Participants completed the 10-m long path at their preferred speed in single task (ST) and under dual-task (DT)-motor and DT-cognitive conditions. During DT walking conditions, participants walked either while carrying a cup of water (DT-motor), or while counting backward by 2s, 3s, or 7s (based on their own preference) from a two- or three-digit number (DT-cognitive). The instructions before ST and DT trials were standardized for all participants and they were not given advice as to which task to prioritize during DT-counting while they were instructed to "try not to spill water" under DT-motor conditions. Gait spatial and temporal parameters were measured by using an inertial measurement unit (IMU) comprising a triaxial accelerometer, gyroscope, and magnetometer (MTx, Xsens, AN Enschede, the Netherlands) that was attached over the skin of the fourth lumbar vertebra (Esser, Dawes, Collett, & Howells, 2009) corresponding to the participant's projected center of mass during walking (Kerrigan, Viramontes, Corcoran, & LaRaia, 1995).

Participants' functional balance was evaluated using the Timed Up and Go (TUG) test (Podsiadlo & Richardson, 1991). In this test, the time (in seconds) required to stand up from an armed-chair, walk 3 m, turn, walk back and sit down again at preferred speed was measured using a stopwatch. Similar to the 10-m walk test, the time to complete the task was recorded in ST condition and two DT conditions; TUG-motor (i.e., while carrying a cup) and TUG-cognitive (i.e., while counting backward).

Each of the walking and functional balance tasks was repeated twice in a pseudo-random order, and for each related outcome the average of the two trials was considered for further analysis. So as to account for the probable effect of desire to void on gait functions (Booth, Paul, Rafferty, & Macinnes, 2013), LUTS/BPH patients were evaluated either when they did not report a strong desire to void or post void. Counting backward performance was assessed by rate (enumerated numbers per minute) and accuracy (percentage of correct answers).

Data Processing and Statistical Analysis

Postprocessing and analysis of the IMU was performed using a customized program written in LabVIEW version 15f (National Instruments, Austin, TX, USA) (Esser et al., 2009). Spatial and temporal gait parameters were then estimated according to the inverted pendulum gait model (Gonzalez, Alvarez, Lopez, & Alvarez, 2007; Zijlstra,

Table1. Participants' Demographics.

	BPH/LUTS $N = 43$ (Mean ± SD)	Older adults $N = 38$ (Mean ± SD)	Independent sample t-test	
			t	Sig. (2-tailed)
Age	64.6 ± 11.5	69.7 ± 6.1	2.540	**.013**
Height (m)	1.71 ± 0.07	1.71 ± 0.06	0.018	.986
Weight (kg)	84.3 ± 13.2	83.5 ± 11.1	−0.295	.768
Number of medications	4.14 ± 2.59	2.39 ± 2.15	−3.275	**.002**
MMSE	27.5 ± 2.4	27.7 ± 1.9	−0.373	.710
SF-36				
Physical functioning	76.3 ± 20.5	78.7 ± 14.7	−0.612	.550
Role functioning/physical	20.3 ± 34.2	73.7 ± 38.1	−6.598	**<.001**
Role functioning/emotional	28.7 ± 42.2	92.1 ± 21.1	−8.706	**<.001**
Energy/fatigue	59.3 ± 18.7	74.6 ± 14.9	−4.083	**<.001**
Emotional well-being	71.0 ± 18.3	84.8 ± 13.5	−3.866	**<.001**
Social functioning	82.6 ± 21.2	89.5 ± 16.6	−1.647	.104
Pain	76.9 ± 22.6	77.4 ± 24.5	−0.098	.922
General health	60.1 ± 16.5	64.3 ± 19.7	−1.048	.298
Health change	56.4 ± 22.6	51.9 ± 21.3	0.908	.367

Note. BPH = benign prostatic hyperplasia; LUTS = lower urinary tract symptoms; MMSE = Mini-Mental State Examination. Significant p values at a prior .05 alpha are in bold.

2004). For the purpose of this analysis, the following parameters (Whittle, 2008) were measured during the 10-m walk test: step time, defined as the time in milliseconds from ground contact of one foot to consecutive ground contact of the other foot; stride length, defined as the distance in meters between ground contact of one foot to subsequent ground contact of the same foot; and cadence, defined as number of steps per minute. Variability for each of these parameters was measured by the standard deviation.

Statistical analysis was performed using IBM SPSS Statistics (version 25 IBM SPSS, Inc, Armonk, NY, USA). Behavioral and demographic data were compared by independent samples t-tests. Gait and balance data were analyzed by conducting a mixed-design (i.e., a mixture of between-group and repeated measures) analysis of variance (ANOVA), with task (three levels; ST, DT-motor, and DT-cognitive) as the independent within-subject's variable for each parameter separately, and participants' group (older adults vs. patients) as the between-subject factor. In order to account for individuals' variances at baseline age, number of medications and counting rate—since some individuals preferred to count backward by 3 s while others by 7 s—were entered as "covariates" to the ANOVA model. All further analyses and pairwise comparisons were performed on adjusted values for these covariates. For all statistical tests, alpha level was set at .05 a priori, and SPSS-generated Bonferroni adjusted p values are quoted.

Results

Groups' Baseline Characteristics

A total of 43 male patients with LUTS secondary to BPH who fulfilled the inclusion criteria, and 38 older men were evaluated. Table 1 summarizes participants' demographics, MMSE scores, and SF-36 scores in different domains. There was no significant difference in MMSE scores between groups, and all participants scored above the cut-off point of 24 suggesting no cognitive impairment (Crum, Anthony, Bassett, & Folstein, 1993). Patients with BPH were significantly younger, took more medications, and reported worse health-related quality of life as opposed to older adults in the following scales: role limitations due to physical health, role limitations due to emotional problems, energy or fatigue, and emotional well-being.

Table 2 summarizes clinical details of BPH patients with LUTS. Based on total IPSS scores, a majority of the patients (67.5%) reported severe symptoms. All patients were on alpha-blockers either alone (53%), in addition to 5-alpha reductase inhibitors (32.5%), or in addition to anticholinergics (14%). Only one patient was on the three medications.

Group and Task Effects on Functional Balance and Walking Time

Differences between LUTS/BHP patients and older adults in functional balance capability (i.e., TUG) and gait speed

Table 2. Patients With LUTS Details.

LUTS onset in months,[a] mean ± *SD*	18.9 ± 12.2
IPSS questionnaire	
Mean ± *SD*	22 ± 6
Median (Min–Max)	21 (8–33)
Moderate symptoms, *N* (%)	14 (32.5)
Severe symptoms, *N* (%)	29 (67.5)
LUTS/BPH medications	
Alpha-blockers, *N* (%)	43 (100)
5-Alpha reductase inhibitors, *N* (%)	14 (32.5)
Anticholinergics, *N* (%)	6 (14)
Urodynamics and ultrasonography	
Pre-void volume (ml), mean ± *SD* (Min–Max)	385 ± 152 (109–650)
Post void residual (ml), mean ± *SD* (Min–Max)	105 ± 69 (0–265)
Q-Max (ml/s), mean ± *SD* (Min–Max)	14 ± 4 (8–34)
Prostate size (ml), mean ± *SD* (Min–Max)	56 ± 14 (26–80)

Note. BPH = benign prostatic hyperplasia; LUTS = lower urinary tract symptoms; IPSS = International Prostate Symptom Score.
[a]Based on their initial visit to JUH urology clinic.

Table 3. Functional Balance (TUG) and Gait Time (10 m).

	BPH/LUTS (*N* = 43) Mean ± *SD*			Older rdults (*N* = 38) Mean ± *SD*			*p* for ANOVA results		
	ST	$DT_{\text{-motor}}$	$DT_{\text{-cognitive}}$	ST	$DT_{\text{-motor}}$	$DT_{\text{-cognitive}}$	Task	Group	Interaction
TUG (second)	12.1 ± 2.7	12.7 ± 3	15.3 ± 4.3	11.1 ± 2.7	13.5 ± 3.7	14.4 ± 4	.509	.684	**.017**
10 m (second)	9.8 ± 1.9	9.9 ± 2.3	13.2 ± 4.2	9.7 ± 2.1	10.3 ± 2.4	11.2 ± 2.6	.341	.476	**.002**

Note. TUG = Timed Up and Go; BPH = benign prostatic hyperplasia; LUTS = lower urinary tract symptoms; ANOVA = analysis of variance; ST = single task; DT = dual task. Significant *p* values at a prior .05 alpha are in bold.

(i.e., 10-m walk test) were examined first. Table 3 summarizes TUG and 10-m walk tests results for both groups while performing under different conditions. Whilst there was no significant main effect of group or task on either TUG or 10-m walk test, ANOVA revealed a significant interaction between task and group for TUG ($f[2, 73] = 4.170$, $p = .017$) as well as for the 10-m test ($f[2, 74] = 6.581$, $p = .001$). To further explore these interactions, a series of pairwise comparisons between and within groups were conducted. For the TUG test, there was no significant difference between groups at any of the test conditions. However, in the older adults group, ST differed significantly from DT-motor ($t = 2.829$, $p = .006$) and DT-cognitive ($t = 3.397$, $p = .001$) with no significant difference between DT-motor and DT-cognitive. In the BPH/LUTS patients group, DT-cognitive differed significantly from ST ($t = 4.327$, $p < .001$) and DT-motor ($t = 2.284$, $p = .007$) with no significant difference between ST and DT-motor.

For the 10-m test, there was a significant difference between groups only while walking under DT-cognitive conditions ($t = 1.995$, $p = .049$). In the older adults group, there were no significant differences between tasks, while in the BPH/LUTS patients groups, DT-cognitive differed significantly from ST ($t = 4.590$, $p < .001$) and DT-motor ($t = 4.269$, $p < .001$) with no significant difference between ST and DT-motor.

Group and Task Effects on Gait Parameters

The effects of task and group on different spatial and temporal parameters of gait (i.e., step time, stride length, and cadence), as well as their variabilities, were examined while performing the 10-m test under different conditions. Table 4 summarizes these results.

ANOVA revealed significant main effects of task ($f[2, 73] = 7.464$, $p = .001$) on step time with no significant difference between groups or interaction between task and group. Further analysis showed significant differences between DT-cognitive and both of DT-motor ($p < .001$) and ST ($p < .001$) with no significant difference between DT-motor and ST (Figure 1a). In other words, participants in both groups demonstrated increased step time while walking under DT-cognitive condition

Table 4. Spatial and Temporal Parameters of Gait.

	BPH/LUTS (N = 43) Mean ± SD			Older adults (N = 38) Mean ± SD			p for ANOVA results		
	ST	DT_{-motor}	$DT_{-cognitive}$	ST	DT_{-motor}	$DT_{-cognitive}$	Task	Group	Interaction
Step time (ms)	591 ± 66	590 ± 70	677 ± 118	559 ± 47	564 ± 62	637 ± 82	**.001**	.156	.779
Step time variability	26.2 ± 13.6	34.0 ± 17.1	40.2 ± 28.4	40.6 ± 32.2	44.3 ± 39.8	56.6 ± 36.7	.382	.092	.709
Stride length (m)	1.41 ± 0.12	1.37 ± 0.11	1.32 ± 0.11	1.43 ± 0.12	1.36 ± 0.11	1.39 ± 0.11	**.018**	.425	<**.001**
Stride length variability (cm)	3.1 ± 1.0	2.3 ± 2.2	3.8 ± 1.6	7.1 ± 4.4	9.7 ± 5.3	8.5 ± 4.5	.311	<**.001**	**.011**
Cadence (step/min)	99.1 ± 11.1	102.4 ± 11.8	90.3 ± 15.4	117.0 ± 26.1	114.8 ± 33.8	104.4 ± 24.3	.218	**.012**	.609
Cadence variability	1.1 ± 2.7	4.8 ± 4.3	1.6 ± 3.3	21.1 ± 35	21.3 ± 54.8	23.9 ± 38	.833	**.010**	.581

Note. BPH = benign prostatic hyperplasia; LUTS = lower urinary tract symptoms; ANOVA = analysis of variance; ST = single task; DT = dual task. Significant p values at a prior .05 alpha are in bold.

compared to ST or DT-motor conditions. For step time variability, there was neither significant main effect of task or group nor an interaction between the two.

For stride length, there was a significant main effect of task (f[2, 73] = 4.109, p = .018), but not group, and there was a significant interaction between them (f[2, 73] = 8.697, p < .001). Further analysis of the task effect showed no significant difference between DT-cognitive and DT-motor, but both of them differed significantly from ST (p < .001 for both comparisons). For the group main effect, pairwise comparison revealed that BPH/LUTS patients and older adults differed significantly only under DT-cognitive (t = 2.324, p = .023; Figure 1b).

For stride length variability, there was a significant main effect of group (f[1, 73] = 39.22, p < .001) but not for task, with a significant interaction between them (f[2, 73] = 4.697, p = .011). Exploring the group effect further showed significant differences between groups in DT-motor (t = 6.992, p < .001) and DT-cognitive (t = 5.129, p < .001) conditions, with no significant differences between groups in ST.

Finally, there was a significant main effect of group on cadence (f[1, 73] = 6.645, p = .012) and cadence variability (f[1, 7]) = 7.030, p = .01) with no significant main effect of task or significant interaction on either of them. Pairwise comparisons between groups showed significant differences in cadence at ST (t = 3.319, p = .001) and DT-cognitive (t = 2.516, p = .014) conditions (Figure 1c), while differences in cadence variability between groups were significant in all conditions (all p values <.001).

Discussion

This is the first study to explore balance and gait characteristics in men with LUTS due to BPH.

Measures of functional balance and gait have been increasingly used to distinguish and monitor individuals with various disorders (Cimolin et al., 2011; Esser et al., 2018; Juen et al., 2014; Kuate-Tegueu et al., 2017; Michael et al., 2005; Valkanova et al., 2018; Zago et al., 2018). Gait and balance deficits are particularly compromised during dual-task requiring additional attention and may lead to decreased mobility and safety in community environments (Al-Yahya et al., 2011; Beauchet et al., 2008, 2009; Shumway-Cook & Woolacott, 2000). Therefore, investigating such deficits under dual-task conditions enables health-care providers to better recognize individuals with reduced mobility and physical activity, and might offer a framework for prophylactic interventions.

Time to execute a functional balance task as well as spatial and temporal gait parameters was compared in males with LUTS to those of older adult males while performing under different conditions of increasing complexities (i.e., ST, DT-motor, DT-cognitive). The research hypotheses were that individuals' performances in both groups would be affected by task complexity, and men with LUTS due to BPH would exhibit more prominent deviations than older adults as the complexity of the task increased. Results from the present study support these hypotheses. That is, men with LUTS due to BPH were more affected than community-dwelling older adults by the additional tasks, and differences between groups were more profound as the difficulty of the functional balance and gait activities increased.

Measuring gait and functional balance in individuals while performing a secondary attentional demanding task, the dual-task approach, has been increasingly used to assess the risk of falls among different populations (Beauchet et al., 2009; Belghali et al., 2017; Montero-Odasso, Verghese, Beauchet, & Hausdorff, 2012). In fact, DT-related deviations in balance and gait are well documented and vary according to difficulty of the walking task, complexity of the additional task, and the individual's age and balance capability (Al-Yahya et al., 2011; Shumway-Cook & Woolacott, 2000). For example, in a

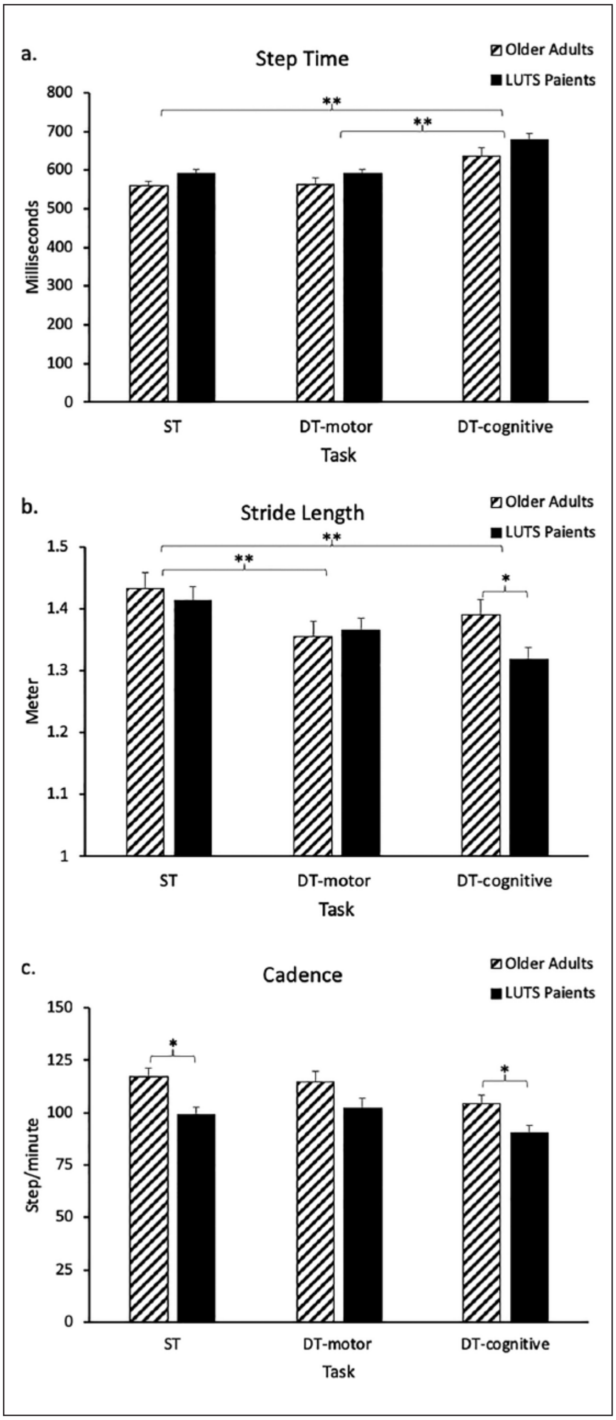

Figure 1. Group means (and standard errors) of different gait parameters (a. step time, b. stride length, and c. cadence) measured while performing the 10-m walking test under different conditions. Asterisks denote significant differences between groups. Double asterisks denote significant differences between tasks.

recent meta-analysis, it has been reported that gait performance was most affected when complex cognitive tasks were concurrently performed, and that older age and poorer cognitive function were strongly associated with gait speed reduction under DT conditions (Al-Yahya et al., 2011). Therefore, present results advocate the utilization of simple DT paradigm to assess gait and balance performance in men with LUTS and older adults. This was evident by the significant task effect on step time observed in both groups while performing under different conditions, and the observation that task interference was more prominent for the cognitive task more than the motor task.

Intriguingly, DT interference for most of the main outcome measures was more prominent in men with BPH compared to older adults. That is, the effect of the additional task on balance and gait was more in men with BPH. Increased DT interference in men with BPH might reflect increased difficulties with gait and balance in them compared to older adults (Al-Yahya et al., 2011; Shumway-Cook & Woolacott, 2000), which might be attributed to the autonomic nervous system overactivation reported in men with BPH. In support for this explanation, it has been reported that autonomic nervous system activity, measured by skin conductance, was increased in older adults when they perform a complex walking task (i.e., obstacle negotiating and DT walking) compared to usual walking (Clark et al., 2014; Hadjistavropoulos et al., 2012), and such autonomic nervous system activity corresponded to the individual's functioning level (Chatterjee et al., 2018). Although the number of medications was adjusted for in the primary analysis, certain medications used in the treatment of BPH may be associated with gait and balance impairment (Woolcott et al., 2009), and adverse events could occur such as dizziness and orthostatic hypotension which could increase risk for falls (Hsieh et al., 2014). In particular, men on prostate-specific alpha antagonists have noticeable increased risks of falling and fracture, as well as increased risk of hypotension and head trauma (Welk et al., 2015). Whether the observed further DT decrements in gait and balance in men with BPH compared to older adults are related to autonomic nervous system activity, medication side effects, or combinations of these and other factors warrants future investigation.

Difficulties with gait and balance in older adults are often multifactorial and have been linked to increased risk of falls and decreased level of physical activity (Tinetti & Kumar, 2010). In particular, DT decrements in gait and balance have been linked to increased risk of falls (Springer et al., 2006). It is also plausible that difficulty completing a DT may be limiting individuals' abilities to be active when additional attention is required (Brustio, Magistro, Zecca, Rabaglietti, & Liubicich, 2017). Taken together, the present results suggest that DT decrements in functional balance and gait might contribute to the decreased level of physical activity and increased risk of falls reported in men with BPH and associated LUTS. Health-care providers for men with LUTS due to BPH should assess for abnormal gait and for falls and maintain vigilant for gait and balance problems that may lead to decreased physical activity and mobility, as well as increased risk of falls. In line with this recommendation, current guidelines advocate that older persons should be screened for falls (Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011). Dual-task approach provides a simple and clinically feasible method to test for functional decline and frailty in men with BPH, and consequently it aids to distinguish potential fallers among them at earlier stages allowing for preventive interventions (Smith, Cusack, & Blake, 2016).

The interpretation and potential practical application of present results should be considered in light of the following limitations. First, the present study was cross-sectional; the risks of falls in men with BPH and their relation to gait deficits and physical activity level have yet to be evaluated . Second, the onset of LUTS/BPH was estimated from the first visit to our clinic, which might not be accurate for all patients. Third, while data collected during the 10-m walking test may provide reliable temporal and spatial gait parameters, measuring their variability reliably may require longer walking distance, particularly under DT condition (Hollman et al., 2010). Finally, although individuals' variability in counting performance was adjusted for, the effect of dual tasking on the cognitive task—the effect of gait on counting rate and accuracy—not measured, which would have enabled ruling out the effect of task prioritization on DT performance.

Acknowledgments

We would like to thank participants who volunteered for this study. Also, we would like to acknowledge the help of research assistants who helped in data collection and filing.

Abbreviations

BPH, benign prostate hyperplasia; LUTS, lower urinary tract symptoms; TUG, timed up and go; IPSS, international prostate symptom score; ST, single task; DT, dual task

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study was funded by the Deanship of Scientific Research of The University of Jordan.

References

Abrams, P., Chapple, C., Khoury, S., Roehrborn, C., & de la Rosette, J. (2009). Evaluation and treatment of lower urinary tract symptoms in older men. *The Journal of Urology*, *189*(1 Suppl), S93–S101.

Al-Rajeh, S., Ogunniyi, A., Awada, A., Daif, A., & Zaidan, R. (1999). Preliminary assessment of an Arabic version of the Mini-Mental state examination. *Annals of Saudi Medicine*, *19*(2), 150–152.

Al-Yahya, E., Dawes, H., Smith, L., Dennis, A., Howells, K., & Cockburn, J. (2011). Cognitive motor interference while walking: A systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews*, *35*(3), 715–728.

Beauchet, O., Annweiler, C., Allali, G., Berrut, G., Herrmann, F. R., & Dubost, V. (2008). Recurrent falls and dual task-related decrease in walking speed: Is there a relationship? *Journal of the American Geriatrics Society*, *56*(7), 1265–1269.

Beauchet, O., Annweiler, C., Dubost, V., Allali, G., Kressig, R. W., Bridenbaugh, S., … Herrmann, F. R. (2009). Stops walking when talking: A predictor of falls in older adults? *European Journal of Neurology*, *16*(7), 786–795.

Belghali, M., Chastan, N., Cignetti, F., Davenne, D., & Decker, L. M. (2017). Loss of gait control assessed by cognitive-motor dual-tasks: Pros and cons in detecting people at risk of developing Alzheimer's and Parkinson's diseases. *Geroscience*, *39*(3), 305–329.

Booth, J., Paul, L., Rafferty, D., & Macinnes, C. (2013). The relationship between urinary bladder control and gait in women. *Neurourology & Urodynamics*, *32*(1), 43–47.

Brustio, P. R., Magistro, D., Zecca, M., Rabaglietti, E., & Liubicich, M. E. (2017). Age-related decrements in dual-task performance: Comparison of different mobility and cognitive tasks. A cross sectional study. *PLoS One*, *12*(7), e0181698.

Chatterjee, S. A., Daly, J. J., Porges, E. C., Fox, E. J., Rose, D. K., McGuirk, T. E., … Clark, D. J. (2018). Mobility function and recovery after stroke: Preliminary insights from sympathetic nervous system activity. *Journal of Neurologic Physical Therapy*, *42*(4), 224–232.

Choi, J. B., Lee, J. G., & Kim, Y. S. (2010). Characteristics of autonomic nervous system activity in men with lower urinary tract symptoms (LUTS): Analysis of heart rate variability in men with LUTS. *Urology*, *75*(1), 138–142.

Chughtai, B., Forde, J. C., Thomas, D. D., Laor, L., Hossack, T., Woo, H. H., … Kaplan, S. A. (2016). Benign prostatic hyperplasia. *Nature Reviews Disease Primers*, *2*, 16031.

Cimolin, V., Vismara, L., Galli, M., Zaina, F., Negrini, S., & Capodaglio, P. (2011). Effects of obesity and chronic low back pain on gait. *Journal of Neuroengineering and Rehabilitation*, *8*, 55.

Clark, D. J., Rose, D. K., Ring, S. A., & Porges, E. C. (2014). Utilization of central nervous system resources for preparation and performance of complex walking tasks in older adults. *Frontiers in Aging Neuroscieince*, *6*, 217.

Crum, R. M., Anthony, J. C., Bassett, S. S., & Folstein, M. F. (1993). Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA*, *269*(18), 2386–2391.

de Rekeneire, N., Visser, M., Peila, R., Nevitt, M. C., Cauley, J. A., Tylavsky, F. A., … Harris, T. B. (2003). Is a fall just a fall: Correlates of falling in healthy older persons. The health, aging and body composition study. *Journal of the American Geriatrics Society*, *51*(6), 841–846.

Esser, P., Collett, J., Maynard, K., Steins, D., Hillier, A., Buckingham, J., … Dawes, H. (2018). Single sensor gait analysis to detect diabetic peripheral neuropathy: A proof of principle study. *Diabetes & Metabolism*, *42*(1), 82–86.

Esser, P., Dawes, H., Collett, J., & Howells, K. (2009). IMU: Inertial sensing of vertical CoM movement. *Journal of Biomechanics*, *42*(10), 1578–1581.

Fino, P. C., Parrington, L., Pitt, W., Martini, D. N., Chesnutt, J. C., Chou, L. S., & King, L. A. (2018). Detecting gait abnormalities after concussion or mild traumatic brain injury: A systematic review of single-task, dual-task, and complex gait. *Gait & Posture*, *62*, 157–166.

Gonzalez, R. C., Alvarez, D., Lopez, A. M., & Alvarez, J. C. (2007). *Modified pendulum model for mean step length estimation*. Paper presented at the Engineering in Medicine and Biology Society. 29th Annual International Conference of the IEEE, Lyon, France.

Graham, J. E., Ostir, G. V., Fisher, S. R., & Ottenbacher, K. J. (2008). Assessing walking speed in clinical research: A systematic review. *Journal of Evaluation in Clinical Practice*, *14*(4), 552–562.

Hadjistavropoulos, T., Carleton, R. N., Delbaere, K., Barden, J., Zwakhalen, S., Fitzgerald, B., … Hadjistavropoulos, H. (2012). The relationship of fear of falling and balance confidence with balance and dual tasking performance. *Psychology & Aging*, *27*(1), 1–13.

Ham, S. A., Kruger, J., & Tudor-Locke, C. (2009). Participation by US adults in sports, exercise, and recreational physical activities. *Journal of Physical Activity & Health*, *6*(1), 6–14.

Hammad, F. T., & Kaya, M. A. (2010). Development and validation of an Arabic version of the international prostate symptom score. *British Journal of Urology International*, *105*(10), 1434–1438.

Hollman, J. H., Childs, K. B., McNeil, M. L., Mueller, A. C., Quilter, C. M., & Youdas, J. W. (2010). Number of strides required for reliable measurements of pace, rhythm and variability parameters of gait during normal and dual task walking in older individuals. *Gait & Posture*, *32*(1), 23–28.

Howcroft, J., Kofman, J., & Lemaire, E. D. (2013). Review of fall risk assessment in geriatric populations using inertial sensors. *Journal of Neuroengineering & Rehabilitation*, *10*(1), 91.

Hsieh, C., Fleegle, S., & Arenson, C. A. (2014). Mobility, gait, balance, and falls. In T. L. Griebling (Ed.), *Geriatric urology* (pp. 89–102). New York, NY: Springer.

Juen, J., Cheng, Q., Prieto-Centurion, V., Krishnan, J. A., & Schatz, B. (2014). Health monitors for chronic disease by gait analysis with mobile phones. *Telemedicine Journal & e-Health*, *20*(11), 1035–1041.

Kerrigan, D. C., Viramontes, B. E., Corcoran, P. J., & LaRaia, P. J. (1995). Measured versus predicted vertical displacement of the sacrum during gait as a tool to measure biomechanical gait performance. *American Journal of Physical Medicine & Rehabilitation*, *74*(1), 3–8.

Kim, E. H., Larson, J. A., & Andriole, G. L. (2016). Management of benign prostatic hyperplasia. *Annual Review of Medicine*, *67*, 137–151.

Kuate-Tegueu, C., Avila-Funes, J. A., Simo, N., Le Goff, M., Amieva, H., Dartigues, J. F., & Tabue-Teguo, M. (2017). Association of gait speed, psychomotor speed, and dementia. *Journal of Alzheimer's Disease*, *60*(2), 585–592.

McVary, K. T., Rademaker, A., Lloyd, G. L., & Gann, P. (2005). Autonomic nervous system overactivity in men with lower urinary tract symptoms secondary to benign prostatic hyperplasia. *The Journal of Urology*, *174*(4 Pt 1), 1327–1433.

Michael, K. M., Allen, J. K., & Macko, R. F. (2005). Reduced ambulatory activity after stroke: The role of balance, gait, and cardiovascular fitness. *Archives of Physical Medicine & Rehabilitation*, *86*(8), 1552–1556.

Mongiu, A. K., & McVary, K. T. (2009). Lower urinary tract symptoms, benign prostatic hyperplasia, and obesity. *Current Urology Reports*, *10*(4), 247–253.

Montero-Odasso, M., Verghese, J., Beauchet, O., & Hausdorff, J. M. (2012). Gait and cognition: A complementary approach to understanding brain function and the risk of falling. *Journal of the American Geriatrics Society*, *60*(11), 2127–2136.

Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. (2011). Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *Journal of the American Geriatrics Society*, *59*(1), 148–157.

Park, H. J., Park, C. H., Chang, Y., & Ryu, S. (2018). Sitting time, physical activity and the risk of lower urinary tract symptoms: A cohort study. *British Journal of Urology International*, *122*(2), 293–299.

Parsons, J. K., & Kashefi, C. (2008). Physical activity, benign prostatic hyperplasia, and lower urinary tract symptoms. *European Urology*, *53*(6), 1228–1235.

Parsons, J. K., Sarma, A. V., McVary, K., & Wei, J. T. (2013). Obesity and benign prostatic hyperplasia: Clinical connections, emerging etiological paradigms and future directions. *Journal of Urology*, *189*(1 Suppl), S102–S106.

Platz, E. A., Kawachi, I., Rimm, E. B., Colditz, G. A., Stampfer, M. J., Willett, W. C., & Giovannucci, E. (1998). Physical activity and benign prostatic hyperplasia. *Archives of Internal Medicine*, *158*(21), 2349–2356.

Podsiadlo, D., & Richardson, S. (1991). The timed "Up & Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, *39*(2), 142–148.

Raheem, O. A., & Parsons, J. K. (2014). Associations of obesity, physical activity and diet with benign prostatic hyperplasia and lower urinary tract symptoms. *Current Opinion in Urology*, *24*(1), 10–14.

Rispens, S. M., van Schooten, K. S., Pijnappels, M., Daffertshofer, A., Beek, P. J., & van Dieen, J. H. (2015). Identification of fall risk predictors in daily life measurements: Gait characteristics' reliability and association with self-reported fall history. *Neurorehabilitation & Neural Repair*, *29*(1), 54–61.

Robinovitch, S. N., Feldman, F., Yang, Y., Schonnop, R., Leung, P. M., Sarraf, T., … Loughin, M. (2013). Video capture of the circumstances of falls in elderly people residing in long-term care: An observational study. *Lancet*, *381*(9860), 47–54.

Sabbah, I., Drouby, N., Sabbah, S., Retel-Rude, N., & Mercier, M. (2003). Quality of life in rural and urban populations in Lebanon using SF-36 health survey. *Health & Quality of Life Outcomes*, *1*, 30.

Sarma, A. V., & Wei, J. T. (2012). Clinical practice. Benign prostatic hyperplasia and lower urinary tract symptoms. *The New England Journal of Medicine*, *367*(3), 248–257.

Shumway-Cook, A., & Woolacott, M. (2000). Attentional demands and postural control: The effects of sensory context. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *55A*, M10–M16.

Smith, E., Cusack, T., & Blake, C. (2016). The effect of a dual task on gait speed in community dwelling older adults: A systematic review and meta-analysis. *Gait & Posture*, *44*, 250–258.

Soliman, Y., Meyer, R., & Baum, N. (2016). Falls in the elderly secondary to urinary symptoms. *Reviews in Urology*, *18*(1), 28–32.

Springer, S., Giladi, N., Peretz, C., Yogev, G., Simon, E. S., & Hausdorff, J. M. (2006). Dual-tasking effects on gait variability: The role of aging, falls, and executive function. *Movement Disorders*, *21*(7), 950–957.

Stevens, J. A., Mahoney, J. E., & Ehrenreich, H. (2014). Circumstances and outcomes of falls among high risk community-dwelling older adults. *Injury Epidemiology*, *1*(1), 5.

Studenski, S., Perera, S., Patel, K., Rosano, C., Faulkner, K., Inzitari, M., … Guralnik, J. (2011). Gait speed and survival in older adults. *JAMA: The Journal of the American Medical Association*, *305*(1), 50–58. doi:10.1001/jama.2010.1923

Tinetti, M. E., & Kumar, C. (2010). The patient who falls: "It's always a trade-off". *JAMA*, *303*(3), 258–266.

Toebes, M. J., Hoozemans, M. J., Furrer, R., Dekker, J., & van Dieen, J. H. (2012). Local dynamic stability and variability of gait are associated with fall history in elderly subjects. *Gait & Posture*, *36*(3), 527–531.

Tromp, A. M., Pluijm, S. M., Smit, J. H., Deeg, D. J., Bouter, L. M., & Lips, P. (2001). Fall-risk screening test: A prospective study on predictors for falls in community-dwelling elderly. *Journal of Clinical Epidemiology*, *54*(8), 837–844.

Valkanova, V., Esser, P., Demnitz, N., Sexton, C. E., Zsoldos, E., Mahmood, A., … Ebmeier, K. P. (2018). Association between gait and cognition in an elderly population based sample. *Gait & Posture*, *65*, 240–245.

van Schooten, K. S., Pijnappels, M., Rispens, S. M., Elders, P. J., Lips, P., & van Dieen, J. H. (2015). Ambulatory fall-risk assessment: Amount and quality of daily-life gait predict falls in older adults. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *70*(5), 608–615.

Vuichoud, C., & Loughlin, K. R. (2015). Benign prostatic hyperplasia: Epidemiology, economics and evaluation. *The Canadian Journal of Urology*, *22*(Suppl 1), 1–6.

Wade, D. T., Wood, V. A., Heller, A., Maggs, J., & Langton Hewer, R. (1987). Walking after stroke. Measurement and recovery over the first 3 months. *Scandinavian Journal of Rehabilitation Medicine*, *19*(1), 25–30.

Weiss, A., Brozgol, M., Dorfman, M., Herman, T., Shema, S., Giladi, N., & Hausdorff, J. M. (2013). Does the evaluation of gait quality during daily life provide insight into fall risk? A novel approach using 3-day accelerometer recordings. *Neurorehabilitation & Neural Repair*, *27*(8), 742–752.

Welk, B., McArthur, E., Fraser, L. A., Hayward, J., Dixon, S., Hwang, Y. J., & Ordon, M. (2015). The risk of fall and fracture with the initiation of a prostate-selective alpha antagonist: A population based cohort study. *The British Medical Journal*, *351*, h5398.

Whittle, M. (2008). *Gait analysis: An introduction* (4th ed.). Philadelphia, PA: Elsevier Ltd.

Wolin, K. Y., Grubb, R. L., 3rd, Pakpahan, R., Ragard, L., Mabie, J., Andriole, G. L., & Sutcliffe, S. (2015). Physical activity and benign prostatic hyperplasia-related outcomes and nocturia. *Medicine & Science in Sports & Exercise*, *47*(3), 581–592.

Woolcott, J. C., Richardson, K. J., Wiens, M. O., Patel, B., Marin, J., Khan, K. M., & Marra, C. A. (2009). Meta-analysis of the impact of 9 medication classes on falls in elderly persons. *Archives of Internal Medicine*, *169*(21), 1952–1960.

Zago, M., Sforza, C., Pacifici, I., Cimolin, V., Camerota, F., Celletti, C., … Galli, M. (2018). Gait evaluation using inertial measurement units in subjects with Parkinson's disease. *Journal of Electromyography & Kinesiology*, *42*, 44–48.

Zijlstra, W. (2004). Assessment of spatio-temporal parameters during unconstrained walking. *European Journal of Applied Physiology*, *92*(1), 39–44.