ORIGINAL RESEARCH

Do Older Adults with Overactive Bladder Demonstrate Impaired Executive Function Compared to Their Peers Without OAB?

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ABSTRACT

Background

Maintaining urinary continence is not an automatic process, but relies on continuous processing of sensory signals from the bladder and suppression of the desire to void. Urinary incontinence (UI) and lower urinary tract symptoms (LUTS), including urinary urgency, frequency, and nocturia are highly prevalent among the general population. This prevalence rises in association with increasing age, and this may be in part due to changes in the central nervous system rather than the urinary tract. The aim of this study was to assess if older adults with overactive bladder (OAB) had demonstrable impairment in executive function.

Methods

This was a cross-sectional study comparing the performance of adults aged 65 and over with and without OAB on two cognitive tests, the Trail Making Test B (TMT-B) and simple reaction time (SRT). OAB was defined as urgency, with at least weekly urgency incontinence and a daytime urinary frequency of 8 or more. The control group were defined as a Bladder control Self-Assessment Questionnaire (B-SAQ) score of ≤4.

Results

56 participants were recruited, of whom 35 met criteria for OAB. The OAB group took significantly longer to complete the TMT-B than the control group (103s vs. 77s, $p = .003$). There was no difference in the SRT

Conclusions

In this sample of older adults, OAB was associated with measurable slower performance on the TMT-B, suggesting that impaired executive function is associated with OAB.

Key words: urinary urgency, urinary incontinence, overactive bladder, executive function, ageing

INTRODUCTION

Urinary incontinence (UI) and lower urinary tract symptoms (LUTS), including urinary urgency, frequency, and nocturia are highly prevalent amongst the general population; this prevalence rises in association with increasing age.[(1)] UI and LUTS are stigmatizing conditions,[(2)] which are often under-reported and under-treated, particularly in older individuals.[(3,4)] The most commonly experienced LUTS are frequency, urgency, and nocturia, which are components of overactive bladder syndrome (OAB).[(5)] The most common form of UI in older people is urgency urinary incontinence (UUI), urine loss associated with urinary urgency, a sudden, compelling desire to void that is difficult to defer.[(5)]

The maintenance of continence is not a wholly automatic process, but rather one which relies on the coordination of multiple areas of the brain, collating and processing sensory input from the bladder.[(6)] Sensory input from the lower urinary tract is conveyed by the pudendal and hypogastric nerves to multiple areas of the brain including the pontine micturition centre, the hypothalamus, the periaqueductal grey matter, and the frontal and pre-frontal cortices.[(6,7)] These latter areas, which also play a role in executive function, also activate to suppress the sensation of urinary urge, allowing an individual to be consciously unaware of their bladder, except at times of experiencing a desire to void. In the healthy individual, this sensation is suppressible, allowing voiding to occur only in at a time and place of one's own choosing.

Given the complexity of neurological control of continence and evidence that urge is less well suppressed in older people,[(8)] it is not surprising that OAB in older people may be as much a brain disease as a disorder of the bladder.[(9)]

There is a strong association between LUTS and falls in older men[(10)] and women,[(11-14)] with estimates of the odds ratios for falls in the presence of LUTS ranging from 1.5 to 2.3.[(15)] This association has not been explained in the literature, but it has been suggested that the sensation of urinary urgency may exert deleterious cognitive effects by acting as a source of diverted attention,[15] the concept where performing two simultaneous cognitive tasks leads to a decline in the performance of one or both of those tasks.[16] Diverted attention has been shown to lead to gait changes in older people.[17,18]

Although largely automatic,[19] successful ambulation is reliant in part on executive function, with impairment of executive function being associated with slower gait speed and increased falls risk in older adults,[20] and poor performance on executive function testing predicting increased falls risk five years before falls occurred.[21] Lower performance on tests of executive function, memory, and verbal IQ are associated with slower gait speed[22] and cognitively-intact older people with "poor" and "intermediate" performance on the Trail Making Test (TMT), a measure of executive function, were slower when completing an obstacle course than those with normal TMT performance.[23]

Given that impairment in executive function is associated with both LUTS and falls, it may be that this impairment forms part of the known association between LUTS and falls by acting as a confounding factor. As part of a wider research program, this study aimed to examine the hypothesis that older adults with OAB may demonstrate impairment in executive function compared to their peers who do not have OAB.

METHODS

This was a cross-sectional study comparing the performance of adults aged 65 years and over with and without OAB on two cognitive tests, one for executive function and the other for reaction time. The study was approved by the local research ethics committee, PRO00079683.

Recruitment and Participants

Potential participants were recruited by advertising in community newsletters for seniors. Participants were included if they were aged 65 or older, community-dwelling, and without a diagnosis of cognitive impairment or dementia, urinary catheter use (indwelling or intermittent self-catheterisation), on dialysis, diagnosed with neurodegenerative disease potentially causing cognitive impairment, or any subjective complaint of cognitive impairment. People were excluded if they were unable to understand English, to complete cognitive testing (for example, due to sensory impairment such as blindness or colour blindness), inability to hold a pen, or being treated for OAB with either bladder antimuscarinics or β3 adrenoceptor agonists.

Procedures

Respondents to the adverts were screened by telephone and those who met the inclusion criteria were invited to participate. Following written informed consent, participants completed the Bladder control Self-Assessment Questionnaire (B-SAQ),[24] a self reported measure of LUTS and bother. Those without LUTS, defined as a B-SAQ of ≤4, comprised the control group, and those scoring 5 or higher comprised the OAB group. The OAB group also required a daytime frequency of 8 or more urinary urgency, and urgency incontinence at least weekly for inclusion.

The study was performed in a quiet office, free from distractions. Patient-reported demographic information, reported comorbidities, and prescribed medication were recorded, and a Charlson Comorbidity Index (CCI)[25] and anticholinergic burden (ACB) score[26] were calculated for each participant. Participants were asked to void their bladder, then complete two tests of cognition, the Trail Making B Test (TMT-B) and a computer-based test of simple reaction time (SRT).[27]

The TMT-B is a validated test of cognition, testing visual search, scanning, mental flexibility, and executive function.[28] Participants were asked to link in sequence a series of 25 circles, each containing one of the letters A to L or the numbers 1 to 12. Normative data by age are available, suggesting, for those aged 65–69 years, a median time for completion of 68 sec, and 142.5 sec in those aged 85–89.[28] The time taken to complete the test and the number of errors made were recorded by a research assistant. The examiner did not interrupt or correct errors during the conduction of the test. To improve data accuracy and reduce the effects of a small number of delays, participants performed two different layouts of the TMT-B, with the mean time taken recorded.

To measure SRT, an online test[27] was used. Participants were asked press the spacebar on a standard computer keyboard as quickly as possible following a visual stimulus (an on-screen image changing from red to green) five times, with the mean reaction time reported by the software. SRT is among the most basic measures of processing speed[29] and correlates well with measures of fluid intelligence.[30]

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics. The differences between the groups were examined using two-way Fisher's Exact Test (for categorical variables with small sample size) and two-way independent samples *t*-test for continuous and ordinal variables which were normally distributed, or the two-way Mann-Whitney U test for those which were not normally distributed and could not be transformed. For the purposes of analysis, the ACB score was treated as an ordinal variable.

For each cognitive test, the time was recorded and compared between groups using a two-way independent samples *t*-test (for normally-distributed data) or two-way Mann-Whitney U-test (for non-normally distributed data). Statistical significance was pre-defined at $p < .05$. Data were analyzed using SPSS v25 (IBM Corp, USA).

Sample Size

No previous work or pilot data were available from which to undertake a sample size analysis. We aimed to recruit at least 20 people per group to allow robust estimates of effect size in order to quantify the size of difference between the two groups.

RESULTS

Fifty-six people were recruited, of whom 35 (62%) met the criteria for inclusion in the OAB group. The OAB group had more women than the control group (85% vs. 62%, p = .054, Fisher's exact test). No significant differences between the groups were seen with age, CCI, number of medications take, or ACB score. These data are summarized in Table 1 and graphically in Figures 1 to 3.

Time to complete the TMT-B was statistically significantly longer in the OAB group (OAB 103 sec, control 77 sec, relative difference 26%, p = .003). There was no statistically significant difference in the number of errors made between the groups (2.28 vs. 2.04, p = .81). There was no difference in SRT between the groups (Table 2).

DISCUSSION

Participants with symptoms of OAB took longer to complete the TMT-B than those without OAB, and no differences were seen between the OAB and non OAB groups in SRT. The two groups were similar in age, comorbidities, and medication use, and none of the participants had subjective experience of any cognitive impairment.

The time taken to complete the TMT-B test is known to be a marker of frontal lobe and executive function,[31] predominantly cognitive flexibility, but is not specific for sub-domains of executive function impairment.[32] Normally, the bladder is held in a state of "tonic suppression of voiding, that is relaxed only when voiding is both desired and socially appropriate", through inhibition by the frontal lobes via the pre-frontal cortices inactivating the periaqueductal grey matter and, in turn, the pontine micturition centre.[7] Urinary urgency, and in turn OAB, could result from changes in the function of the frontal lobes.[9] Studies using functional MRI have identified

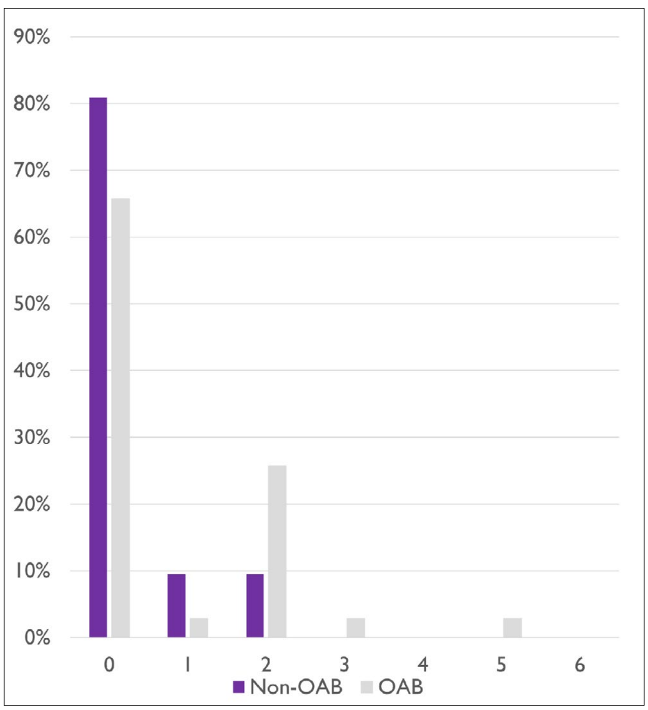

FIGURE 1. Charlson comorbidity index

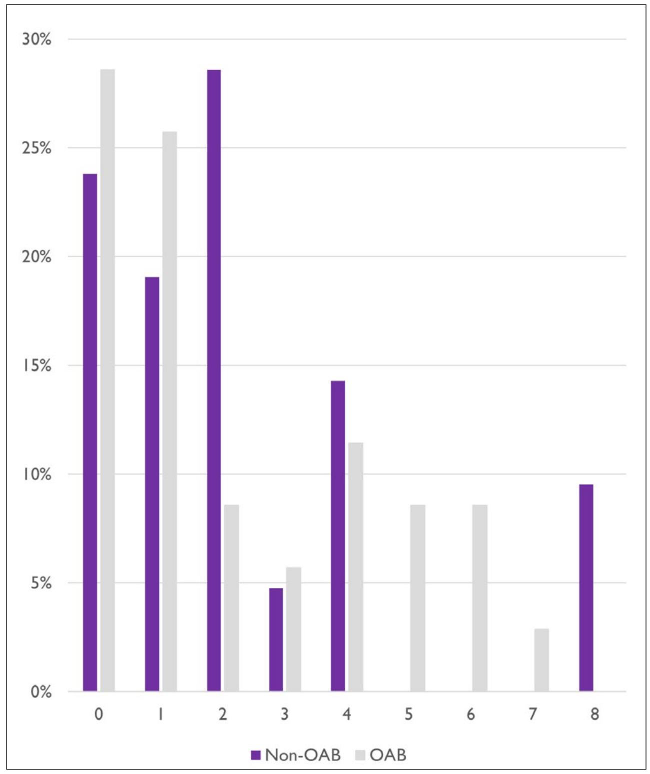

FIGURE 2. Number of prescribed medications

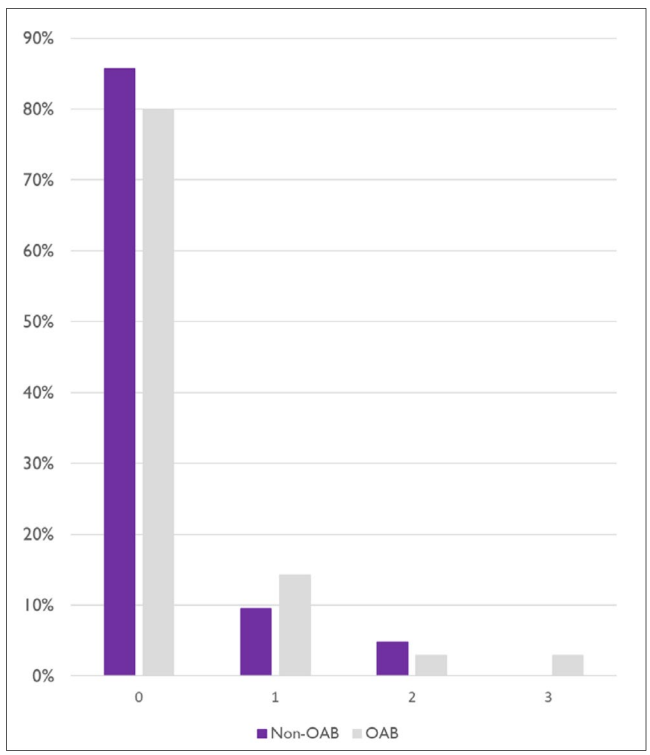

FIGURE 3. Anticholinergic burden score

TABLE 1.
Participant characteristics

	OAB (Mean (SD))	*Non-OAB (Mean (SD))*	*p*
n	*35*	*21*	
Age Range	74.40 (5.6) 65–87	75.44 (5.9) 66–86	.55
Sex (F:M)	30:5 (85%:15%)	13:8 (62%:32%)	.05
Charlson Comorbidity Index	0.77 (1.21) Range 0–5	0.29 (0.64) Range 0–6	.15
Number of Medications	2.17 (2.23) Range 0–7	2.21 (2.32) Range 0–8	.80
Anticholinergic Burden Score	0.26(0.66) Range 0–2	0.19 (0.51) Range 0–3	.77

TABLE 2.
Cognitive testing results

	OAB n=35 (Mean (SD))	*Non-OAB n=21 (Mean (SD))*	*Mean difference (95% CI)*	*p*
TMT-B time (s) Range	103.4 (33.13) 58–180	76.9 (25.95) 41–134	26.4 (9.5 – 43.4)	.003
TMT-B Errors Range	2.29 (3.52) 0–10	2.05 (3.41) 0–8	0.24 (-1.17 – 2.16)	.828
Reaction Time (ms) Range	480.3 (142.5) 313–913	463.9 (114.3) 321–714	36.64 (-57.0 – 89.9)	.722

TMT-B = Trail Making Test B.

changes in frontal lobe activation in patients with OAB.[33,34] SRT is governed by visual and motor cortices, as well as the somatosensory cortex.[35] It is unsurprising that, when the participants felt no desire to void, no difference in reaction time was observed, as neither the visual nor motor cortices are involved in bladder control. SRT is, however, influenced by SDV,[36] and it may be that stimulation of the somatosensory cortex by the sensation of a full bladder acts as a source of diverted attention, thus impairing reaction time.

Walking without falling is also, at least in part, dependent on executive function,[37] and community-dwelling older people with impairment in executive function have been shown to be at higher risk of falls.[21,38] The impaired executive function, especially impaired cognitive flexibility as demonstrated by worse TMT-B performance time, in those with OAB may partially explain the association between urinary urgency, nocturia, urgency incontinence, and falls in older adults. It has been suggested that the sensation of urgency acts as a source of diverted attention, inducing gait changes which may predispose a person to falling.[15] Those with impaired executive function may be less able to compensate for the additional cognitive demand of urinary urgency, and have greater susceptibility to the influence of urgency on their gait.

This study is limited by its small size and cross-sectional design, meaning that it is not possible to assign a direction of causality to the observed association. There is evidence from young, healthy volunteers without LUTS that the experience of SDV induces changes in reaction time[36] and impairment on the Stroop verbal reasoning task,[39] suggesting a bidirectional relationship between processing speed and bladder function. In addition, we used the subjective exclusion criterion of having a diagnosis of dementia; this is justified, as testing for cognitive impairment was the outcome measure and, therefore, couldn't also be an exclusion criteria, but could be a source of selection bias as those having been diagnosed with cognitive impairment may have also been assessed for LUTS.

By ensuring our participants emptied their bladder immediately prior cognitive testing, we sought to minimize the afferent sensation from the bladder. Given that OAB may result from abnormal signalling from the bladder even at low volumes, it is possible that the OAB group were actively attempting to suppress urgency, and it is this that impaired their cognitive function by acting as a source of distraction. The use of functional imaging techniques, such as functional MRI or functional Positron Emission Tomography, may help delineate such effects in future studies. As our study was limited in scope, we did not conduct any brain imaging with participants. Given that the presence of white matter hyperintensities on MRI is associated with LUTS, falls, and other geriatric syndromes,[40] it may be that our OAB group's impaired executive function was as a result of structural brain changes. Including imaging in future studies comparing cognitive function and process between people with and without OAB could increase the understanding of the underlying pathophysiological mechanisms.

We did not measure or examine falls risk or frequency of falls, and further work is needed to examine the links between LUTS, executive function, and falls risk in this context.

CONCLUSIONS

This small sample of cognitively intact older adults with OAB demonstrated impaired performance on a test of executive function, the time to complete the TMT-B, compared to a group of continent peers. This finding potentially informs part of the known association between falls and LUTS in older adults. Clinically, the identification of executive dysfunction by impaired TMT-B performance could also serve as a marker of risk of having or developing LUTS, leading to active case finding and/or pre-emptive bladder health training in older adults.

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CONFLICT OF INTEREST DISCLOSURES

The authors declare that no conflicts of interest exist.

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