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Technology-assisted toilets: Improving independence and hygiene in stroke rehabilitation

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Abstract

Background and Purpose: Dependence on assistance for toileting is a widespread problem for persons receiving healthcare. Technology-assisted toilets, which hygienically wash and dry the perineal region, are devices that could improve toileting independence in a variety of patients. The objective was to investigate whether technology-assisted toilets improve toileting independence, quality of life, and whether technology-assisted toilets can provide sufficient toileting hygiene in stroke rehabilitation.

Methods: This pilot study was carried out in a stroke rehabilitation unit. Thirty participants were recruited. Participants had a bowel movement and cleaned themselves using the technology-assisted toilet on one to three occasions. Participants rated their toileting before using the technology-assisted toilet and after each technology-assisted toilet use with the Psychosocial Impact of Assistive Devices Scale (PIADS). After each session, participants were rated for cleanliness.

Results: PIADS scores were analyzed from eight individual participants, five of whom completed the full protocol. PIADS scores were significantly higher with the technology-assisted toilet than with the participants' regular toileting routine ($p < 0.05$). Technology-assisted toilets cleaned effectively in 73% of cases (16/22, $p < 0.05$).

Conclusion: Technology-assisted toilets improved stroke patients' psychosocial outcomes compared to standard toileting and completely cleaned participants in the majority of cases. A larger study should confirm technology-assisted toilet's benefit in stroke rehabilitation through improved independence and hygiene.

Keywords

Toileting, stroke rehabilitation, assistive technology, hygiene, activities of daily living

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Introduction

Many adults with disabilities and geriatric patients have great difficulty with toileting (i.e. urination and defecation) or are unable to toilet themselves independently. Among adults aged 65 years or older the prevalence of toileting disability has been estimated to range from 6% for community-dwelling adults[1] to as high as 60% for nursing home residents.[2] Health professionals and caregivers must then provide assistance for this very personal activity.[3] While incontinence is widely discussed in the scientific literature, information specific to toileting disability due to a person's inability to effectively cleanse the anal and perineal skin areas is scarce. The high prevalence rates for toileting impairment show the importance of proper toileting assistance, but there is very little research that focuses on improving the capability of those who cannot toilet independently. The purpose of this project was to focus on these toileting concerns and determine the effectiveness of technology-assisted toilets (TATs) and their impact on psychosocial outcomes.

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Stroke patients experience disability related to brain injury and its physical, perceptual, and cognitive consequences. Each of these deficits may contribute to difficult-to-perform, incomplete, and unhygienic toileting. An estimated 40–60% of stroke inpatients have isolated urinary incontinence,[4] 8–30% have isolated fecal incontinence,[5,6] and up to 33% have double incontinence,[5] giving prominence to the issue of effective toileting. One study showed that in stroke patients being discharged from hospital, only 51.6% were functionally independent for toileting one month following discharge and 16.4% remained dependent after six months.[4]

Toileting care places a physical and psychological burden on both the caregiver and the recipient of care,[7] and together with bathing help, it ranks among the most burdensome of care tasks. It can also present obstacles that make the discharge of patients to their homes unfeasible.[8–10] Therefore, the establishment of toileting independence is a critically important issue for stroke rehabilitation patients. Our study investigated whether TATs could be a useful device to assist stroke rehabilitation patients with toileting.

TATs are commercially available toilet seats that clean the user with a stream of water and dry the perineal area with a fan. Additional controls allow the user to adjust water pressure, water temperature, dryer strength, and adjust the position of the stream. They are controlled by a wall-mounted remote which can be accessed by the patient or caregiver. These toilets are extremely common in countries such as Japan, but are available in many North American and European countries, usually as a luxury item. Their use in medicine, however, has not been well documented. TATs have the potential to eliminate the need for wiping, an activity of daily living that is often difficult or impossible for stroke rehabilitation patients. Wiping can be hindered as a result of hemiparesis, which causes sensory and motor losses of the upper extremity and loss of balance,[11] as well as visuo-spatial and cognitive difficulties.[12] The authors hypothesized that if they are effective, TATs could increase stroke patient independence, reduce burden of care, and improve toileting hygiene.

Only one previous study was found that considered the possible benefits of TATs.[13] This study installed TATs in a nursing home for elderly women and had them use the toilets over an extended period of time. Approximately half of the participants using TATs reported them as being positive, but the study had several methodological issues. Many of the residents who rated the TAT negatively were concerned about technical issues, such as improper installation causing leaks in the participant's bathroom, which made them apprehensive about using the TAT. While the authors reported that patients were not fully clean after using the TAT, they did not compare TAT users with the control group of patients to assess effectiveness.

The objective of this project was to investigate the potential use of TATs by stroke patients to:

a. provide adequate toileting hygiene,
b. improve quality of life,
c. be accepted by users,
d. to assess the feasibility of conducting larger scale studies on TATs, and
e. to ascertain whether health care professionals (HCPs) would think that TATs could have clinical benefits.

Methods

Population

A convenience sample of 30 participants was recruited from the stroke rehabilitation in-patient (20-bed dedicated regional unit) and out-patient programs at the Elisabeth Bruyère Hospital, a division of Bruyère Continuing Care, in Ottawa, Ontario.

Stroke rehabilitation English- or French-speaking in-patients and out-patients were included if they had a stroke within the last four years and were still impaired due to the stroke, had sufficient balance to be able to sit independently on the toilet seat, enough manual dexterity to use the remote control, and the ability to give informed consent, which was assessed using the Evaluation to Sign Consent.[14]

Participants were excluded if they showed no sign of disability post stroke, were physically unable to sit on the toilet without assistance, were under isolation precautions, could not use the remote control device for the toilet, or required a commode to use a toilet.

A convenience sample of 12 HCPs, including nurses, physiotherapists, occupational therapists, and social workers, were also recruited for this study. HCPs were included if they were employed at Bruyère Continuing Care, were English-speaking, and worked frequently with stroke rehabilitation patients.

This study was approved by the Bruyère Research Ethics Board, and all participants gave written informed consent before being enrolled. All procedures followed were in accordance with Bruyère Continuing Care institutional guidelines.

Outcome measures

The primary outcome measure used in this study was the Psychosocial Impact of Assistive Devices Scale (PIADS), a validated questionnaire designed to assess a user's feelings of competence, adaptability, and

self-esteem when using an assistive device.[15–17] This questionnaire was used to assess the participants' self-reported sense of their quality of life when using the device. Positive PIADS scores show that a user feels an improvement when using a device. A score of 0 indicates that the user is indifferent towards the device. A negative score means the user feels worse when using the device than without the device.

The secondary outcome measure assessed perineal cleanliness. The cleanliness scale, which was designed for this study due to no equivalent scale existing in the scientific literature, is a 4-point scale in which a score of 0 indicates that the person is completely clean and a score of 3 indicates that they are severely soiled. A score of 1 indicates "mostly clean, but some remaining smears or spots of urine/feces" and a score of 2 indicates "mostly soiled, but some clear evidence of cleaning." It was designed to be used by an investigator or caregiver after visually inspecting the perineal area.

Intervention

Participants were divided into two groups: the bowel movement (BM) group and the dry run (DR) group. Participants in both groups engaged in three separate testing sessions. During each session, the participant was brought to a bathroom and used the TAT. Patients in the BM group were given a visual inspection for cleanliness prior to going to the bathroom. After having a BM and cleaning themselves using the TAT, they received a second visual inspection. For each session, they were given pre-BM and post-cleaning scores for cleanliness based on the visual inspections. DR participants tried the TAT cleaning functions without having a BM and did not receive visual inspections. After each session, both groups answered the PIADS to assess their experience using the TAT. Before any testing sessions were held, each participant answered the PIADS in reference to their standard toileting in which they use a standard toilet and toilet paper to clean themselves.

All participants received a training session on how to use the TAT immediately prior to their first testing session. Training involved an explanation of which buttons to use on the remote control to begin washing, stop washing, and drying. Participants were not instructed on how to adjust water pressure, temperature, dryer strength, and stream position. All of these functions were set to medium levels before each test. After training, the participants operated the TAT without assistance. The TAT used for this study was the TOTO Washlet S350e.

HCPs used the TAT once and answered the PIADS in reference to how they thought a stroke rehabilitation patient would be affected by the experience of using a TAT.

Statistical analyses

Two sets of analyses were conducted on PIADS scores, one to examine differences between baseline and the first TAT trial score and other one to investigate changes in scores over repeated TAT trials.

In order to compare participant satisfaction when using the TAT to regular toileting, we used a repeated measures analysis of variance (ANOVA) using the PIADS scores of participants in the BM group who completed both the baseline PIADS and at least one BM trial ($n = 8$). Scores are divided into three PIADS subscales of competence, adaptability, and self-esteem.

To test whether PIADS scores changed after several uses of the TAT, we conducted a repeated measures ANOVA using the PIADS scores of BM group participants who completed the baseline PIADS and all three BM trials ($n = 4$). Scores were analyzed using the three PIADS subscales.

To analyze cleanliness scale data, we used a binomial test[18] to compare the frequency of participants being completely clean to the frequency of participants remaining unclean (cleanliness scale scores of 1 to 3). We used cleanliness data from every BM trial that was conducted ($n = 22$). We also conducted a one-sample *t*-test to look for agreement between tests. A Friedman test[19] was used to investigate whether there was a difference in cleanliness scores over the three BM trials.

To identify differences between the BM, DR, and HCP groups, we compared the first TAT trials from the BM and DR groups and the single TAT trial from the HCP group using a repeated measures ANOVA.

Results

Population

Of the 30 total recruited participants, 5 participants completed the full protocol and 15 completed part of the protocol as they were discharged from the hospital prior to completing the full study. One participant withdrew from the study due to concerns that it would affect his BM routine and nine participants were discharged before they could complete any part of the study. For each participant, testing was attempted until they were discharged from hospital or finished their outpatient rehabilitation program. For inpatients, this meant that testing was usually completed in less than one month. For outpatients, data collection could occur over a span of a few months.

All 12 HCPs completed the full protocol. Eleven of the HCPs were female. The HCPs included three nurses, two occupational therapists, one physiotherapist, one clinical professor, and five nursing students.

Demographic information was collected for the 20 participants who completed all or part of the protocol. Eleven were female and nine were male. The average age of participants was 64, with a range from 50 to 87. Only one participant had suffered more than one stroke. The average time between the most recent stroke and assessment was 57 days.

Common physical impairments that made toileting difficult for the participants included hemiparesis, inability to transfer onto the toilet independently, difficulty remaining balanced while seated, impaired mobility which made leaning over and reaching to wipe difficult, and reduced hand grip and strength. While most patients did require some assistance to go to the bathroom, some were completely independent at the time of the study. No patients with major cognitive impairments were included, but some patients experienced minor memory and language deficits.

Figure 1. A TAT attached to a standard toilet with the wand extended for spraying. When the cleaning functions of the TAT are not being used, the wand retracts into the toilet seat.

Figure 2. A remote control which would be used to operate a TAT. This remote would be mounted on the wall beside the TAT. The front panel opens to access additional features, such as temperature control.

Toileting hygiene

Of the 22 total BM trials, 16 (73%) resulted in a score of 0, meaning the participants were completely clean. Five trials resulted in a score of 1 and one trial resulted in a score of 2. No participants received a score of 3 with TATs.

The binomial test showed that participants using the TAT were significantly more likely to be completely clean than to not be clean ($p = 0.050$). The one-sample *t*-test confirmed that there was a significant difference in the frequency of clean and unclean BM trials ($p < 0.05$, 95% CI = 9.3, 13.7). The Friedman test showed that there was no significant difference in the frequency of unclean BM trials over the three trials.

PIADS data

A repeated measures ANOVA revealed a significant main effect of session (PIADS scores significantly increased from baseline to first TAT trial in the BM group) ($F(1,7) = 13.164$), $p < 0.01$) for all three PIADS subscales (Figure 1). There was also a significant interaction between session and PIADS subscale ($F(2,6) = 6.453$, $p < 0.05$). Pairwise comparisons of PIADS subscale scores for each session suggested that the largest differences between session occurred for the Competence and Self-Esteem subscales. The ANOVA performed for the three BM trials revealed similar results, but they were not statistically significant (Figure 2). No differences were found when comparing BM, DR, and HCPs PIADS scores (Figures 3 to 5). Previous PIADS studies have indicated that scores higher than one indicate that the user of the device is likely to continue using the device voluntarily.[15–17] Average PIADS scores after using the TAT were close to 2, which indicates strongly that the participants would not abandon use of the TAT over time.

Discussion

Our results show that when using a TAT, stroke rehabilitation in- and out-patients were able to clean themselves thoroughly without assistance almost three quarters of the time. They felt that they had a greater degree of competence, adaptability, and self-esteem

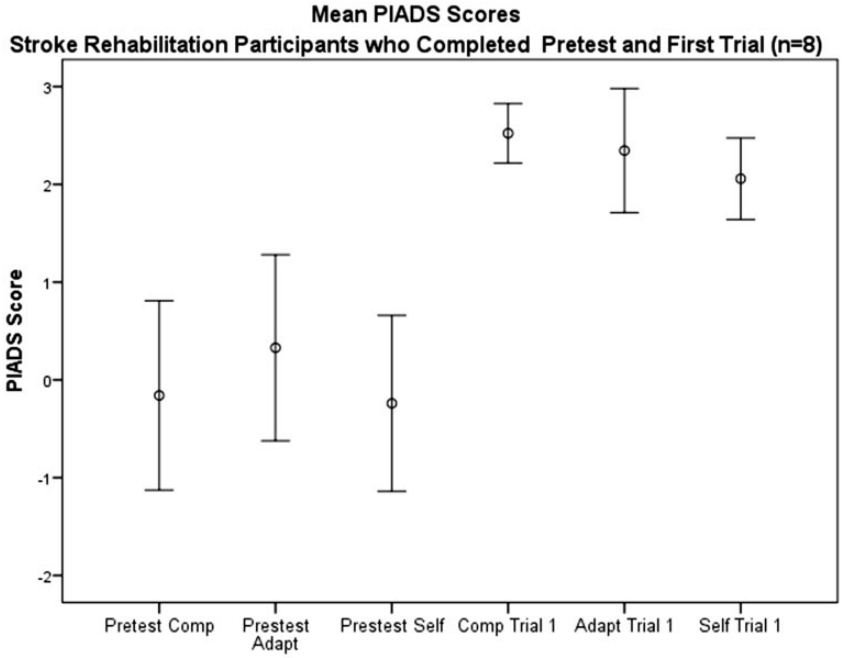

Figure 3. Psychosocial Impact of Assistive Devices Scale (PIADS) scores for participants who completed pretest and at least 1 bowel movement trial. Error bars indicate 95% confidence interval. "Comp" indicates competence subscale, "Adapt" indicates adaptability subscale, and "Self" indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of −1 or lower indicates that participants dislike the device.

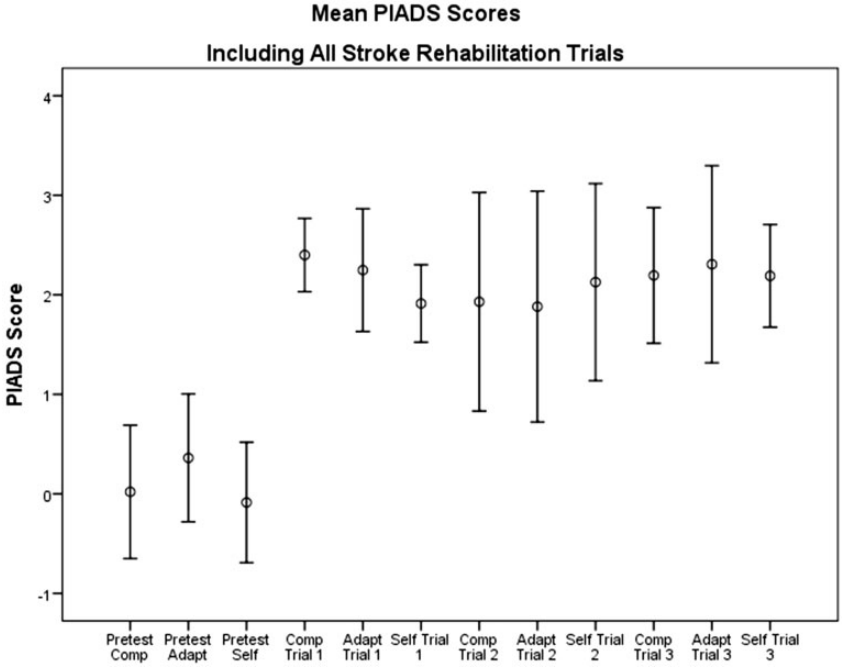

Figure 4. Psychosocial Impact of Assistive Devices Scale (PIADS) scores for all stroke rehabilitation participants. Each trial is divided into competence, adaptability, and self-esteem subscales. Error bars indicate 95% confidence interval. "Comp" indicates competence subscale, "Adapt" indicates adaptability subscale, and "Self" indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of −1 or lower indicates that participants dislike the device.

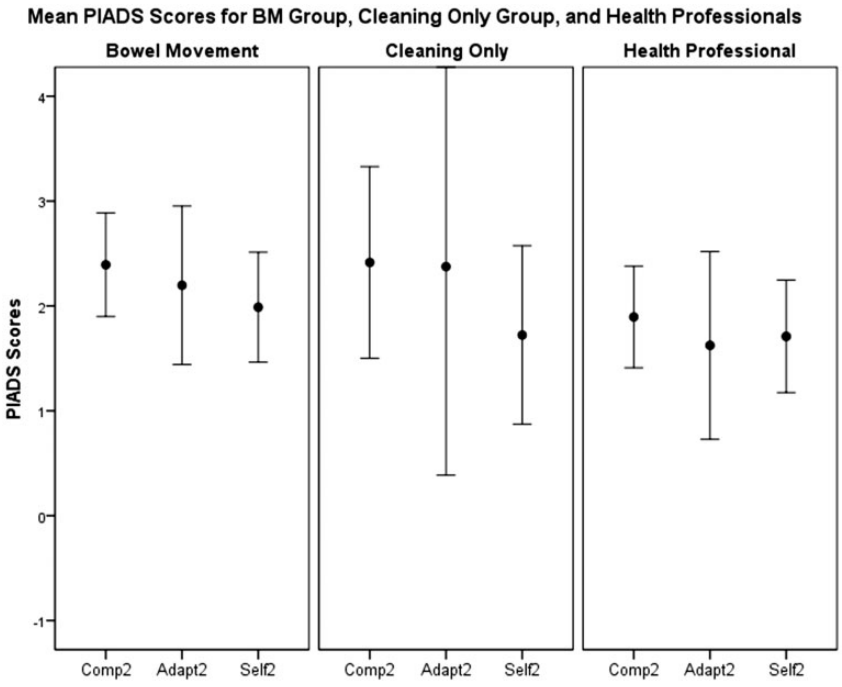

Figure 5. Psychosocial Impact of Assistive Devices Scale (PIADS) scores for first TAT trial in three groups. Error bars indicate 95% confidence interval. "Comp" indicates competence subscale, "Adapt" indicates adaptability subscale, and "Self" indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of −1 or lower indicates that participants dislike the device.

when compared to their regular toileting. These findings suggest that TATs can provide adequate toileting hygiene and use of TATs could benefit the well-being of stroke rehabilitation patients by improving their independence in the bathroom. Data from HCPs indicate that those working directly with stroke rehabilitation patients believe that TATs could prove useful in a clinical setting and could reduce the burden of care necessary for stroke rehabilitation patients.

The results from the PIADS questionnaire show a dramatic increase in the participants' sense of well-being and quality of life when using the TAT. The participants felt that there was a large increase in their ability to toilet on their own, there was a large reduction in feelings of frustration and embarrassment, and they would be able to carry out their activities of daily living more easily if they had regular access to a TAT.

The number of participants who completed multiple BM trials was low, but there was no evidence to suggest that participants felt more comfortable using the TAT more or were more effective at using the TAT over multiple uses. This suggests that using a TAT is fairly simple and does not require a significant amount of practice to use properly.

There were no safety issues related to this study. TATs do not contain many risks that are not found in a regular toilet, but there is still potential for falls when using the TAT. Most models have a seat heater that could cause discomfort or burns but that feature was turned off for this study. None of the participants in this study had urinary tract infections, burns, or skin breakdowns as a result of using the TAT; however, the participants only used the TAT in a few instances. Regular use of TATs would reveal more information on complications such as infection.

Most models of TAT range in price between CAD$400 and CAD$2,500, making them an affordable assistive device. The price varies depending on brand and number of features, but this study used only the most basic functions of TATs which are common to all models. After installation, the TATs did not malfunction and required no further maintenance beyond regular cleaning.

Limitations

Although this study found promising results, there were a number of limitations affecting the project. The first issue is that we had a small sample size and a low rate of completion for our participants. The investigators quickly found out that successfully completing BM trials is challenging. In order to successfully carry out a trial, the researchers needed to be present at the same time as the participant needed to have a BM, which was

difficult to predict. This led to many participants being discharged from hospital before completing the full three trials. Despite the low sample size, we were still able to demonstrate statistically and clinically important improvement when using the TAT. An alternative design for a study of this nature could be to use the nursing staff in the unit as the primary data collectors, but this requires more commitment from the institution in which research is being conducted.

Another limitation was that we were unable to recruit a large enough number of stroke rehabilitation out-patients to analyze them as a separate group. TATs may have a larger benefit to community-dwelling adults by increasing independence and reducing the need for assistance at home. Future studies should target community-dwelling adults.

Out-patients whom we attempted to recruit showed considerable reluctance to participate in the study. They expressed concerns about having a BM at the hospital and seemed more uncomfortable with the visual cleanliness inspections than the in-patients. In general, in-patients were more eager to participate and comfortable with answering personal questions about toileting and being inspected after having a BM. Toileting is an intensely private matter and subjects were reluctant to participate in the study, while at the same time indicating that they recognized its potential importance.

The cleanliness scale that we created is not yet validated and its reliability is thus unknown. No scale currently exists for quantitatively measuring perineal cleanliness, which is a gap that needs to be addressed. We will be conducting another TAT study in which we will also test the validity of our cleanliness scale. Nurses noted to the study authors that the scale created was practical and sensible.

This was a pilot study, and therefore one of our goals was to investigate whether studying TATs was feasible. Although we had difficulty getting participants to complete the full study, we were able to test enough participants to conduct meaningful analyses of our results. This indicates that conducting TAT studies in which participants are measured on multiple occasions may be challenging, but that studying TATs is feasible and worthwhile.

Conclusions

This study shows that TATs have the potential to be beneficial in stroke rehabilitation. It is likely that the benefits of TATs could be extended to elderly adults with a wide variety of disabilities that prevent them from toileting independently. Further research should be conducted to establish the extent to which TATs could be helpful and which groups benefit the most from this device.

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Declaration of conflicting interests

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Guarantor

David Yachnin

Contributorship

David Yachnin, Jeffrey Jutai, and Hillel Finestone designed this study. David Yachnin produced the first drafts of all study materials including proposals, forms, and this manuscript. David Yachnin was responsible for patient recruitment and data collection. Hillel Finestone assisted and advised data collection and recruitment. Jeffrey Jutai provided consultation on all phases of the project and directed the statistical analyses. Georges Gharib assisted in data collection and recruitment, and provided feedback on the manuscript.

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