



# Women with metastatic breast cancer don't just follow step-count trends, they exceed them: an exploratory study

Maxime Caru<sup>1</sup> · Saeed Abdullah<sup>2</sup> · Ling Qiu<sup>2</sup> · Bethany Kanski<sup>3</sup> · Brett Gordon<sup>3</sup> · Cristina I. Truica<sup>4</sup> · Monali Vasakar<sup>4</sup> · Shawna Doerksen<sup>5</sup> · Kathryn H. Schmitz<sup>5,6</sup>

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## Abstract

**Purpose** Metastatic breast cancer (MBC) patients are living longer at the cost of several side effects, affecting their physical and mental health. Physical activity can help women with MBC to improve their wellbeing. Technology-based exercise interventions have shown promising outcomes; however, studies that document their benefits on health behaviors are lacking. Therefore, we aimed to document the impact of virtual assistant technology on enhancing daily step counts in women with MBC.

**Methods** A total of 38 women with MBC participated in the 90-day Nurse AMIE (Addressing Metastatic Individuals Everyday) for Amazon Echo Show study, an artificial intelligence-based supportive care intervention. Each day, Nurse AMIE asked four symptom questions (sleep, pain, fatigue, and distress) and daily step counts. Based on participants' answers, an algorithm provided an activity to assist with symptom management.

**Results** During the first week of the intervention, mean step counts per day were  $4935 \pm 2884$ , and during the last week of the intervention, mean step counts per day were 1044 steps higher, for an average of  $5979 \pm 2651$  steps. Non-significant differences were observed between the first and last week ( $p = 0.211$ ) and between the first and last day ( $p = 0.099$ ), despite an improvement of 21.2% over time and significant differences between baseline and the other days.

**Conclusion** Women with MBC benefited from the Nurse AMIE for Amazon Echo Show intervention. Despite improvements over time (> 20%), we cannot conclude that the intervention significantly enhanced participants' daily step counts. Larger studies using virtual assistant technologies are required, and this study should be considered a first step in this direction.

**Keywords** Supportive care · Exercise · Metastatic breast cancer · Steps · Nurse AMIE

## Introduction

In 2022, more than 4 million women were living with a history of breast cancer in the United States [1]. Due to early detection, the number of women living with metastatic breast cancer (MBC) in the United States increased by 31% from 2010 to 2020 and is expected to increase to 55% by 2030 [2, 3]. MBC is considered the most advanced form of breast cancer. While its prevalence has increased over the years, one third of women are expected to live with MBC for 5 years or more [3]. Although these women with MBC are living longer, it is important to recognize that they often live at the expense of several side effects and symptoms related to their cancer and treatments, affecting their physical and mental health [4].

In these women, evidence has shown that lifestyle interventions, such as exercise, have an impact on survivorship,

✉ Kathryn H. Schmitz  
schmitzk@upmc.edu

<sup>1</sup> Division of Hematology and Oncology, Department of Pediatric, Pennsylvania State Health Children's Hospital, Hershey, PA, USA

<sup>2</sup> College of Information Sciences and Technology, Pennsylvania State University, University Park, PA, USA

<sup>3</sup> Department of Public Health Sciences, Pennsylvania State University College of Medicine, Hershey, PA, USA

<sup>4</sup> Division of Hematology and Oncology, Department of Medicine, Pennsylvania State University College of Medicine, Hershey, PA, USA

<sup>5</sup> Division of Hematology and Oncology, University of Pittsburgh, Pittsburgh, PA, USA

<sup>6</sup> UPMC Hillman Cancer Center, 5150 Centre Ave., Room 549B, Pittsburgh, PA 15232, USA

by reducing cancer-related symptoms [5]. Headley et al. conducted a pilot randomized controlled trial focusing on 32 women with MBC who participated in a 30-min seated exercise program using home videotapes 3 times a week [6]. The authors observed a slower decline in total and physical well-being scores and a smaller increase in fatigue scores for those in the intervention group, compared to the control group [6]. In a longitudinal pilot study, Cormie et al. have reported the findings of a 3-month supervised resistance exercise program in prostate and breast cancer patients with bone metastatic disease [7]. They highlighted the safety of their intervention, in addition to showing significant improvements in physical function (muscle strength, aerobic capacity, ambulation) and quality of life [7]. Recently, Shachar et al., conducted a single-arm feasibility study on 52 women with MBC to explore the effects of a home-based walking intervention [8]. Women with MBC participating in the walking intervention increased their self-reported physical activity, and their anxiety score was reduced. They also observed that a higher number of steps per week was correlated with larger improvements in general wellbeing, physical wellbeing and mental health [8]. Considering the good acceptability rate reported in these studies, the authors showed that women with MBC are interested in engaging in exercise interventions. Moreover, these studies show that physical activity can help women with MBC to improve their quality of life and wellbeing.

Virtual assistant technology-based exercise interventions have shown promising outcomes in women diagnosed with early-stage breast cancer, such as improvements in physical function and psychosocial health, pain management, quality of life and global health status [9–11]; however, studies in women with MBC that document the benefits of such interventions on health behaviors are few. Our team recently performed a study in 42 women with MBC participating in a 90-day technology-based exercise intervention (NCT04673019) [12]. This partial crossover randomized clinical trial provided findings on the effect of the intervention on physical and mental health outcomes, but our team did not present step counts data since this data were collected as a process measure, and not as an outcome measure. Therefore, this paper aims to present the step counts data from this study as exploratory evidence to document the impact of virtual assistant technology on enhancing daily step counts in women with MBC.

## Methods

This exploratory study aimed to recruit women with MBC, aged  $\geq 18$  years, who received active care at Penn State Cancer Institute and who had sufficient vision and hearing to interact with the virtual assistant (or family support to

help). Pregnant women and those who had an ECOG (Eastern Cooperative Oncology Group) Performance Status score of  $> 2$ , significant medical or psychiatric conditions outside of cancer and a life expectancy of 6 months or less (determined by the treating physician) were not eligible to participate in this study. Women already participating in behavioral intervention trials were not eligible to participate. The approval of the medical oncologist was obtained for each woman eligible to participate in the study. This study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the Penn State University Institutional Review Board (#00016221). Written informed consent was obtained from every participant prior to any study-related activities. The trial was registered on ClinicalTrials.gov (NCT04673019).

Each woman with MBC participated in the 90-day Nurse AMIE (Addressing Metastatic Individuals Everyday) for Amazon Echo Show with Alexa, an artificial intelligence-based supportive care intervention. The design and implementation of the Nurse AMIE for Amazon Echo Show with Alexa have been fully described elsewhere [12–14]. This study was conducted during the COVID-19 pandemic and all study activities were conducted online. Each day, when the participants wanted to interact with Nurse AMIE, they would say "Alexa, Open Nurse AMIE". Then, Nurse AMIE would ask participants to provide a verbal rating of four symptom questions (sleep, pain, fatigue, and distress) on a 0–10 scale. Based on participants' answers, an algorithm provided an activity, such as soothing music, cognitive behavioral therapy lessons, guided relaxation and mindfulness meditation, exercise videos (balance, strengthening, stretching), or audio messages to assist with symptom management [12, 14–16]. Participants could choose a different activity if they wanted, however. These activities were provided every time the participants decided to interact with Nurse AMIE.

Each day, participants had to self-report their step counts from the prior day to the Nurse AMIE platform. This step took them less than 5 min to complete through Amazon Echo Show. Step counts were recorded using an analog pedometer (3D Tri-Axis Sensor, A420S, 3DAActive, USA). Participants had to wear the analog pedometer every day when they woke up until they went to bed, allowing the device to recharge overnight.

## Statistical analysis

All statistical analyses were performed using IBM SPSS statistics, version 26.0 (IBM Corp., Armonk, NY, USA). Data on demography and clinical characteristics of the participants are presented with descriptive statistics [mean  $\pm$  standard deviation (SD)]. The normality assumption for continuous variables was verified using Shapiro–Wilk tests. Paired sample *t* tests were performed to compare two means. The

differences were considered significant when the  $p$ -value was  $< 0.05$  with an alpha level of 5%. The effect sizes were calculated and presented using Cohen's  $d$  coefficients.

## Results

A total of 133 patients were assessed for eligibility between January and May 2021. A total of 42 women with MBC were recruited and data from 38 are presented. Four participants were not included in our analyses: 1 participant did not use the Nurse AMIE platform, 2 interrupted their participation, and 1 died during the study.

Women with MBC were aged  $52.4 \pm 11.0$  years old and had received their initial cancer diagnosis 8.6 years ago prior to their enrollment in our study. The mean time since metastatic cancer diagnosis was  $4.0 \pm 2.5$  years. Our population was predominantly White or Caucasian (89.5%), and not Hispanic or Latino (84.2%). Participants' characteristics are presented in Table 1.

Over the 90-day of the Nurse AMIE for Amazon Echo Show intervention, we observed a non-significant improvement of 21.2% in the number of steps. During the first week, mean step counts per day were  $4935 \pm 2884$ , and during the last week of the intervention, mean step counts per day were 1044 steps higher for an average of  $5979 \pm 2651$  step counts ( $p = 0.211$ ; Cohen's  $d = 0.360$ ). Overall, women with MBC improved their step counts every day over the 90-day, as shown in Fig. 1. Analyses showed, however, that step counts at days 30 ( $p = 0.195$ ), 37 ( $p = 0.110$ ), 67 ( $p = 0.131$ ), 89 ( $p = 0.072$ ) and 90 ( $p = 0.099$ ) were not significantly different from step counts at baseline.

## Discussion

Our virtual assistant technology-based exercise intervention, Nurse AMIE for Amazon Echo Show with Alexa, showed promising results regarding step counts among women with MBC. Previous studies already showed the interest of women with MBC to engage in exercise interventions and their ability to successfully achieve them. Addressing their needs should be the cornerstone of every intervention and this study should be considered a first step in this direction.

This study highlighted that our participants became more physically active over the 90-day Nurse AMIE for Amazon Echo Show intervention. It is highly encouraging to observe that they went from 4935 steps during the first week to 5979 steps during the last week of the intervention. An increase of 1000 steps per day has been associated with health benefits, such as reducing risk of developing chronic disease and improving cardiovascular health [17, 18]. A few years ago, healthy adults were encouraged to reach 10,000 steps

**Table 1** Clinical characteristics

	Total ( $N = 38$ )
Age, years	
Mean (SD)	$52.4 \pm 11.0$
Median (range)	53.0 (34.0; 74.0)
Time since initial diagnosis, years	
Mean (SD)	$8.6 \pm 7.2$
Median (range)	6.5 (2.0; 28.0)
Time since metastatic cancer diagnosis, years	
Mean (SD)	$4.0 \pm 2.5$
Median (range)	3.0 (1.0; 10.0)
Self-reported treatment at the time of enrollment, $N$ (%)	
Trastuzumab	11 (15.5)
Fulvestrant	10 (14.1)
Palbociclib	8 (11.3)
Anastrozole	5 (7.0)
Capecitabine	5 (7.0)
Abemaciclib	4 (5.6)
Denosumab	4 (5.6)
Pertuzumab	4 (5.6)
Letrozole	3 (4.2)
Docetaxel	2 (2.8)
Exemestane	2 (2.8)
Zoladex	2 (2.8)
Zoledronic acid	2 (2.8)
Alpelisib	1 (1.4)
Carboplatin	1 (1.4)
Cyclophosphamide	1 (1.4)
Eribulin mesylate	1 (1.4)
Everolimus	1 (1.4)
Sacituzumab govitecan	1 (1.4)
Tamoxifen	1 (1.4)
Temodar	1 (1.4)
Tucatinib	1 (1.4)
Marital status, $N$ (%)	
Never married	3 (7.9)
Currently married	30 (79.0)
Divorced/separated	4 (10.5)
Widowed	1 (2.6)
Race, $N$ (%)	
White	34 (89.5)
Black	2 (5.3)
Native Hawaiian	1 (2.6)
Other	1 (2.6)
Ethnicity, $N$ (%)	
Hispanic/Latino	4 (10.5)
Not Hispanic/Latino	32 (84.2)
Unknown	2 (5.3)
Education, $N$ (%)	
High school	7 (18.4)
Some college, including junior college, secretarial school, or technical college	10 (26.3)

**Table 1** (continued)

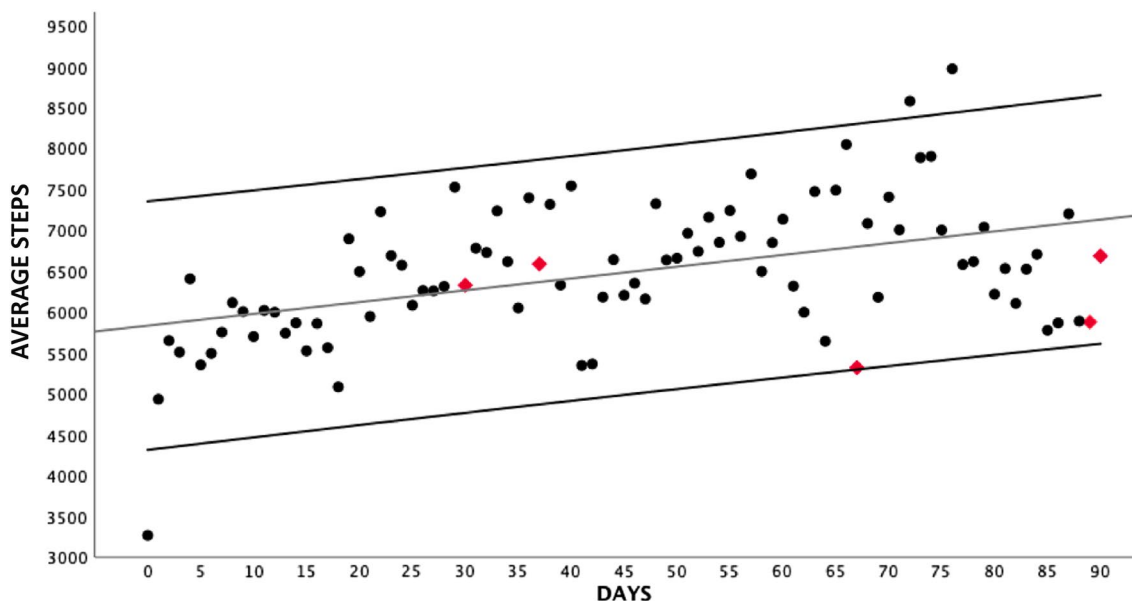
	Total (N=38)
4-Year degree or more	21 (55.3)
Occupation, N (%)	
Full time	16 (42.1)
Part time	2 (5.3)
Unemployed	9 (23.7)
Retired	11 (28.9)

per day for its health benefits [19, 20]. Studies also showed, however, that 10,000 steps per day might not be achievable for patients living with chronic diseases [21]. Tudor-Locke et al., proposed a step index to classify pedometer data where people engaging in <5000 steps per day are considered sedentary, while those engaging in 5000–7499 steps per day are considered to be low active [21]. The authors also specified that people who are low active are representative of the general population engaging in typical daily activities excluding sports and exercise [21]. Thus, women with MBC who participated in our study went from sedentary to low active in only 90 days.

A study interested in older adults who walked an average of 5835 steps per day found that higher step counts were associated with fewer hospitalizations and all-cause mortality risk [22]. These findings are of interest for women with MBC since they often incur healthcare costs due to outpatient visits and recurrent hospital admissions (inpatient and emergency room visits) [23]. In a larger prospective cohort

study, del Pozo Cruz et al. found that in older adults who walked an average of 7198 steps per day, more steps per day (up to ~10,000 steps per day) was associated with lower risk of all-cause and cancer mortality [20]. Thus, moving more every day is associated with substantial health benefits from which women with MBC can also benefit.

In fact, a study interested in women with MBC (age  $62.2 \pm 10.6$  years) who participated in a home-based exercise intervention with a walking component observed an improvement in their physical capacity [24]. Another study providing guidance about increasing step goals and time spent walking showed that women with MBC (age  $55.1 \pm 12.2$  year) improved their general quality of life, symptoms and physical activity behavior [25]. The authors reported no adverse events or injuries following the exercise interventions [24, 25]. A recent study in women with MBC (aged  $55.0 \pm 11.1$  years) showed that a higher number of steps per week was associated with improved overall wellbeing, physical wellbeing and mental health after a home-based walking intervention [8]. Nevertheless, this study was designed to increase step counts per week [8], while our study did not aim to focus on this outcome when designed and did not specifically prescribe walking activities, as specified in the methods section. In this sense, we did not expect that women with MBC would significantly increase their daily step counts even though we were eager to document the impact of virtual assistant technology on maintaining or enhancing daily step counts in these women. The recent exercise guidelines for cancer survivors recommends that women with MBC receive a



**Fig. 1** Self-reported step counts per day in 38 women with MBC who participated in the 90-day Nurse AMIE for Amazon Echo Show intervention. Average step counts that are not significantly different from step counts at baseline are identified by red dots

pre-exercise medical evaluation, clearance by their physician prior to engaging in an exercise program and a referral to an exercise expert in exercise oncology [26].

Notwithstanding these promising findings, it is important to mention that our small sample size and the lack of reported data during the last days of the intervention might have limited our statistical power and the scope of our findings. Moreover, the lack of a control group in the design of this exploratory analysis limited our ability to draw a meaningful conclusion from our results. Finally, it should be mentioned that women with MBC who consented to participate in our study might have been more inclined to become active due to the description of our study. Nevertheless, women with MBC already participating in behavioral intervention trials were not eligible to participate. Studies have also shown that these women are interested in engaging in exercise interventions [5, 7, 8, 12].

In conclusion, women with MBC benefited from the Nurse AMIE for Amazon Echo Show with Alexa intervention. We cannot conclude that our intervention significantly enhanced participants' daily step counts, despite improvements over time. This study was conducted during a global pandemic, which showed that the Nurse AMIE for Amazon Echo Show intervention can be fully conducted online and reach women who want to engage in physical activity. Larger studies using virtual assistant technologies are still required.

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**Author contributions** All authors made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND drafted or revised the work critically for important intellectual content; AND provided final approval of the version to be published; AND agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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**Data availability** Our data are not deposited in publicly available repositories. However, the datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

**Code availability** Not applicable.

## Declarations

**Conflict of interest** The authors declare that they have no conflicts of interest and no competing interests.

**Ethics approval** This study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the Penn State University Institutional Review Board (#00016221).

**Consent to participate** Written informed consent was obtained from every participant prior to any study-related activities.

**Consent to publish** Not applicable.

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