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ORIGINAL PAPER

Twelve-month pilot study on wearables to enhance health and quality of life in older adults

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Abstract

Purpose Engagement in physical and social activities is crucial for successful aging.

Methods This study evaluates fall probability, quality of life and cognitive status following 12-month intervention. The intervention consisted in a monitoring scenario in which older adults were equipped with a smartwatch to track step count and home sensors to measure micro-environmental parameters. We evaluated the intervention overall and regrouped based on participants' daily step count: low (<4500 steps/day) and high (≥4500 steps/day).

Results The intervention had an increase in Tinetti Balance Assessment scores indicating a reduced fall probability. The low steps group benefited the most, suggesting that even light activities positively impacted balance and mobility. Quality of life significantly improved after 6 months, particularly in the high steps group. Cognition measured with the Mini-Mental State Examination improved in the high steps group compared to the low steps and the control group.

Conclusions Providing wearable technology can promote physical activity and positively influence overall health, even in older individuals with low activity levels. This real-world approach without external enforcement highlights the potential for simple technological interventions to promote active aging.

Keywords Wearable technology · Active aging · Health monitoring · Digital health · Lifestyle intervention

1 Introduction

As the world grows older, the goal of society in general, and of healthcare institutions in particular, is to minimize physical and mental deterioration. There are several modifications that the body goes through while aging, such as progressive loss of muscle mass, balance and flexibility. Sarcopenia is a condition which is a consequence of aging, it is characterized by loss of muscle strength and mass which in turn exacerbate sedentariness, physical inactivity and increase risk of falls [1]. Falls are among the leading causes of injury and death [2] and can result in loss of independence for the older adult and in disabilities that need hospitalization or institutionalization.

Physical activity and exercise are terms which are often used interchangeably. However, physical activity refers to all the bodily movement that results in energy expenditure, whereas exercise is a subset of physical activity, which is planned, structured, repetitive and has the intent of improvement or maintenance of physical fitness. Physical activity and exercise are suggested to be an accessible and cost-effective methods to prevent falls and attenuate the aging process by reducing cognitive decline [3, 4]. Studies have shown that physical activity in middle and old age lowers the risk of developing dementia [5] and increases the chance of aging healthily [6]. Furthermore, short randomized controlled trials (8- to 12-week) improved cognitive performance [7, 8], yet longer trials yield mixed results [9–12]. Nevertheless, maintaining or increasing fitness benefits cognition [10–12].

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Walking is one of the simplest ways to keep the body active and can help maintain an active lifestyle. Typically, physical activity guidelines, online materials and pamphlets report 10 000 steps as the daily step goals for adults [13]. On the other hand, the World Health Organization recommends 150–300 min of moderate aerobic activity per week, and that all physical activity counts, meaning that all movement done throughout the day is beneficial to reduce unhealthy sedentary behavior [14]. Other than physical benefits, higher levels of physical activity seem to be associated with lower dementia risk and lower mortality rates, and research has shown that as few as 3800 daily steps are able to reduce dementia risk by 25% and 6300 steps offering the largest decrease [15]. Moreover, the dose-response association for all-cause mortality is L-shaped, with declining risk being associated with daily steps up to 7000–9000 steps and further increasing the number of steps resulting in only marginally reducing the risk [16–18]. The cut-off number of steps to have an overall risk reduction seems to be centered around 4500 steps. For example, in patients with pulmonary arterial hypertension, those who walked less than 5000 steps had more sever disease than those who walked more than the arbitrary threshold [19]. For older women, 4400 steps are linked to lower mortality rates (compared to <3000 steps per day), with benefits leveling off around 7500 steps [20]. Similarly, in middle to older adults the minimal dose to reduce cardiovascular disease was found to be between 4000 and 4500 steps per day [16], and in community-dwelling older adults 70 years old≥4500 steps have been shown to lower the risk of diabetes by 60% [17]. A meta-analysis did not show sex differences in the daily steps in ≥60 years, revealing that 6000–8000 steps per day reduced mortality rates [21] regardless of walking intensity [20–22].

In recent years, a variety of physical activity trackers have been designed to continuously monitor biological and behavioral data. Data from smartwatches can be connected to a mobile application, allowing users to track their physical performance and receive notifications that promote healthy behaviors to prevent or reduce health issues. Studies have shown that smartbands are highly usable for older adults with diverse cognitive abilities [23, 24], and the step count seems to be reliable closely aligning with actigraphy measures [25].

Other than physical/cognitive benefits, it is also important to assess the subjective perception of well-being. Physical activity has been found to be associated with self-reported happiness [26], and the link seems to be mediated by cognitive function and quality of life (QoL) [27]. Indeed, older adults at risk for mobility disability show lower rates in QoL, but users taking part in a physical activity intervention reported slower decline rates than controls [28].

Given their usability, affordability and availability, commercial fitness trackers are valuable tools that can help reduce physical inactivity and potentially increase QoL and cognitive status. To the best of authors' knowledge, no study has evaluated these devices and the effects on cognitive status and physical health over 12 months in real-world setting. For all these reasons, this paper aims to assess the monitoring scenario deployed in the Italian pilot of the Pharaon project for 12-months. The scenario provided older adults with a FitBit smartwatch to let them keep track of their own number of steps. Participants also filled in questionnaires which assessed estimated fall probability, perceived health-related QoL, and cognitive status. Data from the questionnaires was related to the number of daily steps to investigate the following research questions (RQ):

- **RQ1**: Assess whether the intervention successfully decreased the estimate of fall probability, increased QoL, and maintained/increased cognition.
- **RQ2**: We used a thresholding approach to determine whether the dose of daily steps over the course of the intervention (high step count≥4500, low step count<4500) has a positive influence on questionnaire scores over time. Specifically, the threshold of 4500 daily steps was chosen on the basis of the minimal dose to reduce disease risk or promote positive effects found in the literature [15–20].

2 Methods

2.1 Service description and recruitment

The Italian pilot comprises two sites in distinct locations (Apulia and Tuscany) and recruitment took place at the participating centers. Before deployment, the technologies were pre-validated [29] to gather information on possible issues, find solutions and how to tackle them during deployment. Inclusion criteria encompassed being ≥60 years and having a frailty score between non-frail to moderately frail. Exclusion criteria were conditions that caused memory impairment and/or difficulty engaging with the technology. The study was approved by local ethical committees, participants were educated on the study objectives and provided their written informed consent.

Participants were randomized 1:1 to the intervention or control group, where the control group only filled in questionnaires but did not interact with technology. Two scenarios were deployed based on the functional needs identified in a previous needs analysis [30]. This paper focused on the "health management and monitoring" (monitoring) scenario, which was evaluated as usable in the Italian sample [31]. In this scenario the older adults were provided with a FitBit Versa 2 smartwatch (FitBit, USA) that recorded the number of daily steps and encouraged them to stay active by sending a notification. FitBit has been shown to be significantly associated with clinical parameters [19], and step count as a metric can therefore be a simple device that provides insight on the health status of different populations. Furthermore, participants using the FitBit were identified as those with highest long-term engagement and retention rate compared to other devices [30]. These prompts reminded the user to reach the hourly activity goals of 250 steps per hour for 9 h. Moreover, sensors were placed in the older adults' home to measure micro-environmental parameters and movement (QuingPing Air Quality Monitor, China; Shelly sensors, Shelly Italia). These technologies were connected to IoTool (Senlab, Slovenia) and Thingsboard (Ericsson Nicola Tesla, Croatia), and the caregivers could visualize the older adults' activity and environment on a web-based user dashboard (Ascora, Germany). Of the aforementioned technologies, in the present study only smartwatch data was employed.

2.2 Questionnaires

Questionnaires were administered over the 12-month intervention period. Demographic data only at baseline; QoL was assessed at baseline, 6-month follow-up and 12-month follow-up; and balance and cognitive status were evaluated at baseline and again at 12-month follow-up. The specific timeline of data collection is depicted in Fig. 1.

Demographic data included date of birth, sex, educational attainment, and digital skills. Educational attainment was measured using the international standard classification of education (ISCED) and then re-coded into three levels: primary (ISCED 0–2), secondary (ISCED 3–4) and tertiary (ISCED 5–8) school.

The Tinetti Balance Assessment (TBA) evaluates balance and mobility problems in elderly patients [31]. It consists of two sections: balance, consisting of 9 items, and gait, comprising 7 items. The score ranges from 0 to 28, providing an estimate of fall probability.

The EQ-5D-3 L from the EuroQol group measures older adults' health-related QoL [32]. The questionnaire is composed of two sections: the system description questionnaire and the visual analogue scale (VAS). In the system description questionnaire, for each of the 5 questions investigating aspect of health (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) the older adult selects the most appropriate answer option (1: no problems, 2: some problems and 3: extreme problems). The answers are combined into 243 possible health states ranging from 11,111 (full health) to 33,333 (worst possible health). The VAS contains an image depicting a "health thermometer" which goes from 0 (worst imaginable health) to 100 (best imaginable health). In this paper we employed the QoL VAS score as a general measure of health-related QoL.

The Mini-Mental State Examination (MMSE) is a 30-point neuropsychological questionnaire that assesses cognitive status [33]. The questionnaire is composed of 11 questions spanning in 6 sections each designed to evaluate a different cognitive area. Scores were adjusted for educational level.

The Frontal Assessment Battery (FAB) is a cognitive test used to assess executive functions and to screen for frontotemporal dementia [34]. It consists of six areas of investigation: similarities, lexical fluency, motor series, conflicting instructions, Go-NoGo, and prehension behavior. Each component has a score between 0 (error) to 3 (correct), and the total score is obtained by summing all the components resulting in a total score ranging from 0 to 18.

2.3 Statistical analysis

Statistical analyses were performed with RStudio (version 4.4.2) [35] and a two-tailed p value lower than 0.05 was considered statistically significant.

Participants in the control and intervention group were compared in demographic characteristics and cognitive status. The continuous variables age, TBA, MMSE, FAB and QoL VAS were checked for normality using the Shapiro-Wilk test and then t-test or Mann-Whitney U test were used to check for group differences. Gender, digital skills and

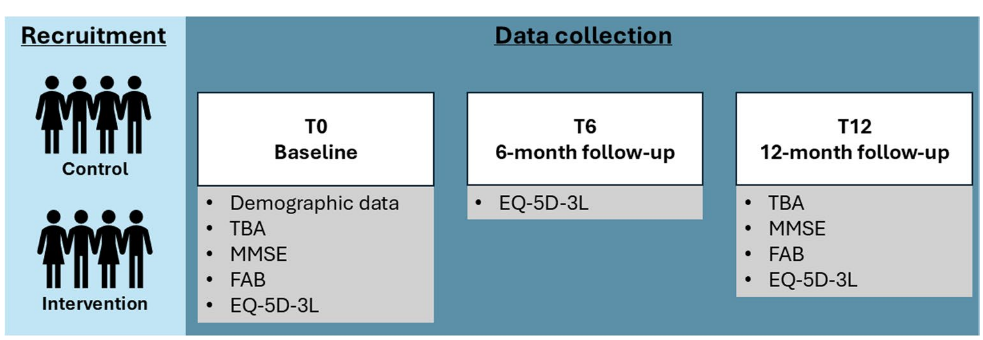

Fig. 1 Timeline of the intervention showing when the questionnaires were filled in by the control and intervention groups

education were compared between groups using the Chi-squared test or Fisher's Exact Test depending on the number of occurrences in each group. The most appropriate effect size (i.e., Cohen's d [d], rank-biserial correlation [r], or Cramer's V [V]) was calculated for significant differences between groups.

For each participant in the intervention group, the recorded steps were averaged across each month of deployment to obtain the mean daily steps per month.

To evaluate whether the intervention had a positive effect in declining the probability of falls, increasing QoL and cognitive status, linear mixed models were used (RQ1). Separate models were performed using the "lmer" package [36] looking at the effect of the group*time interaction on the dependent variables (TBA, QoL VAS, MMSE and FAB). A random intercept was included for each participant.

To further assess the dose of physical activity that is beneficial for declining the probability of falls, increasing QoL and cognitive status (RQ2), participants in the intervention group that used the FitBit for at least 6 months in the 12-month period were grouped into "high" and "low" based on the number of median daily steps across the entire intervention. The median was chosen to divide the groups in approximately equal number of participants. Specifically, the high group had median daily steps equal or higher than 4500, and the low group lower than 4500. The linear mixed models were repeated considering the new grouping variable (control, high steps and low steps) and the group*time interaction.

Cohen's d applied to the linear mixed model (lme-d) was calculated for the significant fixed effects as 2 multiplied by the t value, and the result divided by the square root of the degrees of freedom.

Post-hoc intra-group comparisons from baseline to the end of the intervention were applied using the "emmeans" R package [37], and intra-group contrasts were selected and corrected for multiple comparisons using the Holm-Bonferroni method.

3 Results

A total of 53 participants were recruited, 26 in Tuscany and 27 in Apulia. Enrollment of intervention group participants was distributed across the year (first trimester: $n=9$; second trimester: $n=7$; third trimester: $n=1$; final trimester: $n=11$).

Participants in the control and intervention group did not have any significant differences among the investigated demographic characteristics or cognitive status ($p>0.3$) but were significantly different in the QoL VAS score ($p=0.01$, $r=0.34$), where the intervention group evaluated their health-related QoL as worse than the control group (Table 1).

3.1 Effects of the intervention on fall estimate, quality of life and cognition

From a visual inspection we can observe that participants maintained their step count during the first 3 months of intervention. This was followed by a drop around month 8 of intervention and a subsequent increase (Fig. 2). This drop may reflect the disengagement of less motivated participants which either walked less or used the Fitbit less before eventually dropping out, while those who remained throughout the 12-month period were likely more committed and consistent in their device usage. In fact, not all subjects had data available for the full 12 months. One subject used Fitbit for 6 months, three for 7-months, four for 8-, 9- and 10-months. Three subjects had data for 11 months and nine had a complete 12-month dataset. On average, the mean number of daily steps of the first month was 4517.9 steps, at the end of the 12-months there was an increase to 4975.1 steps (10.1%).

Linear mixed model investigating the TBA score showed a significant group*time interaction ($p=0.012$, lme-d$=0.69$) with the intervention showing a significant increase over 12-months in TBA compared to the control group (Fig. 3A).

With respect to QoL VAS score, the linear mixed model identified a significant group*time interaction at 6-months ($p=0.033$, lme-d$=0.42$), which was not present at 12-months ($p=0.134$). At 6-month, the intervention group had a significant 8.0 points higher QoL VAS compared to the control group, and then at 12-months remained higher (5.3 points) but it was not significant (Fig. 3B).

Table 1 Demographic characteristics and cognitive status of the control group and intervention group at baseline

	Control $N=25$	Intervention $N=28$
Gender (%Male)	40.0	57.1
Age [median (Q1, Q3)]	72.0 (66.0, 78.0)	70.0 (64.8, 75.0)
Digital skills		
%None	28.0	25.0
%Some experience	68.0	60.7
%Experienced/Proficient	4.0	14.3
Education		
%Primary	48.0	50.0
%Secondary	44.0	32.1
%Tertiary	8.0	17.9
TBA [median (Q1, Q3)]	28.0 (27.0, 28.0)	28.0 (26.0, 28.0)
FAB [median (Q1, Q3)]	17.0 (15.0, 17.1)	17.0 (14.8, 18.0)
MMSE [median (Q1, Q3)]	27.2 (26.0, 29.3)	27.8 (26.6, 29.5)
QoL VAS [median (Q1, Q3)] *	80.0 (80.0, 90.0)	72.5 (58.8, 80.0)

* denotes a significant difference between the intervention and control groups ($p < 0.05$)

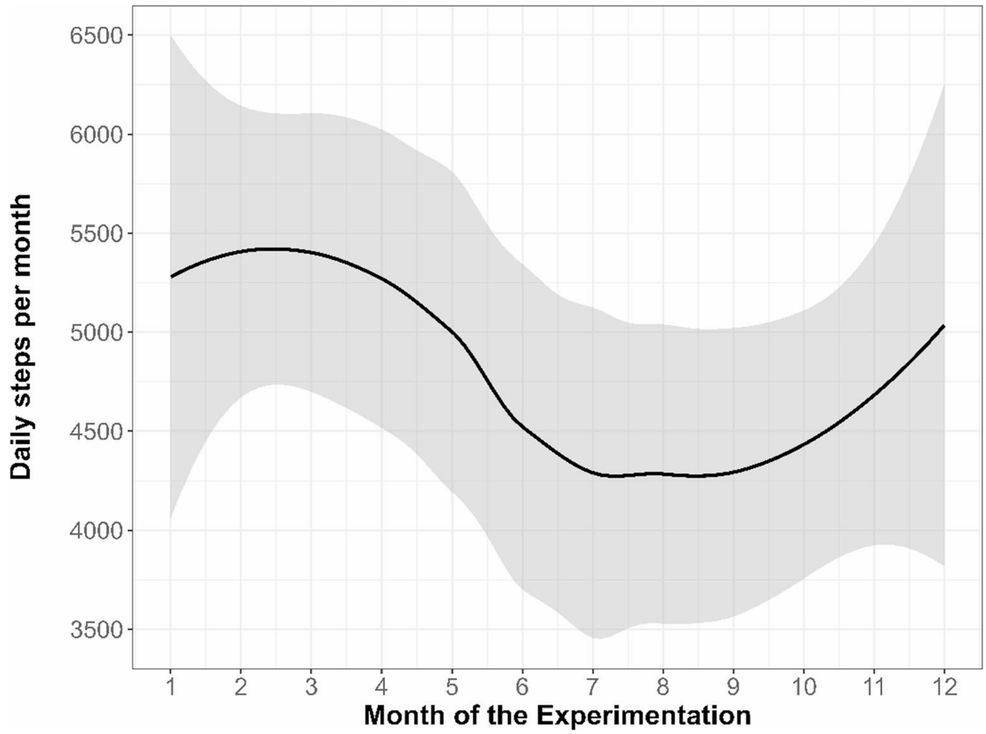

Fig. 2 Number of daily steps per month of experimentation. The grey shade represents the standard error around the smooth local regression

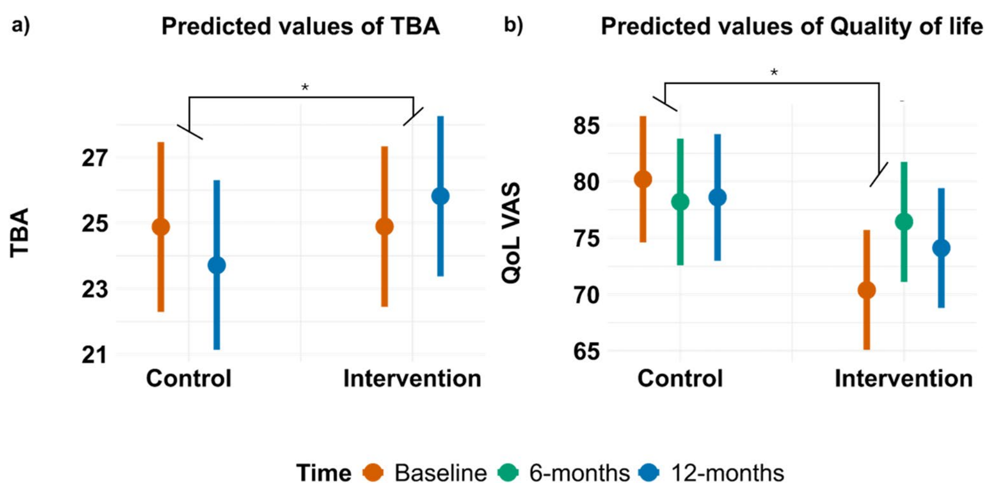

Fig. 3 Results from the linear mixed model of the predicted values in the control and intervention group for (**A**) TBA and (**B**) QoL VAS. The asterisk denotes a statistically significant result

The results of the linear mixed models did not demonstrate a significant positive effect of the intervention over time for the cognitive status (MMSE or FAB).

Post-hoc contrast did not highlight significant changes either in the control or intervention from baseline to 12-months for TBA, QoL VAS, MMSE or FAB.

3.2 Effects of step count on fall estimate, quality of life and cognition.

Participants in the intervention group were divided into those who had a median number of daily steps equal or higher ($N = 14$) and lower than the a-priori threshold of 4500 daily steps ($N = 14$).

From a visual inspection of the trends, we can observe that participants in the high steps group maintained high daily steps for around half of the intervention and then experienced a slight decrease (Fig. 4). The low daily steps group maintained the number of steps in the first part of the intervention, had a decrease from month 4 and 8 of the intervention followed by a steady increase up to month 12 (Fig. 4). On average, the mean number of daily steps of the first month for the high steps group was 6479.5, which increased to 7173.5 daily steps (10.7%) at the end

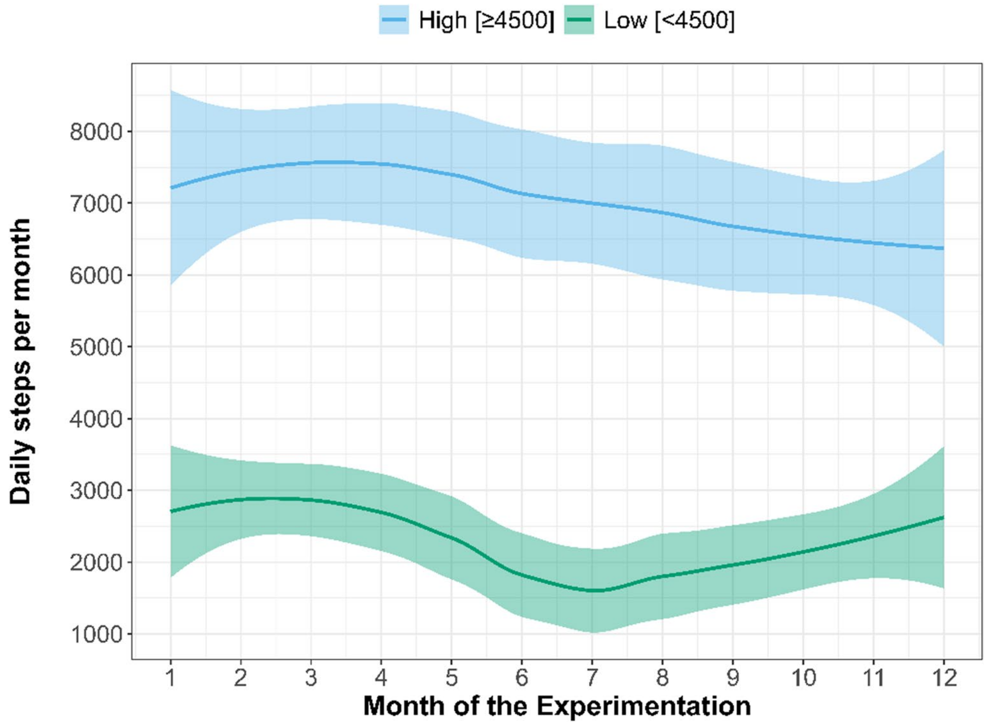

Fig. 4 Number of daily steps per month of experimentation in participants in the high and low step count groups. The shaded color represents the standard error around the smooth local regression

of the intervention. The low steps entered the intervention with a mean of 2556.3 steps and ended the intervention (12-months) at 2410.2 daily steps (−5.7%).

The high steps group was significantly younger than the low steps group (median high 65.5, median low 76.0, $p<0.001$, $r=0.65$) and had significantly higher TBA (median high 28, median low 26, $p=0.005$, $r=0.53$), but was otherwise comparable in the other demographics, QoL, cognitive status.

Linear mixed model exploring the effects of being in the control group, high steps or low steps groups on the TBA score, showed a significant group*time interaction ($p=0.007$, lme-d = 0.78) with the low steps group showing a significant increase over 12-months in TBA compared to the control group, but no difference compare to the high steps group (Fig. 5A).

The high steps group had a significant group*time interaction at 6-months for QoL VAS score ($p=0.013$, lme-d = 0.49), with a 11.3 point higher score compared to the control group (Fig. 5B). The effect was not present at 12-month follow-up. Compared to the control group, the low steps group did not have a significantly higher QoL VAS, but the scores at 6-months and 12-months were 5.0 and 6.5 points higher than the control group. There was no significant difference over time between the high and low steps group.

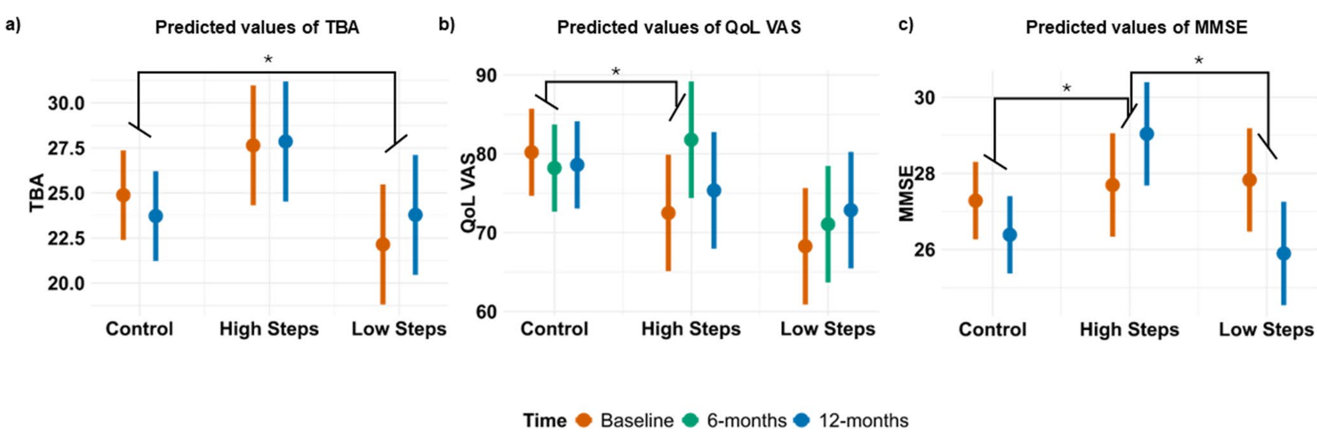

Fig. 5 Results from the linear mixed model of the predicted values in the control, high steps and low steps groups for (**A**) TBA, (**B**) QoL VAS and (**C**) MMSE. The asterisk denotes a statistically significant result

The Linear mixed model for cognition, showed that the high steps group had a significant increase in MMSE score over the 12-month intervention compared to the control group ($p = 0.005$, lme-d = 0.82), and the low steps group ($p < 0.001$, lme-d = 1.02) (Fig. 5C). There was no significant difference over time between the control and low steps group. There was no significant effect of the intervention on FAB over time.

Post-hoc contrast did not highlight significant changes either in the control, high or low steps from baseline to 12-months for TBA, QoL VAS, or FAB. The low steps group however had a significant decline in MMSE from baseline to 12-months ($p = 0.013$).

4 Discussion

In the present study we evaluated the estimate of fall probability, QoL and cognitive status of older adults taking part in a health monitoring intervention (RQ1). The intervention compared to the control group increased the TBA score, and thus the estimated fall probability decreased. Regrouping of the intervention group based on the number of steps (RQ2) showed that the low steps group was the one that benefited the most. The intervention group also displayed higher levels of QoL after 6 months and this was driven by the high steps group (≥4500 daily steps), although the low steps group also had an increase over time. With respect to the cognitive scores (MMSE and FAB), the progression over time did not differ between intervention and control group. On the other hand, the analysis with three groups showed that the high steps group had a significant increase in MMSE score compared to a decrease over time for the low steps and control group.

To age successfully, it is essential to promote engagement in social, physical, leisure activities, and preserve independence as they can impact the QoL of older adults. In the last decades, scientific research has highlighted physical activity and exercise as potential ways to counteract the age-related decrease in muscle mass, balance and tone, and possibly reduce the risk of falls [38]. Other than just physical changes, physical activity and exercise have been pointed out as means to increase or maintain cognitive abilities [4]. These prospects show that physical activity can be used as a tool to reduce the social and economic burden associated with aging.

In the present study, the intervention group at baseline had an average number of steps that were around half of the commonly recommended 10 000 steps per day for the general population [13]. No clear step-based equivalent of the public World Health Organization guideline of 150–300 min of moderate activity (or 75–150 min if vigorous) had been established [14]. Nevertheless, previous research has shown that in older adults fewer than 10 000 steps can still have an overall effect of health and mortality risk reduction [15–18]. The number of daily steps appeared to decline around the eighth month of the intervention (relative to each participant's recruitment month). Other than possible motivation loss, the observed decline may also reflect seasonal variation. As most participants were recruited in the first and last trimesters of the year, months 6 to 10 of their intervention would coincide with the summer holiday period. Among participants who retained the smartwatch for the full year but had missing data, the gaps most often occurred between May and August, suggesting temporary interruptions during the summer months, after which the use resumed.

One of the key results found in the present paper was a significant increase in TBA score in the intervention group. Merely being part of an intervention and providing a fitness tracker could promote physical activity and overall movement, and thus a decrease in the probability of falls. This finding is consistent with earlier observations, which showed an increase in TBA in participants residing in residential facilities after 9-weeks of joining a "walking club" [39] and following an 8-week of resistance training and free-walking [40].

When looking at the high and low steps groups compared to the control, the group that had a beneficial effect on TBA was the low steps group. The result might be surprising given the small decline in the total number of steps over 12 months, yet the smartwatch may have encouraged activities that were not limited to increasing the daily step count such as standing or light activities, which may have resulted in an improvement in TBA scores. In other words, older adults might have engaged in less step-intensive routines which could have led to performing other activities that, in the end, contributed to better health outcomes. Notably, the low steps group was older than the high steps group, making this a pivotal finding for future studies. As a result, for less active participants, wearing a smartwatch might have created a behavioral shift that, given the low baseline activity levels, even modest involvement could have led to significant health improvements. This is consistent with the work of [39], where the increase in TBA score was found in participants that were on average 80 years old and had low TBA scores at pre-test. It is also important to mention that the TBA score does not only assess the gait but evaluates also the balance of the individual, and it is therefore possible that the intervention targeted more effectively this other component. Furthermore, the high steps group already had a high number of daily steps, were younger and had a significantly higher TBA score at baseline and additional increases in number of steps are relatively irrelevant to produce positive and measurable effects on health.

The intervention group at baseline had a significant lower perception of their health-related QoL. The most striking finding was that after 6-months of intervention the scores reversed the pattern, and the intervention group had a significantly higher QoL VAS score compared to the control group. This different result was not maintained at the 12-month assessment. Nevertheless, it is possible to observe that the intervention group from baseline to 12-months had an increase in QoL VAS score compared to a negative trend for the control group. Although the present study is not an exercise intervention, the results are consistent with a systematic review on physical activity, physical health and health-related QoL, which shows that an active lifestyle is associated with positive outcomes and maintenance of older adults' independence [41]. In particular, the review showed that all the included studies that measured health-related QoL had an increase in scores following the intervention. In our paper, the result was present mainly in the high steps group, and the pattern of significant increase in QoL VAS score mimicked the result of the intervention group as a whole. It should be emphasized that although the effect was not present in the low steps group, the QoL VAS score increased over time also in these participants. The results are in line with the results of a multi-modal intervention [42] which found a significant difference between the intervention and the control in health-related QoL. However, it is in contrast with a study on pulmonary patients, which did not find differences in QoL VAS in those who walked more and those who walked less than 5000 steps [19]. Interestingly, there was no significant difference in the number of steps, suggesting that a more comprehensive lifestyle intervention could benefit more in the perception of QoL. An important implication of our findings could be that providing technology to older adults which prompts them to move has the potential to increase the QoL of older adults, also in those, although to a lesser extent, that are older and are less active.

The study did not detect evidence that the intervention can maintain or increase cognitive scores compared to a control group. However, when looking at the high steps group, there was a significant group*time interaction demonstrating an increase in MMSE score after 12-months of intervention compared to the decrease in the low steps and control groups. This finding is parallel to what was found in a Chinese community, where they observed higher MMSE scores in participants who regularly exercised [43]. Similarly, active participating in a multi-domain intervention promoting healthier lifestyle has been found to significantly increase global and specific cognitive domains [44]. The observed cognitive benefits in the high steps group may be attributed to several factors. The high steps group had overall higher step count at baseline and throughout the intervention. Furthermore, the group was younger and had higher values in TBA. These participants might also have had greater physiological reserve that allowed them to experience greater benefits from the intervention compared to older counterparts.

Despite these results, there are some limitations that should be addressed. We did not collect data about previous physical activity levels, or current leisure physical activities, which could have influenced the positive cognitive outcomes, as it has been shown that middle aged physical activity is protective for cognitive aging [45]. Another limitation was the absence of daily step count for the control group and thus the difficulty of comparing physical activity in the two groups. Yet the focus of the present intervention was not to directly compare physical activity measurements, but rather the effects of introducing a technological device to older adults in order to increase their QoL. Furthermore, the smartwatch was not the only technology that was provided in the monitoring scenario, and the older adult was not required to use it continuously. As a result, not all participants engaged with the wearable for the entire 12-month period. However, this study was designed to closely mirror real-world conditions, without external pressures or enforced usage. This approach allowed the assessment of how older adults naturally integrated technologies into their daily lives. This reinforces the idea that simple and accessible tools can support well-being and active ageing in a realistic, non-intrusive way.

The findings of our study demonstrate that providing a smartwatch to older adults is an effective intervention for positively influencing their physical activity habits. Despite a modest increase in the median daily step counts over the 12-month period, the intervention successfully encouraged beneficial behavior changes beyond just increasing step counts, potentially through enhanced self-monitoring, greater mobility awareness, and improved engagement in healthier daily routines. These changes contributed to positive outcomes in the probability of falls (TBA), quality of life (EQ VAS) and cognitive functioning (MMSE) of older adults, highlighting the potential of technology-assisted interventions to support aging populations. In the future, studies should consider the transition toward a multi-domain intervention approach providing older adults with comprehensive tools that allow them to make healthier lifestyle choices. For example, organized walking groups could not only promote physical activity but also provide opportunities for social interaction, thereby addressing both physical and psychosocial well-being.

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Declarations

Ethical approval The study is in line with the principles of the Declaration of Helsinki and was approved by local ethical committees. In Apulia it was approved with the Prot. Nr 1669.01 DG on the 14/06/2021, whereas in Tuscany it was approved by Azienda USL Toscana Sud-Est with the Prot 2021/000227 on the 22/07/2021 and by the Azienda USL Toscana Centro with Prot. 2022/22131 on the 18/10/2022.

Consent to participate All participants were educated on the study objectives and provided their written informed consent.

Consent to publish All authors reviewed, commented on and edited the manuscript and approved the final version.

Competing interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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