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Effectiveness of light paths coupled with personal emergency response systems in preventing functional decline among the elderly

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Abstract

Introduction: The elderly population is at high risk of functional decline, which will induce significant costs due to long-term care. Dependency could be delayed by preventing one of its major determinants: falls. Light paths coupled with personal emergency response systems could prevent the functional decline through fall prevention.

Methods: This study aimed to evaluate the effectiveness of light paths coupled with personal emergency response systems on the functional decline in an elderly population living at home. It is a secondary analysis on data from a previous cohort. In all, 190 older adults (aged 65 years or more) living at home participated. Participants in the exposed group were equipped with home-based technologies: light paths coupled with personal emergency response systems. The participants' functional status was assessed using the Functional Autonomy Measurement System scale at baseline (T0) and at the end of the study (T12-month). Baseline characteristics were evaluated by a comprehensive geriatric assessment.

Results: After 1 year, 43% of the unexposed group had functional decline versus 16% of the exposed group. Light paths coupled with personal emergency response systems were significantly associated with a decrease in the functional decline (Δ Functional Autonomy Measurement System ⩾ 5) at home (odds ratio = 0.24, 95% confidence interval (0.11–0.54), $p = 0.002$).

Discussion: This study suggests that light paths coupled with personal emergency response systems prevent the functional decline over 12 months. This result may encourage the prescription and use of home-based technologies to postpone dependency and institutionalization, but they need a larger cost-effectiveness study to demonstrate the efficiency of these technologies.

Keywords

Light paths, personal emergency response systems, functional decline, elderly

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Introduction

The functional decline in the elderly is a major concern and will become an increasingly significant health issue because the aging population is growing. United Nations predicts that 22% of people in the world will be aged over 60 years by 2050 (32% in industrialized countries). In European countries such as the United Kingdom, the total public expenditure on long-term care for elderly dependence in 2004 was evaluated at 17 billion euros.[1] These figures will increase with the growing aging population. Aging brings health and autonomy issues because of slow physiological functional decline, mostly accelerated by chronic diseases. Loss of autonomy has serious complications leading to high costs for society due to multiple

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hospitalizations, institutionalizations, and professional homecare.

Several kinds of interventions can be provided to prevent the functional decline, such as exercise-based programs, caregiver interventions, health management programs for chronic diseases, and technological interventions.

Technological solutions have already been vastly investigated and numerous scientific evaluations of telehealth have already been reviewed.[2,3] In the specific case of personal emergency response systems (PERS), research has suggested that PERS reduces admissions to institutions[4] and admissions to hospitals as well as inpatient days.[5–8] No longitudinal studies on light paths were found in the literature apart from our main study.[9] This ancillary study is a secondary analysis on secondary data of our previous cohort.

Falls induce a higher risk of the functional decline among the elderly,[10,11] and therefore, this topic has been studied thoroughly.[12] Literature is available on fall detectors,[13] but global technological strategies to reduce the risk of the functional decline have not yet been investigated. The use of multifactorial interventions to prevent falls has been proven to reduce significantly the rate of falls in a Cochrane review.[14] Functional decline assessment in technological studies is a major challenge to demonstrate that new technologies can have an impact on global functioning and hence, on dependency-related costs. We hypothesized that as light paths coupled with PERS may prevent falls at home as suggested by the ESOPPE study,[9] the functional decline should decrease among subjects equipped with these technologies.

We proposed an assessment of the effects of simple, home-based technologies (light paths combined with PERS) on global functioning of a community-dwelling elderly population, measured at 1 year using the Functional Autonomy Measurement System (SMAF).[15]

Methods

Study design

This analysis was based on a previous,[9] prospective, cohort study, conducted from July 2009 to July 2010. It began with the pre-selection of elderly persons enrolled in the local council registry for eligibility to receive care through financial aid. The population was divided into two groups defined by dynamic random allocation using the minimization method: one group was qualified as "exposed" and the other as "unexposed." The source population was elderly people living at home in the Corrèze area (Limousin, France). Subjects were aged 65 years and older and were registered as elderly people with a functional decline in autonomy. All participants have been diagnosed in the previous 2 years. As people suffering from severe dementia are unable to use such technologies, they were excluded as well as those already included in a fall prevention program. Every subject received information and was asked to give written informed consent. The study protocol was accepted by the local ethics committee and the National Committee for the Protection of Computerized Data.

Study intervention

The exposed group included 94 subjects. They were equipped with PERS (a 100-m range electronic bracelet or pendent, a shower, and toilet cord emergency alarm) and light paths. Light paths were variable length light-emitting diode (LED) band devices installed from the bed to the bathroom, which were triggered on automatically when the person set one foot on the ground. These are believed to help in preventing falls by offsetting the aging-related neurosensorial malfunction by improving consciousness and visibility for people waking up and getting up during the night. PERS were connected remotely via Bluetooth® to a central intercom and hotline, available 24/7. Every device was able to self-test and report for failures and technical help was sent within 24 h to replace faulty devices in such cases. Equipment installation and operation was free of charge for the participants of the study. More detailed procedures have been described in a previous publication.[9]

Study assessments

Every subject from both groups received a baseline clinical assessment and a follow-up assessment at home1 year after the inclusion. Assessments consisted of a standard comprehensive geriatric assessment[16] as well as gathering sociodemographic data. A functional autonomy assessment was performed using the SMAF,[15] the Timed Up and Go test,[17] activities of daily living (ADL),[18] and instrumental ADL.[19] Subjects who were unable to comply with a follow-up visit because of incapacity, such as institutionalization or hospital admission, remained in the study and a maximum of data were gathered. Withdrawal of consent and drop outs were reported anytime during the follow-up until 1 year. Assessments were performed by a trained geriatrician accompanied by a trained nurse or social worker.

Definitions and main outcome assessment

The definition of functional decline was similar to the one used by Hébert et al.[20] We used a composite criterion, which was the increase of at least five points of the SMAF score between the baseline and the 1-year follow-up visit or institutionalization. Subjects who died were not considered as losing autonomy (unlike in the Hébert et al. study) and were rather used as a censoring variable. Usually, the ADL scale[19] is used to monitor functional decline; however, we chose the SMAF scale because it is a much wider scale which consists of 29 items related to the functional status. It covers ADL, mobility, communication, cognitive functions, instrumental ADL, and neurosensorial status. The scale also takes into account whether each deficiency is compensated by a human aid, which is useful for the practitioner to point out eventual lack of care. The scale is rated on an 87-point score; the score increases with increasing global physical and cognitive decline (in other word, functional autonomy decline). A difference of five points or more is considered as a real change in the autonomy of an elderly person.[21] This 5-point threshold was used to determine a significant loss of autonomy in epidemiological studies[22,23] and in efficacy studies where the functional decline was the outcome variable.[20] However, to be comparable to the most frequently used scales, the ability of subjects to perform ADL was also measured using the scale developed by Katz et al.[18] (ranging from 0 *dependent* to 6 *independent*) and the ability of participants to perform instrumental ADL was measured using the scale originally developed by Lawton and Brody,[19] but the scoring was altered to range from 8 (*independent*) to 31 (*dependent*), according to Cromwell et al.[24]

Depression was determined using the geriatric depression scale, where a score >14 was considered abnormal.[25] Malnourishment was determined with the Mini Nutritional Assessment scale,[26] rated on 30 points.

Sample size and statistical analysis

The sample size was determined to detect a 20% reduction in the rate of falling at home from an expected rate of 33.0 elderly falls per year in 65 years and over to 50.0 in people older than 80 years and with 80% power and 5% significance (two-sided). A total of 202 participants (101 in each group) were needed. Allowing for 15% dropout, we set a recruitment target of 232 people. Descriptive statistics were expressed as mean ± standard deviation (SD). Student's *t*-test was used to compare the means of continuous variables and normal distribution data in factors associated with a functional decline. Categorical data were tested using chi-square analysis. Multivariate analysis was performed by applying a multiple logistic stepwise regression procedure.[27] The variables at initial assessment, which presented a p value of <0.25 after univariate analyses were taken into account for the multivariate model. Analyses were performed using SAS® 9.3 software (2012; SAS Institute, Cary, NC, USA).

Results

Population characteristics

A total of 110 persons were preselected to receive equipment and 94 were included in the study. Some met the exclusion criteria and were therefore not included in the study (Figure 1). Our unexposed group included 96 of 108 preselected persons.

During the study, three participants of the exposed group withdrew their consent because they did not want "an intrusion on their privacy." Indeed, the acceptance rate was 97%. Other baseline characteristics are presented in Table 1.

Impact of home-based technologies on functional decline

After 1 year, 167 participants (81 in the exposed group and 86 in the unexposed group) were analyzed for functional decline. The average follow-up time was 383 days. Exclusion from analysis was due to death ($n=5$), drop outs ($n=5$), or missing data ($n=14$). In the exposed group, 13 persons (16%) presented a functional decline in 1 year versus 37 (43%) in the unexposed group (Figure 1).

Functional decline variations measured by the SMAF score are presented in Figure 2. This study showed that both groups had a similar percentage of stable autonomy; however, decliners were in greater numbers in the unexposed group (46% vs 16%) and improvers were in greater numbers in the exposed group (31% vs 2%).

The variables at initial assessment, which presented a p-value of <0.25, such as type of housing, ADL score, mini mental state score, and Mini Nutritional Assessment (described in Table 2) were taken into account for the multivariate model.

Light paths coupled with PERS were significantly associated with a decreasing risk of functional decline at home according to our criterion (Table 3) (odds ratio (OR) = 0.24, 95% confidence interval (CI) (0.11–0.54), $p<0.002$). The baseline Mini Nutritional Assessment score and ADL score were also found to be significantly associated with a decreasing risk of the functional decline (OR = 0.88, 95% CI (0.88–0.98), $p<0.042$ and OR = 0.62, 95% CI (0.36–0.96), $p<0.014$, respectively).

Discussion

This study showed that light path coupled with PERS were significantly associated with a decreased risk of the functional decline in elderly persons at 1 year (i.e. people equipped with light paths coupled with PERS were less prone to an increase of at least five points on the SMAF scale or being institutionalized). The findings were both the efficacy of light paths and PERS.

The ADL score at the initial assessment was found to be associated with the functional decline. This was expected because it is part of the SMAF scale. Conversely, instrumental ADL were not found to be associated with a decline in functional autonomy, even if instrumental ADL are also included in the SMAF scale. This may be explained by the fact that in the process of losing autonomy, instrumental ADL usually declines sooner than ADL. As both groups were already slightly dependent with a moderate functional decline at the start of the study, they had previously lost their instrumental ADL ability, but preserved their ADL. Therefore, participants who already had lost instrumental ADL could not lose them again. A decreasing Mini Nutritional Assessment score was also associated with the functional decline in autonomy. This underlies the prominent effect of the nutrition in the prognosis of functional decline in elderly people.

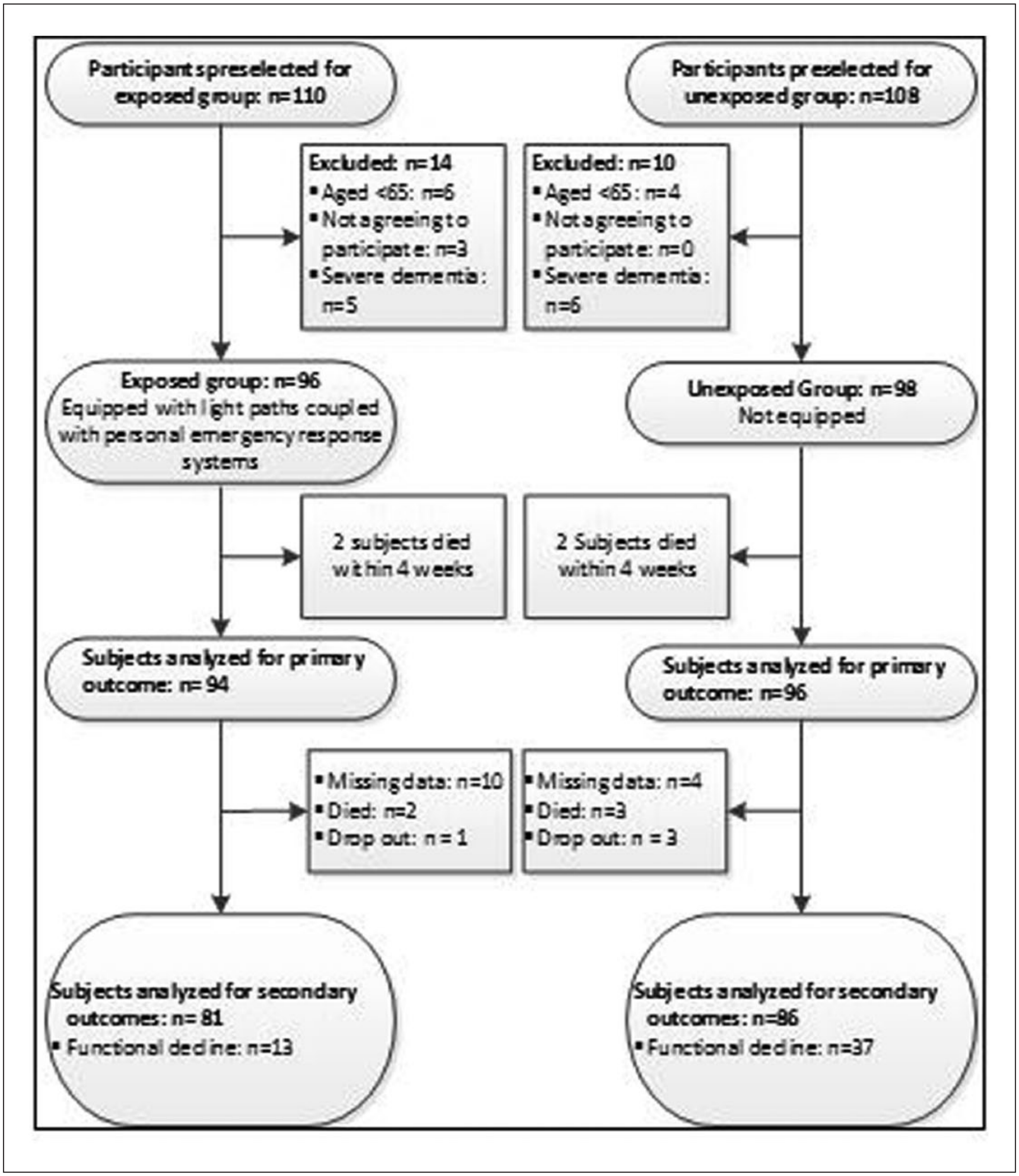

Figure 1. Flowchart of the participants through the study addressing the effectiveness of light paths coupled with personal emergency response systems in preventing the functional decline of an elderly population, from July 2009 to July 2010, Limousin, France.

Mortality was almost the same in both groups (5% in the unexposed group vs 4% in the exposed group) and was not related to the tested technologies.

Study limitations

Our study had some limitations. Attrition bias could be one of them as data of 23 SMAF assessments were missing (12%); however, this represented only 12% of the initial population and was thus acceptable.

The outcome was a composite criterion (SMAF score increase and institutionalization or hospital admission) because we could not assess people in nursing homes or hospitals for logistical or ethical reasons.

Population pre-selection from the local council registry could have generated selection bias as the entire elderly

Table 1. Baseline characteristics of participants ($N = 190$) of a study addressing the effectiveness of light paths coupled with personal emergency response systems in preventing the functional decline of an elderly population, from July 2009 to July 2010, Limousin, France.

Characteristics	Population, N = 190 (%)	Exposed group, n = 94 (%)	Unexposed group, n = 96 (%)	p value
Mean age ± SD in years	83.4 ± 6.2	84.9 ± 6.5	82.0 ± 5.7	**0.001**
[65–80]	48 (25)	18 (19)	30 (31)	
⩾80	142 (75)	76 (81)	66 (69)	
Women	147 (77)	72 (77)	75 (78)	0.80
Marital status				0.053
Married	49 (26)	17 (18)	32 (33)	
Widow(er)	112 (59)	62 (66)	50 (52)	
Unmarried	29 (15)	15 (16)	14 (15)	
Presence of caregivers	164 (86)	86 (91)	78 (81)	**0.040**
Scholarly grade				0.23
Illiterate	51 (27)	21 (22)	30 (31)	
Primary level	113 (60)	57 (61)	56 (58)	
Secondary level	26 (14)	16 (17)	10 (10)	
Type of housing				0.072
Individual (private)	146 (77)	67 (71)	79 (82)	
Residence for seniors (collective)	44 (23)	27 (29)	17 (18)	
Residence				0.98
Rural	81 (43)	40 (43)	41 (43)	
Urban	109 (57)	54 (57)	55 (57)	
Mean SMAF score ± SD	19.0 ± 13.8	20.6 ± 11.8	17.3 ± 15.4	0.104
Mean ADL score ± SD	5.0 ± 1.2	5.0 ± 1.1	5.1 ± 1.3	0.60
Mean IADL score ± SD	17.7 ± 6.4	18.6 ± 5.6	16.7 ± 6.9	**0.037**
At least five drugs (polypharmacy)	163 (86)	85 (90)	78 (81)	**<0.001**
At least three comorbidities	26 (14)	7 (7)	19 (20)	**0.013**
Mild-to-moderate cognitive impairment	67 (35)	34 (36)	33 (34)	0.80
Malnourished	68 (36)	40 (43)	28 (29)	0.054
Depression	130 (68)	68 (72)	62 (65)	0.25
Hypertension	118 (62)	61 (65)	57 (59)	0.43

SD: standard deviation; SMAF: Functional Autonomy Measurement System; ADL: activities of daily living; IADL: instrumental activities of daily living.
The bold values identify significantly different characteristics ($p < 0.05$).

population was not considered. This is especially true for elderly people with good and stable functional autonomy, therefore not receiving any financial aid and not taken into account for selection, whereas they may be less likely to lose autonomy in 1 year. Indeed, this has been shown by Hébert et al.[22] where the incidence of functional decline was lower in previously stable elderly people (11.9%) than among previously declining people (15.7%). It also suggests that elderly people who are already presenting functional decline could show higher benefits from preventive interventions to spare their autonomy. However, as both studied groups of our study were comparable, it underlines the importance of the results in this selected population which has to be targeted. The hypothesis of light paths efficacy was to prevent the fall event by improving vision acuity. PERS was added to the light paths, to communicate with teleassistance center for caring strategies.

Study strengths

This study is the first study to attempt to assess if the functional decline at home could be prevented through the use of simple home-based technologies. Indeed, measuring functional decline at home is quite a logistical challenge and all our assessments were made face to face in the real living environment. Data collection for both groups was made by two separate teams to try to avoid confusion bias since blinding was obviously not possible. Pre-study staff training in SMAF rating was made to guarantee quality of the results and minimize inter-rater variability.

This study implies that simple technologies could prevent the functional decline in the elderly living at home, potentially avoiding the high cost of dependency and perhaps also postponing institutionalization.

Only a few studies were found in the literature associating technologies and assessments at home.[13,28] Moreover, outcomes (and sample sizes) were not the same (i.e. fear of falling and physical performance) and the functional decline prevention has rarely been explored. This study can be compared to the study by Hébert et al.[20] who aimed to validate the efficacy of a nurse-led, multidimensional program on functional decline. Hébert et al. revealed that functional decline proportions at 1 year were similar in compared groups (20%). In this

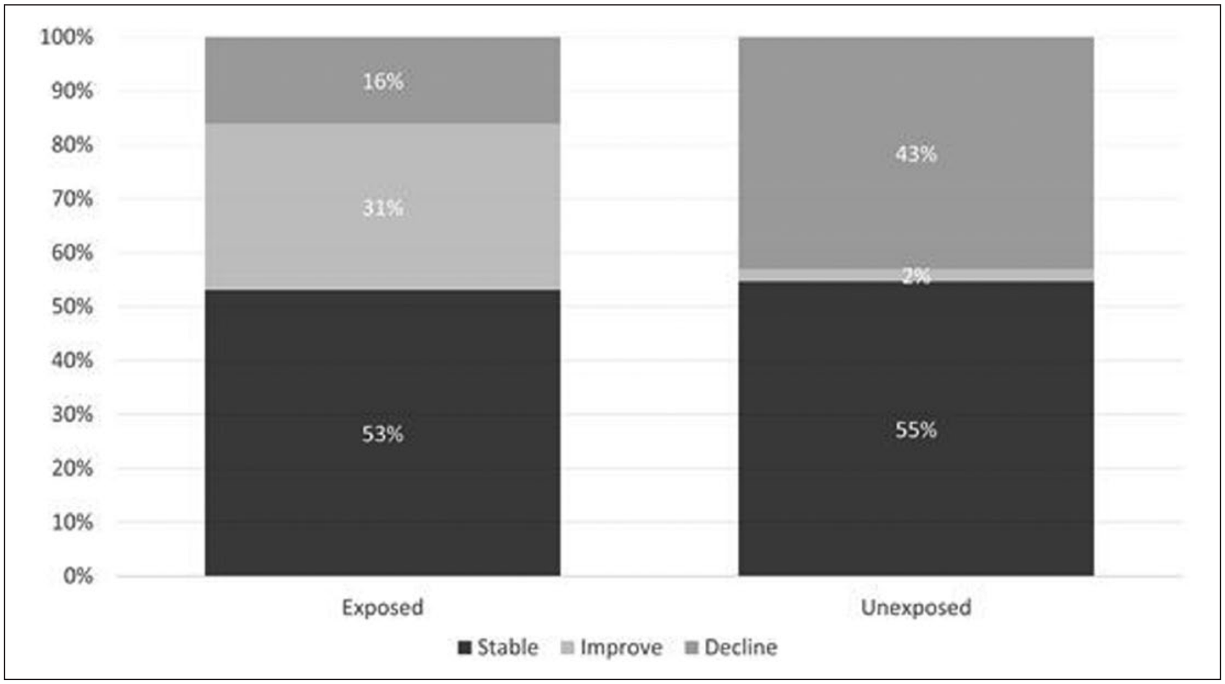

Figure 2. Functional decline variations assessed by the gain/loss of at least five points of the SMAF scale in a study comparing elderly people using light paths coupled with PERS (exposed, $n=81$) to controls (unexposed, $n=86$), from July 2009 to July 2010, Limousin, France.

Table 2. Logistic univariate regression analysis of functional decline status over 12 months (SMAF increase ⩾5, institutionalization, or hospital admission) in a study ($N=167$) addressing the effectiveness of light paths coupled with personal emergency response systems in an elderly population, from July 2009 to July 2010, Limousin, France.

Baseline characteristics	OR	95% CI	*p* value
Age (years)	0.98	0.94–1.05	0.91
Gender			
Women	1.00	Reference	–
Men	1.05	0.48–2.29	0.90
Education achievement			
<High school	1.00	Reference	–
High school	0.73	0.33–1.62	0.44
College or vocational training	0.75	0.24–2.33	0.62
Type of housing			
Individual	1.00	Reference	–
Collective	0.39	0.16–0.96	**0.040**
Living in urban area	0.69	0.35–1.34	0.27
ADL score (0–6)	0.65	0.48–0.88	**0.006**
IADL score (8–36)	1.03	0.98–1.09	0.21
MMS score(0–30)	0.91	0.84–0.97	**0.006**
HBT	0.25	0.12–0.53	**0.002**
GDS score (0–30)	1.03	0.98–1.08	0.190
MNA score (0–30)	0.87	0.79–0.95	**0.022**
Timed Up and Go test	1.04	0.53–2.04	0.91
Polypharmacy	1.86	0.66–5.26	0.24
Multimorbidity	1.26	0.59–2.67	0.55
Hypertension	1.42	0.69–2.93	0.35
Diabetes	1.31	0.54–3.18	0.55
Hypercholesterolemia	0.81	0.41–1.60	0.54

OR: odds ratio; CI: confidence interval; ADL: activities of daily living; IADL: instrumental activities of daily living; MMS: Mini Mental State; HBT: home-based technologies coupled with teleassistance service; GDS: Geriatric Depression Scale; MNA: Mini Nutritional Assessment.
The bold values identify significantly different characteristics.

Table 3. Final model of logistic multivariate regression analysis of functional decline status over 12 months (SMAF increase ⩾5, institutionalization, or hospital admission), in a study (N = 167) addressing the effectiveness of light paths coupled with personal emergency response systems in an elderly population, from July 2009 to July 2010, Limousin, France.

Baseline predictors	OR	95% CI	p value
Home-based technology (HBT)	0.24	0.11–0.54	0.002
Mini Nutritional Assessment (MNA) score (0–30)	0.88	0.88–0.98	0.042
Activity of Daily Living (ADL) score (0–6)	0.62	0.36–0.96	0.014

OR: odds ratio; CI: confidence interval.

study, the rate of the functional decline is significantly higher in the unexposed group and lower in the exposed group. This may be explained by the different natures of the initial populations. As mentioned above, unlike in the study by Hébert et al., our study subjects were receiving a financial help by the local council (for helping with autonomy issues) and therefore were already declining, as shown by the baseline mean SMAF score (19.0 ± 13.8), which was significantly higher than in the study by Hébert et al.[20] (9.9 ± 8.8). This suggests again that home-based technologies might be more effective on people at higher risk and who are beginning to decline.

Concerning the nutritional state, no previous studies have associated Mini Nutritional Assessment scores and functional decline. However, Mini Nutritional Assessment has been found to be a predictor of falls,[29] which in return could induce a functional decline.[10]

The results of this study may be explained by the fact that home-based technologies coupled with PERS mainly act on fall prevention[9] through compensation of the neurosensorial declining effect of aging (light path) and through probable positive activity stimulation in a safer environment where elderly people do not restrict their mobility as they know they can be rescued if they fall. Indeed, activity may be stimulated in the exposed group as participants were reassured. However, this explanation requires activity to be measured precisely as another variable in further studies.

In conclusion, this study revealed that light paths coupled with PERS could prevent the functional decline of autonomy in elderly people who have already begun declining at home. A larger randomized trial is needed to confirm these results and compare the efficiency of these devices.

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Declaration of conflicting interests

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

Ethical approval

Ethical approval for this study was obtained from The Commission Nationale Informatique et Liberté (DR-2010-329).

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Informed consent

Written informed consent was obtained from all subjects before the study.

References

1. Molinuevo D. Services for older people in Europe: facts and figures about long term care services in Europe. *The European Social Network*, http://ec.europa.eu/health/mental_health/docs/services_older.pdf (October 2008, accessed 22 June 2015).
2. Wootton R. Twenty years of telemedicine in chronic disease management: an evidence synthesis. *J Telemed Telecare* 2012; 18: 211–220.
3. Barlow J, Singh D, Bayer S, et al. A systematic review of the benefits of home telecare for frail elderly people and those with long-term conditions. *J Telemed Telecare* 2007; 13: 172–179.
4. Ruchlin HS and Morris JN. Cost-benefit analysis of an emergency alarm and response system: a case study of a long-term care program. *Health Serv Res* 1981; 16: 65–80.
5. Koch WJ. Emergency response system assists in discharge planning. *Dimens Health Serv* 1984; 61: 30–31.
6. Dibner AS (ed.) *Personal response systems: an international report of a new home care service*. New York: Haworth Press, 1992.
7. Roush RE, Teasdale TA, Murphy JN, et al. Impact of a personal emergency response system on hospital utilization by community-residing elders. *South Med J* 1995; 88: 917–922.
8. Roush RE and Teasdale TA. Reduced hospitalization rates of two sets of community-residing older adults after use of a personal response system. *J Appl Gerontol* 1997; 16: 355–366.
9. Tchalla AE, Lachal F, Cardinaud N, et al. Efficacy of simple home-based technologies combined with a monitoring assistive center in decreasing falls in a frail elderly population (results of the Esoppe study). *Arch Gerontol Geriatr* 2012; 55: 683–689.
10. Keene GS, Parker MJ and Pryor GA. Mortality and morbidity after hip fractures. *BMJ* 1993; 307: 1248–1250.

11. Tinetti ME and Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. *N Engl J Med* 1997; 337: 1279–1284.
12. Tinetti ME, Speechley M and Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988; 319: 1701–1707.
13. Brownsell S and Hawley MS. Automatic fall detectors and the fear of falling. *J Telemed Telecare* 2004; 10: 262–266.
14. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev* 2009; 2: CD007146.
15. Hebert R, Carrier R and Bilodeau A. The Functional Autonomy Measurement System (SMAF): description and validation of an instrument for the measurement of handicaps. *Age Ageing* 1988; 17: 293–302.
16. Solomon D, Sue Brown A, Brummel-Smith K, et al. National Institutes of Health Consensus Development Conference Statement: geriatric assessment methods for clinical decision-making. *J Am Geriatr Soc* 1988; 36: 342–347.
17. Podsiadlo D and Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991; 39: 142–148.
18. Katz S, Downs TD, Cash HR, et al. Progress in development of the index of ADL. *Gerontologist* 1970; 10: 20–30.
19. Lawton MP and Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist* 1969; 9: 179–186.
20. Hébert R, Robichaud L, Roy P, et al. Efficacy of a nurse-led multidimensional preventive programme for older people at risk of functional decline. A randomized controlled trial. *Age Ageing* 2001; 30: 147–153.
21. Hébert R, Spiegelhalter DJ and Brayne C. Setting the minimal metrically detectable change on disability rating scales. *Arch Phys Med Rehabil* 1997; 78: 1305–1308.
22. Hébert R, Brayne C and Spiegelhalter D. Incidence of functional decline and improvement in a community-dwelling, very elderly population. *Am J Epidemiol* 1997; 145: 935–944.
23. Hébert R, Brayne C and Spiegelhalter D. Factors associated with functional decline and improvement in a very elderly community-dwelling population. *Am J Epidemiol* 1999; 150: 501–510.
24. Cromwell DA, Eagar K and Poulos RG. The performance of instrumental activities of daily living scale in screening for cognitive impairment in elderly community residents. *J Clin Epidemiol* 2003; 56: 131–137.
25. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res* 1982; 17: 37–49.
26. Rubenstein LZ, Harker J, Guigoz Y, et al. Comprehensive geriatric assessment (CGA) and the MNA: an overview of CGA, nutritional assessment, and development of a shortened version of the MNA. In: Vellas B, Garry P, Guigoz Y (eds) *Mini nutritional assessment (MNA): research and practice in the elderly, Nestlé Nutrition Workshop Series Clinical & Performance Programme, Karger Eds* vol.1 1994, pp. 101-116.
27. Hosmer DW, Hosmer T, Le Cessie S, et al. A comparison of goodness-of-fit tests for the logistic regression model. *Stat Med* 1997; 16: 965–980.
28. Schoene D, Lord SR, Delbaere K, et al. A randomized controlled pilot study of home-based step training in older people using videogame technology. *PLoS ONE* 2013; 8: e57734.
29. Chien M-H and Guo H-R. Nutritional status and falls in community-dwelling older people: a longitudinal study of a population-based random sample. *PLoS ONE* 2014; 9: e91044.