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Effects of an Exergame Software for Older Adults on Fitness, Activities of Daily Living Performance, and Quality of Life

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Abstract

Background: As people become older, the biological process of aging leads to a decline in functional capabilities, which entails difficulties in the performance of daily tasks. Within the ''Active and Assisted Living Joint Programme'' a consortium from Spain, Germany, and Switzerland developed an interactive Exergame software for older adults to maintain their physical abilities and independence within the daily tasks.
Subjects and Methods: An interventional study was conducted to validate the software. For 3 months, Swiss and Spanish seniors used the system at least three times a week for minimum half an hour in their homes. The physical condition in terms of maintaining or increasing strength, balance, safety, and mobility of the seniors was assessed by using the Berg Balance Scale and the Senior Fitness Test. In addition, the effect on independence within the activities of daily living was assessed by using the Canadian Occupational Performance Measure, the Performance Quality Rating Scale, and the Iconographical Falls Efficacy Scale. We used the EQ 5D to evaluate the ''quality of life.''
Results: Twenty-nine participants (male; $n=14$; female; $n=15$) completed the study. Scores of endurance (2 minutes step test; $P=0.01$, $\eta^2=0.3$) increased significantly. Moderate effect sizes in quality of life ($r=0.3$), lower body strength ($\eta^2=0.08$), and large effect sizes in endurance ($\eta^2=0.3$) were detected. A small effect was evaluated within the gait speed ($r=0.2$), mobility in the lower body ($r=0.2$), and the balance capabilities ($r=0.2$).
Conclusion: The results of this study lead us to the conclusion that physical training with activity-focused exergames that are related to the everyday tasks of older adults could help to maintain and improve the individual fitness status.

Keywords: Daily living performance, Endurance, Fitness, Older adults, Quality of life

Introduction

As people become older the biological process of aging leads to a decline in functional capabilities, such as reduction of movement ranges, muscular strength, and endurance, which entails difficulties in the performance of ''Activities of the Daily Living'' (ADLs).[1]

Colombo et al.[2] point out that the proportion of older adults between 65 and 79 in the European society is expected to increase from 15% in 2010 to 25% in 2035. For the population above the age of 80 years, the OECD expects an increase from 4% in 2010 to 9.4% in 2050. Therefore, the number of people dependent on care and assistance is rising in Western countries. Much of the tasks related to caring are taken up by relatives. In the OECD, 1 in 10 adults is involved in informal care giving that is defined as providing help with personal care or basic ADLs to people with limitations. Although the percentage of people giving informal care is at around 10% to 11% for Switzerland, Germany, and Austria, informal care giving is much more common in Spain and Italy with 15% to 16% of population reporting being involved in informal care giving.

Nonprofessional caregivers should be supported in the provision of care. Support can be provided through new technologies, such as communication technologies and digital electronics, which were developed to empower a collaborative caring and training between older persons and their nonprofessional caregivers to promote the

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independent living of the older persons. The Active and Assisted Living (AAL) Joint Programme aims at enhancing the quality of life of older people and strengthening the industrial base in Europe through the use of ''Information and Communication Technologies.''[3]

One of those systems, the ''WeTakeCare System,'' aims to support older adults by training their physical capabilities, and offers helpful information about compensation strategies, assistive devices, etc. The development of the software is based on the results of a comprehensive literature review, data reanalysis, and focus groups to identify the needs and difficulties of older persons and their nonprofessional caregivers. The analysis of the findings showed that activities such as getting dressed, lifting heavy weights, walking, and cleaning are the most difficult tasks for older people. In addition, the target groups, older adults, and their informal caregivers prefer to get information about nutrition, improving quality of life, and getting tips to improve their fitness.

We found no system that encourages the individual autonomous performance of ADL by the older person and at the same time trains and supports the caregiver in the provision of care, improving the quality of the provided care, and safeguarding their own physical, physiological, and occupational health.

Aim of the study

This article presents the last validation phase of the software by evaluating a measurable effect on defined body functions, the performance of daily activities, risk of falls, and the quality of life in healthy older adults after using the system. We made subgroup analysis (gender differences and country differences) to find out whether some groups use the system more often or profit more or less than the other group. We use these results for further development of the prototype.

The results of the study concerning the acceptance, usability, and assessability of the WeTakeCare System will be described in another article.

Subjects and Methods

The system is an interactive and multimodal Information- and Exergame software based on an Internet protocol television platform. The user's movements are detected by a Microsoft Kinect sensor, and made visible on the TV screen by navigating an avatar. The contents of the three exergames were developed to simplify daily functional tasks like, for example, putting on socks and shoes, a pair of trousers, or a jacket, by maintaining body functions such as balance, endurance, and mobility (Fig. 1).

The system is adaptable to the users' needs and scope of performance: Before starting to play, the user has to complete the assessment incorporated in the system. Participants have to indicate physical restrictions and problems in performing daily tasks. According to the outcome of this questionnaire, the software adapts to the individuals' needs.

The validation of the software was divided into three phases. In the first validation, a total number of six focus groups (''seniors,'' ''caregivers,'' and ''health professionals'') were run in Spain and Switzerland. In the second validation, members of the target group tested the system under laboratory conditions. The results of both validation phases flowed into the construction of the third prototype, evaluated in the third validation phase, which represents the main subject of this article.

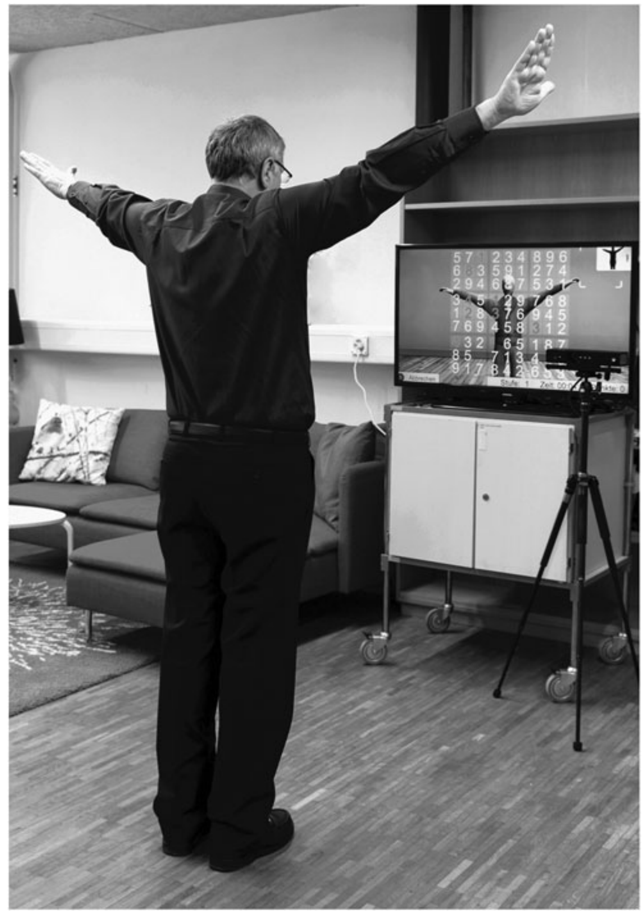

FIG. 1. Participant is playing 3D Sudoku.

Intervention

An interventional study was conducted to validate the third prototype of the system. The number of participants was 40 seniors in Switzerland and Spain. The participants of the study should use the system at least three times a week for minimum half an hour in their homes for 3 months. Data about frequency and duration of the use have been recorded by the system itself.

The Spanish participants were recruited from the Mislata community, whereas the Swiss people were recruited with the help of a Swiss association of elderly people (VASOS [Vereinigung aktiver Senioren- und Selbsthilfe-Organisationen derSchweiz]).

Three serious games are available on the system: (1) Sound Movement, (2) Treasure hunt, and (3) Sudoku. The games train the following functional capabilities: (1) mobility of the upper limb, (2) mobility of the lower limb, (3) prevention of the falling risk, (4) balance, (5) endurance, and (6) strength in the upper limbs. After installing the devices in the participant's homes, therapists explain the use of the system to the elderly people.

Ethics approval from the cantonal Ethics Committee Zurich/Switzerland (KEK-ZH-No. 2015-0366) and from the

Universitat Politecnica de Valencia was obtained before commencement of the study.

Study design

We assessed the efficacy of the third prototype by means of a user-centered interventional study. Ethics approval from KEK, Cantonal Ethic Committee, Zurich, Switzerland, was granted. All participants signed the informed consent.

Participants

Eligibility criteria of the participants for the third validation included targeting older persons (>50 years), with age-related mild-to-moderate restrictions in performance of daily tasks. Participants were included if they had a Mini Mental State Examination Score[4] of not <24, a Berg Balance Scale outcome of ≥ 45,[5] and at least three ADLs that they perform with some difficulties, assessed by the Health Assessment Questionnaire.[6]

Older adults were excluded with medical restrictions or instabilities such as (1) history of epilepsy, (2) diagnosed severe cardiovascular disorders/high blood pressure, (3) diagnosed severe neurological disorders, (4) surgery <3 months ago, (5) recent fractures (<6 weeks ago and/or instable), (6) moderate-to-severe depression/anxiety diagnosis, (7) non-correctable hearing and/or visual impairment, (8) progressive or terminal illness, (9) falls in the past 6 months, (10) upper or lower limb rehabilitation, (11) high risk of falling, (12) severe restrictions in ADL performance, and (13) living in a care facility or receiving professional care (Fig. 2).

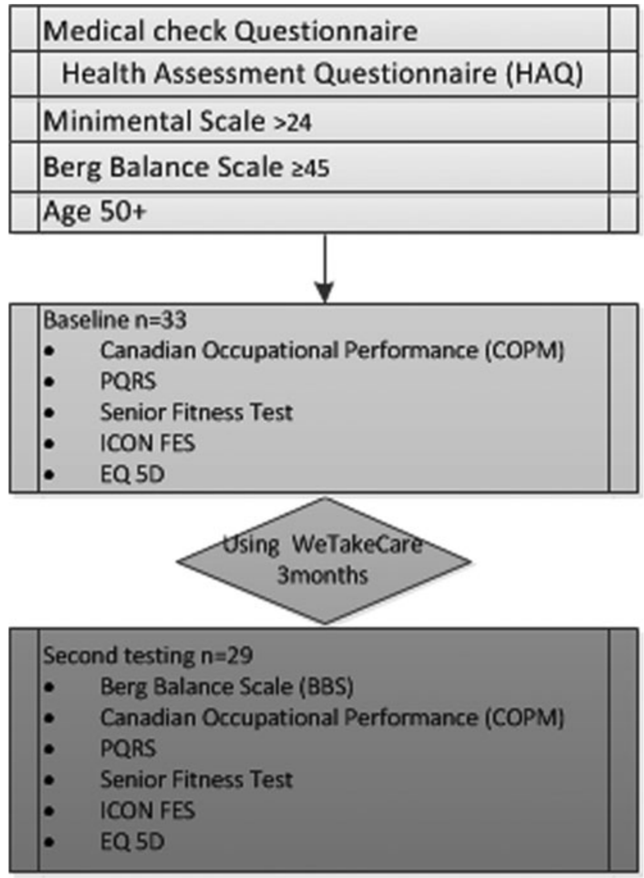

FIG. 2. Flow chart. PQRS, Performance Quality Rating Scale; Icon FES, Iconographical Falls Efficacy Scale; EQ-5D, quality of life.

Outcome measures

The first aim of the study is to assess the physical condition in terms of maintaining or increasing strength, balance, safety, and mobility of the seniors.

In addition, the effect on independence within the ADLs as well as a change in the ''fear of falls'' scale and the ''quality of life'' was assessed.

Measurement of physical functioning. *Berg Balance Scale.* This test assesses mobility tasks such as getting up from a chair to standing on one foot. By using a 5-point scale that ranges from 0 (most impaired balance) to 4 (normal balance), the functional capabilities of an older person can be assessed (ICC = 0.97).[5]

Senior Fitness Test. The Senior Fitness Test (SFT) is a functional fitness test battery that assesses the physiological parameters that support physical capabilities such as endurance, flexibility, and strength of upper and lower body in older adults (ICC = 0.89–0.96).[7]

Measurement of ADL performance. *Canadian Occupational Performance Measure.* The Canadian Occupational Performance Measure (COPM) assesses the self-awareness of occupational performances in areas of self-care, productivity, and leisure. The subjective outcome of the most important problems will be estimated concerning the ''performance'' and ''satisfaction'' for these problems (ICC = 0.92–0.93).[8,9]

Performance Quality Rating Scale. The completeness and quality of performance of client-selected, personally meaningful activities were assessed by using the Performance Quality Rating Scale (PQRS) (ICC = 0.88).[10]

Iconographical Falls Efficacy Scale. The fear of falling has serious consequences for the independence of older adults, because it may limit activities of daily life, which could lead to inactivity and dependence from others for help. We measured the fear of falling by using the shortened 10-item Iconographical Falls Efficacy Scale (Icon FES). Ten drawings that include demanding activities in different environmental contexts were shown to the participants. The participants had to rate their concern about falling if they would perform these tasks. The test–retest reliability for the total score is excellent with an intraclass coefficient of 0.90.[11]

Quality of life

EQ-5D. The EQ-5D assesses the health-related quality of life (ICC = 0.70–0.94).[12] The participants report their current health status on a questionnaire, and on a visual analogue scale.[13]

Statistical analysis

All statistical analyses were performed by using SPSS software version 24.0 (IBM; SPSS Statistics, Chicago).

Table 1. Baseline Characteristics and Time of Usage

Characteristics	*Values*
Number of participants	33 (20 Spanish; 13 Swiss)
Drop outs	4 (1 Swiss; 3 Spanish)
Age general mean (range, years)	70.27 (53–93)
Age mean (male/female, years)	66.15/70.8
Gender (male/female)	17/16
MMSE (female/male)	Swiss: 28.7/28.2 Spanish: 28.33/27.80
HAQ (female/male)	Swiss: 1.165/0.625 Spanish: 1.163/1.050
Time used (mean)	1050 minutes (SD 927.65)
Time used (mean)	Swiss: 1450.92 minutes; (SD 1065.02) Spanish: 837.45 minutes; (SD 786.21)

HAQ, Health Assessment Questionnaire; MMSE, Mini Mental State Examination; SD, standard deviation.

The analysis of variance was calculated to compare pre- and post-test results of the whole group, as well as the difference between men and women, and differences between Spanish and Swiss participants in case the values are metric and normally distributed. Due to the fact that the differences of the mean-value for age between the Spanish and the Swiss population was significant, the analysis of covariance was conducted to eliminate this confound.

The Wilcoxon signed-rank test was used to compare pre–post-test results in nonparametric data. The effect size statistic is recommended for use as an indicator of responsiveness, providing direct information on magnitude of change.[14]

Therefore, the effect sizes η^2 (for metric values) and $r = z/\sqrt{N}$ (for nonparametric or non-normally distributed values) were calculated.

Considering the differences in level of baseline values between the countries and genders, the significance of progress while using the system was analyzed by using the Mann–Whitney *U* Test.

The intention to treat analysis was performed by replacing the missing values with the mean outcome of the variable. All results were deemed to be statistically significant at $P \leq 0.05$.

Results

Twenty Spanish and 13 Swiss people were recruited to test the prototype 3 months in their private homes to evaluate the system. (Table 1) The average number of occasions of using the system was four times a week for 30 minutes.

Seventeen male (10 Spanish and 7 Swiss) and 16 female (10 Spanish and 6 Swiss) seniors participated in the study. A significant difference between the mean age between Spanish and Swiss participants was found ($P = 0.006$).

Four people dropped out of the study. One Swiss senior (male, age 86) terminated the study prematurely due to illness. Three Spanish people (two men and one woman) rejected to repeat the assessments in the final measurement phase due to illness and family issues (ages 83, 54, and 58).

The average time of use was 1050 minutes (SD 927.65) per person. That means that the participants used the system about 90 minutes per week. The adherence of the Swiss participants is higher (mean use 1450.92 minutes; SD 1065.02) than the adherence of the Spanish participants (mean use 837.45 minutes; SD 786.21).

In Table 2, the results of the pre–post comparisons of the metric scaled outcomes show significant improvements in the subitem ''SFT 2 minutes step test'' ($P = 0.01$) with a large effect ($\eta^2 = 0.3$). In addition, a significant difference between the Spanish and Swiss participants ($P = 0.00$) was found; the progress in endurance of the Swiss participants was significantly higher ($P = 0.03$) than that in Spanish participants.

A medium effect as well as a significant difference was detected within the item that measures the lower body strength (''SFT 30-Second Chair Stand''; $\eta^2 = 0.08$).

A small effect was evaluated within the gait speed (''SFT-8-Foot Up and Go''; $r = 0.2$), mobility in the lower body

Table 2. Participants' Baseline and Postintervention Outcomes (Metric and Normally Distributed Values)

Dependent variable	*Mean ± SD* Baseline outcome	*Mean ± SD* Final outcome	*Significance pre/post* P ≤ 0.05	*Effect size* (η^2)	*Significance gender pre/post* P ≤ 0.05	*Significance country pre/post* P ≤ 0.05	*Significance in progress (countries)* P ≤ 0.05	*Significance in progress (gender)* P ≤ 0.05
PQRS	8.1 ± 1.5	8.4 ± 0.9	0.335	0.03	0.85	0.19	0.03[a]	0.2
COPM performance	5.4 ± 1.6	5.7 ± 1.6	0.246	0.042	0.769	0.96	0.35	0.16
COPM satisfaction	6.1 ± 1.9	6.4 ± 2.2	0.194	0.052	0.61	0.34	0.2	0.27
SFT 2 minutes Step Test	51.7 ± 14.7	61.2 ± 21.6	0.01[b]	0.3[c]	0.12	0.00[d]	0.03[a]	0.10
SFT Arm Curl	14.6 ± 3.02	14.76 ± 3.2	0.725	0.004	0.02[e]	0.64	0.05[a]	0.27
SFT 30-Second Chair Stand	10.8 ± 2.5	11.44 ± 3.5	0.12	0.08[c]	0.02[e]	0.10	0.26	0.10
SFT Back Scratch[3]	2.9 ± 6.9	0.9 ± 6.0	0.76	0.010	0.63	0.00[d]	0.4	0.31

[a]Significance in progress in gender and country (Mann–Whitney *U* Test).
[b]Significant within-group differences pre–post calculated with ANOVA.
[c]Effect size η^2 (0.01 = small effect; 0.06 = medium effects; 0.14 = large effect)
[d]Significance in ''between-groups'' effects in country (ANCOVA).
[e]Significance in ''between-group'' effects in gender (ANOVA).
ANCOVA, analysis of covariance; ANOVA, analysis of variance; COPM Canadian Occupational Performance Measure; SFT, Senior Fitness Test; PQRS, Performance Quality Rating Scale.

Table 3. Participants' Baseline and Postintervention Outcomes (Nonparametric or Non-normally Distributed Values)

	Mean ± SD				
	Baseline	*Final Outcome*	P < *0.05*	r	Z
BBS	53.39 ± 3.2	52 ± 6.0	0.09[a]	0.2	1.3
EQ 5D	0.84 ± 0.17	0.85 ± 0.2	0.3	0.08	0.7
Icon FES	17.57 ± 6.1	17.4 ± 6.0	0.3	0.08	0.7
SFT Chair Sit and Reach[b]	0.45 ± 4.7	1.7 ± 3.2	0.1	0.2	1.3
SFT 8-Foot Up and Go[b]	14.6 ± 12.4	12.8 ± 8.6	0.07[a]	0.2	1.5

Effect size $r = z/\sqrt{N}$ ($r = 0.1$ small effect; $r = 0.3$ medium effects; $r = 0.5$ large effect).
[a]Significant within-group differences pre–post calculated with Wilcoxon signed rank test.
[b]Metric measurements, but not normally distributed.
BBS, Berg Balance Scale; Icon FES, Iconographical Falls Efficacy Scale.

(''SFT-8-Foot Up and Go''; $r = 0.2$), and the balance capabilities between pre- and post-results ($r = 0.2$) measured by the Berg Balance Scale (Table 3).

In every item of the SFT-test, women started with a lower baseline value and made fewer improvements than men.

Significant values were shown in a pre–post effect in gender in arm strength (''SFT- Arm Curl,'' $P = 0.02$; Table 2) and lower body strength (''SFT 30-Second Chair Stand,'' $P = 0.02$).

Concerning the outcome describing the mobility of the upper limbs (''SFT-Back Scratch''), there is a high significance to the advantage of the Spanish participants ($P = 0.000$) compared with the Swiss participants (Table 2).

No significant changes were observed in COPM, Icon FES, and the EQ 5D in the results (Table 2). Comparing the two countries, the results of PQRS show a significant difference in favor of the Spanish people ($P = 0.03$, Table 2).

Discussion

The aim of this study was to evaluate the effect of training with the WeTakeCare-System on defined body functions, performance of daily activity, and quality of life in older adults after using the system.

Owing to the fact that the average age of the tested population was 70 years and the period of the validation was only 3 months, we did not expect a strong improvement of physical abilities in the participants that would be visible within activities of the daily life.

However, we found positive effects in clinical measures like, for example, endurance (especially the Swiss) and arm strength (Spanish group). These results are remarkable because the Swiss group was in average 10 years older than the Spanish. Interestingly the Swiss people, who prefer the game ''Treasure hunt,'' which trains the lower body, have a better outcome in endurance, whereas the Spanish people, who liked ''Sudoku,'' showed an increase of the strength and mobility of the upper limbs (''SFT Back Scratch''; ''SFT Arm curl'').

According to van Heuvelen, a good level of physical fitness, for example, endurance is an important predictor for people to avoid disability.[15]

Maybe one reason of the improvements was the adherence of the participants to the system. On average, the participants stick to the recommended time of use (90 minutes) per week.

This meets the American College of Sports Medicine (ACSM) recommendations. According to the ACSM guidelines, adults should accumulate at least 30 minutes of moderate intensity physical activity most days per week to improve or maintain overall fitness.[16]

Especially the Swiss participants used the system more often than expected (120 minutes per week). The Spanish participants used the system about 70 minutes per week on average, which is also a good adherence.

Often studies demonstrate a poor adherence of older adults to the use of games and game systems.[17,18] Older adults dislike violent[19] or very fast and reflex-oriented[20] digital games. De Schutter[21] emphasized that older adults prefer intellectual games. This result confirms our findings we got from all focus groups who performed in preparation of the software development. Older adults, their relatives, and experienced therapists prefer game contents that are related to the seniors' everyday life. Digital games should be either intellectual or physical demanding. We assume that the intensive use of the system is caused in this ''user-centered'' approach of the project. Participants appreciate the exercises that are designed for and together with older adults and based on their age-related needs and requirements.

Self-rated assessment that measures ADL performance (COPM), fear of falling (Icon FES), and quality of life (EQ 5D) did not show significant improvements.

However, it is interesting that the external rated assessment PQRS, which affects ADL independency, shows significant objective measured improvements within the Spanish participants ($P = 0.03$). We assumed that the Spanish participants, who had a significant improvement in their upper limb mobility, were able to transfer this benefit into their everyday activities.

Concerning the physical tests, women mostly started on a much lower level of physical fitness at baseline than men did and showed a larger progress between the first and the second assessments. This seems to be a result of the higher usage of the system by women. Nevertheless, we could not find a significant difference of the pre- and post-measured results between men and women.

These findings confirm the results of Rikli and Jones who measure physical capabilities of older adults between 60 and 94 years. They found a definite gender difference with men consistently scoring better than women on strength, endurance, agility, and balance tests.[7]

This multicomponent exercise approach that affects physical fitness is highly recommended by several studies.[22,23]

The limitation of this study was difficulties in recruiting Swiss participants. The targeted participation of 50 years or older adults could not have been reached related to massive recruiting problems in Switzerland. We can only refer this problem to the argument we often hear while talking to elderly people: older adults did not want to take part in the study because older adults often consider themselves as physically fit and independent. They did not see themselves as in the need to change their current status quo. Furthermore, many elderly people express fear of becoming lonely and isolated while using the training software. Their perception of the training was that it would take away too much time they would rather spend outside and in company.

Another shortcoming was the large difference between the mean age of Swiss and Spanish participants and the distinctions in the usage of the system, which made it difficult to compare both groups.

Finally, the results of the study allow us to conclude that physical training with activity-focused exergames that are related to the everyday tasks of older adults can help to maintain and improve the individual fitness status as well as self-reported health status.

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References

1. Hwang HL, Lin HS, Tung YL, Wu HC. Correlates of perceived autonomy among elders in a senior citizen home: A cross-sectional survey. Int J Nurs Stud 2006; 43:429–437.
2. Colombo F, Llena-Nozal A, Mercier J, Tjadens F. Help Wanted? Providing and Paying for Long-Term Care, OECD Publishing. 2011. www.oecd.org/els/health-systems/47836116.pdf (accessed February 15, 2018).
3. AAL-Active and Assisted Living Programme; Objectives; ICT for ageing well. 2016. www.aal-europe.eu/about/%20objectives (accessed February 15, 2018).
4. Braekhus A, Laake K, Engedal K. The mini-mental state examination: Identifying the most efficient variables for detecting cognitive impairment in the elderly. J Am Geriatr Soc 1992; 40:1139–1145.
5. Berg K, Wood-Dauphinee S, Williams JI, Gayton D. Measuring balance in the elderly: Preliminary development of an instrument. Physiother Can 1989; 41:304–311.
6. Bruhlmann P, Stucki G, Michel BA. Evaluation of a German version of the physical dimension of the Health Assessment Questionnaire in Patients with rheumatoid arthritis. J Rheumatol 1994; 21:1245–1249.
7. Rikli RE, Jones J. Development and validation of a functional fitness test for community-residing older adults. J Aging Phys Activity 1999; 7:129–161.
8. Dedding C, Cardol M, Eyssen IC, et al. Validity of the Canadian Occupational Performance Measure: A client-centred outcome measurement. Clin Rehabil 2004; 18:660–667.
9. Bortnick K. *Occupational Therapy Assessments for Older Adults: 100 Instruments for Measuring Occupational Performance*. SLACK Incorporated, Thorofare, NJ; 2017.
10. Martini R, Jorge R, Polatayko H, et al. The performance quality rating scale (PQRS): Reliability, convergent validity, and internal responsiveness for two scoring systems. Disabil Rehabil 2015; 37:231–238.
11. Delaere K, Smith ST, Lord SR. Development and initial validation of the Iconographical Falls Efficacy Scale. J Gerontol A Biol Sci Med Sci 2011; 66:674–680.
12. Diaz-Redondo A, Rodriguez-Blazquez C, Ayala A, et al. EQ-5D rated by proxy in institutionalized older adults with dementia: Psychometric pros and cons. Geriatr Gerontol Int 2014; 14:346–353.
13. Cabasés J, Rabin R, Szende A, et al. (eds.), *Self-Reported Population Health: An International Perspective based on EQ-5D*. Springer Open. 2014; pp. 1–6.
14. Husted JA, Cook RJ, Farewell VT, Gladman DD. Methods for assessing responsiveness: A critical review and recommendations. J Clin Epidemiol 2000; 53:459–468.
15. Van Heuvelen MJG, Kempen GIJM, Brouwer WH, DeGreef MHG. Physical fitness related to disability in older persons. Gerontology 2000; 46:333–341.
16. ACSM Guidelines. Increasing Physical Activity for Adults with a Disability. Brochure. In: American College of Sports. www.acsm.org/docs/default-source/brochures/increasing-physical-activity-for-adults-with-a-disability.pdf?sfvrsn=4 (accessed February 15, 2018).
17. Tan B, Aziz AR, Chua K, Teh KC. Aerobic demands of the dance simulation game. Int J Sports Med 2002; 23:125–129.
18. Boot WR, Champion M, Blakely DP, et al. Video games as a means to reduce age-related cognitive decline: Attitudes, compliance, and effectiveness. Front Psychol 2013; 4:31.
19. Nap HH, de Kort YAW, IJsselsteijn WA. Senior gamers: Preferences, motivations and needs. Gerontechnology 2009; 8:247–262.
20. Pearce C. The truth about baby boomer gamers: A study of over-forty computer game players. Games Cult 2008; 3:142–174.
21. De Schutter B. Never too old to play: The appeal of digital games to an older audience. Games Cult 2011; 6:155–170.
22. Skjaeret N, Nawaz A, Morat T, Schoene D, Helbostad JL, Vereijken B. Exercise and rehabilitation delivered through exergames in older adults: An integrative review of technologies, safety and efficacy. Int J Med Informatics 2016; 85(1):1–16.
23. Cadore EL, Rodríguez-Mañas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. Rejuvenation Res 2013; 16:105–114.

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