AN APPROACH TO PREVENT FRAILTY IN COMMUNITY DWELLING OLDER ADULTS: a pilot study performed in Campania region in the framework of the PERSILAA project

Cataldi M1, De Luca V2, Tramontano G2, Del Giudice C3, Grimaldi F3, Cuccaro P3, Speranza P3, Iadicicco G3, Iadicicco V2, Carotenuto F2, Riccio PA4, Di Spigna G5, Renzullo A6, Vuolo L6, Barrea L6, Savastano S8, Colao A6, Liotta G7, Iaccarino G8, Abete P3, Buono P9, Vollenbroek-Hutten M10, Illario M2-5-11

1Dipartimento di Neuroscienze, Scienze Riproduttive ed Odontostomatologiche, Università degli Studi di Napoli Federico II, Napoli, Italy; 2Unità Operativa Semplice Ricerca e Sviluppo, Azienda Ospedaliera Universitaria Federico II, Napoli, Italy; 3Unità Operativa Complessa Gestione Affari Generali, Azienda Ospedaliera Universitaria Federico II, Napoli, Italy; 4Associazione Progetto Alfa ONLUS; 5Dipartimento di Scienze Mediche Traslazionali, Università degli Studi di Napoli Federico II, Napoli, Italy; 6Dipartimento di Endocrinologia ed Oncologia Molecolare e Clinica, Università degli Studi di Napoli Federico II, Napoli, Italy; 7Dipartimento di Biomedicina e Prevenzione, Università di Roma, Tor Vergata, Roma, Italy; 8Dipartimento di Scienze Mediche Avanzate, Università degli Studi di Napoli Federico II, Napoli, Italy; 9Dipartimento di Scienze Motorie e del Benessere, Università degli Studi di Napoli Parthenope, Napoli, Italy; 10Institute for Biomedical Technology, University of Twente, Twente, The Netherlands; 11Unità Operativa Dirigenziale Promozione e Potenziamento Programmi di Health Innovation, Regione Campania, Naples, Italy

(Send correspondence to Dr Maddalena Illario, e-mail: maddalena.illario@regione.campania.it)

ABSTRACT

We developed and tested an innovative physical training method in older adults that embeds the gym program into everyday life in the most conservative way possible. Physical training was included in the activities of local parishes where older women from Southern Italy spend most of their free time and was delivered by trained physical therapists with the support of an ICT tool known as CoCo. 113 older women (aged 72.0 [69.0-75.0] years) noncompliant to conventional exercise programs participated to the study. 57 of them underwent the final anthropometric assessment and 50 the final physical tests. In study completers handgrip strength and physical performance evaluated with the chair-stand, the two minutes step and the chair-sit and -reach tests significantly improved. Quality of life as evaluated with the EuroQol-5dimension (EQ-5D) questionnaire improved as well. In conclusion, a training program designed to minimally impact on life habits of older people is effective in improving fitness in patients noncompliant to other physical exercise programs.

Key words: physical training; community; parish; ICT; physical function; physical performance

I. INTRODUCTION

A progressive decrease in physical function - the ability to carry out physical action from simple to very complex tasks [1] - takes place with ageing and is mainly due to inadequate physical activity and related sarcopenia (ICD-10 code- M62.84) [2]. Ageing-related physical activity decline increases frailty and disability, contributes to falls, and is associated with higher than normal cardiovascular risk [3]. Sarcopenic older adults with limited mobility have a shorter life expectancy than people of similar age but with a better preserved muscle mass [4]. The pathogenetic mechanism of age-related sarcopenia is still uncertain although a definite role can be ascribed to the progressive loss of fast-type motor neurons and of the fast myofibers with a compensatory increase of slow motoneurons and slow myofibers [5,6], to the negativization of protein synthesis balance in muscles [7,8], and to alterations in muscle mitochondria [9]. Because of the incomplete understanding of its pathophysiology, a rationale treatment of sarcopenia is still lacking. Nevertheless, it is largely acknowledged that this syndrome should be prevented before its occurrence with appropriate physical exercise programs and concurrent nutritional interventions [10,11]. The rationale behind the effectiveness of physical exercise is that like younger muscles, although probably with different molecular mechanisms, the neuromuscular unit may adapt to the increased functional demand by increasing muscle mass and strength [12]. The efficacy of a structured physical exercise intervention on muscle mass and strength in older people has been documented in randomized clinical trials [13, 14]. Importantly, physical exercise has been shown to improve survival [15] and to
decrease the occurrence of falls [16-20]. However, the implementation of such a kind of interventions in clinical practice is often problematic because of a number of barriers that dramatically lower patient adherence [21-24].

Some of these barriers are infrastructural because in modern, not elder-friendly towns it can be difficult and expensive to go to the gym and sometimes the car may be needed [23]. Other barriers are directly related to ageing such as the lack of motivation due to social isolation and depression, and cognitive and memory difficulties. Several strategies have been suggested to improve adherence to the treatment [25,26]. Many of them include the use of Information and Communications Technology (ICT) supports with the aim of guiding patients in the execution of physical exercises and of increasing motivation by making the training session also a gaming activity as in exergaming [27-30]. However, the low computer literacy of older adults may represent an additional barrier to the implementation of ICT solutions.

Starting from the working hypothesis that the best way to maximize older patient cooperation to a health program was that this program does not substantially modify patient life habits we designed an intervention aiming to embed physical training sessions in the ordinary social activities of a group of older women in Italy. To this aim we identified the local parishes as a preferential location for our intervention because in Southern Italy older adults, especially women, gather there for a number of social and religious activities (e.g. playing cards, charity, etc.). Therefore, with the help of the parsons, we performed a pilot study to evaluate the effect of adding ICT-assisted gym sessions to the schedule of these social activities. To enhance the informatics literacy of the participants we also included in the program computer classes. This intervention was delivered as part of the activities of PERSSILAA (Personalised ICT Supported Service for Independent Living and Active Ageing) (https://perssilaa.com/) [31], a project of the A3 action group of the European Innovation Partnership on Active and Healthy Ageing (EIPonAHA) (https://ec.europa.eu/eip/ageing/home_en) [32].

II. METHODOLOGY

Study design

The present investigation was designed as an open, prospective, interventional pilot study. The study was carried out in 3 parishes (Confalone, Rogazionisti and Pilar) of the big Naples metropolitan area from January 2015 to June 2016. The study protocol n. 178/2014 was approved by the “Università Federico II” ethics committee and all the participants gave their informed consent to the experimentation. Procedures were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Inclusion and Exclusion Criteria

Participants were recruited among the older adults attending their parish.

Inclusion criteria were: females, aged higher or equal to 65 years with an apparent good health status that had been non-compliant to physical exercise programs prescribed by their physicians.

Exclusion criteria were: one or more major cardiovascular events (including stroke and myocardial infarction) during the last 6 months, neoplastic or autoimmune diseases, and severe cognitive impairment including Alzheimer disease and other forms of dementia and invalidating neurological disorders including Parkinson’s disease. Bedridden patients and patients with major disability and mobility disorders were excluded as well.

Study protocol

Volunteers were appointed for a first visit during which we performed a comprehensive evaluation of their medical, cognitive and fitness status by using health questionnaires and physical and instrumental examination as detailed in “Variables”. After completing the basal visit, subjects matching the inclusion and exclusion criteria, signed the informed consent and were enrolled to the intervention described in the next paragraph. At the end of the treatment study participants were reevaluated in a final visit with the same protocol.

Study Intervention

Study intervention consisted of exercise training and computer classes given twice a week at the local parish. During the exercise classes with the help of a licensed physical therapist study participants performed physical exercises based on the OTAGO exercise program [18,19]. This program consists of a set of leg muscle strengthening and balance retraining exercises progressing in difficulty, and a walking plan [33]. The strength exercises comprise calf rise, toe rise, front knee, back knee and side hip strengthening exercises. The balance exercises include Knee Bends, Stand To Sit backwards-, sideways-, stair-, heel- and toe- walking, walking and turning around, Heel Toe and One Leg Standing, Stand To Sit. The physical therapists were assisted by a specific web-based software named CoCo that was developed by Roessingh Research and Development (Enschede, NL: http://www.rrd.nl/en/) in the context of the PERSILLAA project. CoCo is an ICT coaching and counselling system web-accessible to registered users. This application has been developed to suggest to subjects undergoing exercise training the specific physical exercises to be performed in each physical activity session and guide them during their execution. It also helps adjusting the exercise program on the basis of individual and class progress.

Variables

General health status was measured with EuroQol-5 dimension (EQ-5D), a questionnaire evaluating 5 health dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) [34]. At the time of first visit (T0) study participants underwent
anthropometric indices assessment (assessment of height, weight, waist circumference, waist-hip ratio, BMI) and their heart rate and blood pressure were also recorded. In order to identify and exclude patients with Alzheimer disease or other forms of dementia, a detailed neuropsychological examination was performed by a registered neurologist also using specific diagnostic questionnaires (QMCI and AD8 tests) [35]. Because study intervention involved a specific physical activity program, the physical activity readiness questionnaire (PAR-Q), which is a widely accepted tool to assess the eligibility to non-competitive fitness programs [36,37], was preliminarily administered to all study participants.

A battery of complementary physical tests from the Fullerton Senior Fitness Test [38] was used to evaluate the physical fitness of study participants [39-42]. More specifically, lower body strength was assessed with the Chair Stand Test (CST) that measures the number of full stands that can be completed in 30 seconds with arms folded across chest; Aerobic endurance was evaluated with the two-minute step Test (TMST) that counts the number of full steps completed in 2 minutes, raising each knee to a point midway the patella and iliac crest. Finally, to evaluate lower body flexibility we performed the Chair sit and reach Test (CSRT) that measures the minimal distance between finger tips and toes when the patient tries to touch his feet from the sitting position [43].

Maximum isometric strength of the hand and forearm muscles was measured with the handgrip strength test using a handgrip dynamometer ARW WAP 80KG [44-46]. The values obtained were considered indicative of sarcopenia if lower than 20 kg for women and 30 kg for men [2].

To assess adherence of the study population to the intervention we took the attendance to each training session and we recorded the data on a centralized web-based database. For each parish we first calculated the number of the attendants to each session and then we added up the number of attendants to the different training sessions to obtain the total number of attendants per parish. Total percent attendance was then calculated for each parish as the percent ratio between the total number of attendants and the product of the number of the study participant of the parish by the number of sessions (which represents the highest possible number of attendants).

Statistical analysis
Statistical analysis was carried out with IBM SPSS.20 (SPSS Inc, Chicago, IL) and Sigmmaplot 11 (Systat, San Jose, CA, USA). Data were examined for normality with the Shapiro-Wilk test and reported as median and IRQ or as mean±SD if normally distributed or not, respectively. Two group comparisons were performed with paired Student’s test or with Wilcoxon paired rank test as appropriate. The threshold for statistical significance was set at p<0.05.

III. RESULTS

Study population and adherence to the intervention
A total of 236 older adults expressed their consent to take part to the study and underwent the first visit evaluation. Only 113 of them (median age: 72.0 yr [69.0-75.0]) met the inclusion criteria specified in the methods section and were enrolled in the study. The results of the anthropometric and physical tests that were performed in these subjects and of the self-rated health status questionnaires that they filled out are summarized in Table 1. Overall our study population was composed by young older adults with a high degree of independence, a slight, initial degree of frailty and a normal cognitive status for their age.

Average attendance to gym classes was 40.0 % [30.8-42.0], 57 of the enrolled subjects showed up at the final anthropometric assessment and 50 underwent the final physical tests. Therefore we could evaluate the efficacy of the intervention only in this group of study completers. The results of this analysis are reported in the next paragraph.

Table 1. BASELINE CHARACTERISTICS OF THE POPULATION STUDY

| Parameter                        | n   | Average       |
|----------------------------------|-----|---------------|
| Age                              | 113 | 72.0 [68.0-75.0] |
| Body weight                      | 113 | 69.0 [62.8-76.4] |
| BMI (Kg/m²)                      | 113 | 28.8±4.1     |
| Waist Circumference (cm)         | 113 | 92.8±12.1    |
| Hip Circumference (cm)           | 113 | 103.0 [100.0-109.6] |
| Waist to Hip ratio               | 113 | 0.88±0.08    |
| Handgrip strength (Kg)           | 78  | 20.3 [16.4-23.0] |
| EQ-5D (total score)              | 113 | 0.73 [0.69-0.85] |
| Chair Stand Test (number of stands) | 113 | 13.0 [10.0-16.0] |
| Chair sit and reach Test (cm)    | 113 | 6.0 [3.0-8.0] |
| Two minutes step test (number of cycles) | 113 | 62.5 [40.0-110.0] |

Reference values for people in the age range of the study population are as follows: EQ-5D, 0.823 and 0.724 in people aged 65–74 and 75+ years, respectively [34]; Chair Stand Test, < 10 in females aged 65-69 and < 11 if aged 70-74 [58]; Chair sit and reach Test (cm): -1.27-11.43 in females aged 65-69 and -2.54-10.16 if aged 70-74 [37]; Two minutes step test (number of cycles): 75-107 in females aged 65-79 and 68-100 if aged 65-79 [37].

Effect of the intervention on quality of life, anthropometric parameters and physical fitness
Perceived physical fitness was evaluated by comparing the scores recorded in the mobility and usual activity fields of the EQ-5D questionnaire. The results obtained showed a significant improvement only in the EQ-5D mobility score with no change in the usual activity field. No change was observed in the self-care, pain, anxiety and general health status fields. Total score of the EQ-5D test was significantly higher following treatment suggesting an improvement of the quality of the life of the study participants (Table 2).

Significant changes also occurred in anthropometric parameters. We observed a slight increase in BMI that was accompanied by a significant decrease both in waist circumference and in waist to hip ratio (Table 2).
Handgrip dynamometer-measured muscle strength significantly increased from 21.1 Kg [16.4-23.5] at baseline up to 24.3 Kg [21.0-28.0] at the end of the intervention (Table 2).

Physical fitness improved as well as indicated by the significant increase in the score of two physical tests measuring physical endurance, the Chair Stand Test and the Two minutes step test (Table 2). The improvement of the results of the Chair sit and reach Test showed that the intervention also ameliorated body flexibility (Table 2).

IV. DISCUSSION

The data reported in the present paper provide the proof of evidence of the efficacy of a physical training program for older people that minimally impacts on their consolidated life habits. This intervention induced a significant improvement in physical performance and enhanced social interactions hence improving the quality of life.

It is well established that older people do not like to break their habits [47-49]. Going to gym, which is an ordinary and simple task for the youngest, may, on the contrary, be a destabilizing, changing-habit event for older people. We reasoned that all together this factor could significantly lower the acceptability of gym programs in older adults. Therefore we designed an innovative approach aiming to embed physical training in their usual day-life activities. We identified the local parish as a potential ecosystem in which our intervention could be introduced with minimal changes in everyday life of study participants. Indeed, our study sample consisted of older women who regularly took part to the activities of their parishes, attending an average of twice/week. Choosing the parish also has the advantage that it is usually close to patient home and that the patient already knows well people attending to its community hence minimizing the detrimental effect of novelty. Obviously, the intervention that we designed was very context-oriented and, therefore, with this study we did not mean to propose a universal model that could be applied in all the social contexts of the Western countries. We intended, instead, to suggest that efforts should be done to identify the microenvironments where ageing people are used to routinely go and where they continue to spend some time together. We used the parishes but in other social contexts, totally different structures, such as, for instance, the Bingo hall could serve the same function.

The efficacy of our intervention in improving the fitness of study participants was documented by the substantial increase in handgrip strength and in physical tests. As expected physical training decreased waist circumference and the waist to hip circumference ratio suggesting that study participants lost fat mass.

Table 2. ANTHROPOMETRIC PARAMETERS AND SCORES AT THE PHYSICAL TESTS AND QUALITY OF LIFE QUESTIONNAIRES IN STUDY PARTICIPANTS WHO UNDERWENT THE FINAL VISIT

| Parameter                              | n  | BEFORE THE INTERVENTION | AFTER THE INTERVENTION |
|----------------------------------------|----|-------------------------|------------------------|
| Body Weight (Kg)                       | 57 | 70.0 [61.8-75.9]        | 69.0 [62.8-76.4]       |
| BMI (Kg/m²)                            | 57 | 28.2±3.7                | 28.8±4.1               |
| Waist Circumference (cm)               | 57 | 98.5±10.6               | 92.8±12.1*             |
| Hip Circumference (cm)                 | 57 | 106.0 [100.8-111.5]     | 103.0 [100.0-109.6]    |
| Waist to Hip ratio                     | 57 | 0.90 [0.88-0.98]        | 0.88 [0.82-0.93]*      |
| Handgrip strength (Kg)                 | 47 | 21.1 [16.4-23.5]        | 24.3 [21.0-28.0]*      |
| EQ-D5 (total score)                    | 62 | 0.727 [0.689-0.848]     | 0.796 [0.725-0.849]*   |
| Chair Stand Test (number of stands)    | 50 | 12.0 [9.0-15.0]         | 15.0 [12.0-22.0]*      |
| Chair sit and reach Test (cm)          | 50 | 7.0 [4.0-8.0]           | 0.0 [0.0-5.0]*         |
| Two minutes step test (number of full stepping cycles) | 50 | 55.0 [37.0-100.0]       | 102.5 [70.0-136.0]*    |

*= p<0.05, paired t-test

In the present study adherence to the gym program was about 40%. Many patients skipped one or more training sessions per month whereas only few of them were fully non compliant, not attending at all to the gym. Although this value of percentage adherence could seem small it is important to emphasize that we obtained it in our population made of older adults that were completely non-compliant to standard physical exercise results, similar to those usually reported in unselected older adults [50].

An important component of our intervention is the use of ICT. Previous investigations clearly...
demonstrated that ICT may effectively support physical training in older adults. Web-based ICT interventions delivered on different devices such as mobile phones or tables have been shown to increase motivation and help older people correctly performing complex exercises hence enhancing the efficacy of physical training [29,30, 51-54]. An additional feature of the software we used is that it can help adjusting the exercise program to the progress of the class [55]. However, poor computer literacy is still a strong barrier to the implementation of ICT programs in selected social context such as in our study population. Therefore, we decided to include in our intervention also a PC training course as well as a “brain training” app as part of the course. This intervention and its positive effect on cognitive performance will be described in a future paper. It has also to be considered that the improvement in cognitive functions caused by the ICT support could have played a role in the improvement that we observed in physical tests. It has been reported, indeed, that ICT strategies increasing cognitive abilities such as attention and executive functions can help in reducing the impact of physical performance impairment and reduce the risk of falls [56].

A limitation of our intervention is that it was delivered to patients with only a mild impairment of physical performance. All of them were still fully independent and they did not need a continuous support in everyday life. It is unlikely that this model could be successfully extended to patients with a more serious physical impairment because an essential requirement of our intervention is that the patient is still engaged to some extent in social life outside his/her house. It has to be considered, however, that the young older people are the ideal target of any preventive intervention in geriatric medicine because, different from the old-old and the oldest old they have a life expectancy long enough to benefit of the treatment [57].

V. CONCLUSIONS

In conclusion, we reported preliminary evidence of the efficacy in older women non-compliant to conventional exercise interventions of program that embeds physical training in their every-day life with minimal impact on their habits. Further studies will be required to assess whether adherence can be improved, also in the long term, and to determine the threshold of adherence to obtain an improvement in physical functioning and quality of life.

REFERENCES

1. van Lummel RC, Walgaard S, Pijnappels M, Elders PJ, Garcia-Aymerich J, van Dieën JH, Beek PJ Physical Performance and Physical Activity in Older Adults: Associated but Separate Domains of Physical Function in Old Age. PLoS One 2015;10(12):e0144048.
2. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M, Zamboni M; European Working Group on Sarcopenia in Older People. European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010; 39(4):412-423.
3. Visser M, Schaap L.A. Consequences of sarcopenia. Clin Geriatr Med. 2011; 27(3):387-399.
4. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, Brach J, Chandler J, Cawthon P, Connor EB, Nevitt M, Visser M, Kritchevsky S, Badinelli S, Harris T, Newman AB, Cauley J, Ferrucci L, Guralnik J. Gait speed and survival in older adults. JAMA 2011; 305(1):50-58.
5. Luff AR. Age-associated changes in the innervation of muscle fibers and changes in the mechanical properties of motor units. Ann N Y Acad Sci. 1998; 854:92-101.
6. Mosole S, Carraro U, Kern H, Loefler S, Fruhmann H, Vogelauer M, Burggraf S, Mayr W, Krenn M, Paternostro-Sluga T, Hamar D, Cvecka J, Sedlak M, Tirpakova V, Sarabon N, Musarò A, Sandri M, Protasi F, Nori A, Pond A, Zampieri S. Long-term high-level exercise promotes muscle reinnervation with age. J Neuropathol Exp Neurol. 2014; 73(4):284-294.
7. Trappe T, Williams R, Carrithers J, Raue U, Esmarck B, Kjaer M, Hickner R. (2004). Influence of age and resistance exercise on human skeletal muscle proteolysis: a microdialysis approach. J Physiol. 2004; 554 (Pt.3):803-813.
8. Churchward-Venne TA, Breen L, Phillips SM. Alterations in human muscle protein metabolism with aging: protein and exercise as countermeasures to offset sarcopenia. Biofactors 2014; 40(2):199-205.
9. Zampieri S, Mamucari C, Romanello V, Barberi L, Pietrangelo L, Fusella A, Mosole S, Gherardi G, Höfer C, Löfler S, Sarabon N, Cvecka J, Krenn M, Carraro U, Kern H, Protasi F, Musarò A, Sandri M, Rizzuto R. Physical exercise in aging human skeletal muscle increases mitochondrial calcium uniporter expression levels and affects mitochondria dynamics. Physiol Rep. 2016; 4(24).
10. Beaudart C, Dawson A, Shaw SC, Harvey NC1, Kanis JA, Binkley N, Reginster JY, Chapurlat R, Chan DC, Bruyère O, Rizzoli R, Cooper C, Dennison EM; IOF-ESCEO Sarcopenia Working Group. Nutrition and physical activity in the prevention and treatment of sarcopenia: systematic review. Osteoporos Int. 2017; 28(6): 1817-1833.
11. Landi F, Abbatecola AM, Provinciali M, Corsonello A, Bucstachini S, Manigrasso L, Cherubini A, Bernabei R, Lattanzio F. Moving against frailty: does physical activity matter? Biogerontology 2010; 11(5):537-545.
12. Tallis J, Higgins MF, Seebacher F, Cox VM, Duncan MJ, James RS. The effects of 8 weeks voluntary wheel running on the contractile performance of isolated locomotory (soleus) and respiratory (diaphragm) skeletal muscle during early ageing. J Exp Biol. 2017; 220(Pt 20): 3733-3741.
13. American College of Sports Medicine, Chodzko-Zajko WJ, Proctor DN, Fiararone Singh MA, Minson CT, Nigg CR, Salem GI, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc. 2009; 41(7): 1510-1530.

14. Karani R, McLaughlin MA, Cassel CK. (2001). Exercise in the healthy older adult. Am J Geriatr Cardiol. 2001; 10(5): 269-273.

15. Rizzuto D, Orsini N, Qiu C, Wang H, Fratigioni L. Lifestyle, social factors, and survival after age 75: population based study. BMJ 2012; 345: e5568-e5568.

16. Barnett A, Smith B, Lord SR, Williams M, Baumann A. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. Age Ageing 2003; 32(4): 407-414.

17. Buchner DM, Cress ME, de Lateur BJ, Esselman, PC, Margherita AJ, Price R, Wagner EH. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. J Gerontology A Biol Sci Med Sci. 1997; 52(4): M218-M224.

18. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. BMJ 1997; 315(7115): 1065-1069.

19. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. Age Ageing 1999; 28(6): 513-518.

20. Sherrington C, Whitney JC, Lord SR, Herbert RD, Cumming RG, Close JC. Effective exercise for the prevention of falls: a systematic review and meta-analysis. J Am Geriatr Soc. 2008; 56(12): 2234-2243.

21. Björnsdóttir G, Arnadóttir SA, Hallldórsdóttir S. Facilitators of and barriers to physical activity in retirement communities: experiences of older women in urban areas. Phys Ther. 2012; 92(4): 551-562.

22. Costello E, Kafchinski M, Vrael J, Sullivan P. Motivators, barriers, and beliefs regarding physical activity in an older adult population. J Geriatr Phys Ther. 2011; 34(3): 138-147.

23. Horne M, Tierney S. What are the barriers and facilitators to exercise and physical activity uptake and adherence among south Asian older adults: a systematic review of qualitative studies. Prev Med. 2012; 55(4): 276-284.

24. Horne M, Skelton DA, Speed S, Todd C. Perceived barriers to initiating and maintaining physical activity among South Asian and White British adults in their 60s living in the United Kingdom: a qualitative study. Ethn Health 2013; 18(6): 626-645.

25. Goode AD, Reeves MM, Eakin EG. Telephone-delivered interventions for physical activity and dietary behavior change: an updated systematic review. Am J Prev Med. 2012; 42(1):81-88.

26. Osaka Y, Jung S, Kim T, Okubo Y, Kim E, Tanaka K. Does attending an exercise class with a spouse improve long-term exercise adherence among people aged 65 years and older: a 6-month prospective follow-up study. BMC Geriatr. 2017; 17(1), 170.

27. Blázun H, Saranto K, Kokol P, Vošner J. Information and communication technology as a tool for improving physical and social activity of the elderly. NI 2012: 11th International Congress on Nursing Informatics, June 23-27, 2012, Montreal, Canada, 2012, 26-30.

28. Dekker-van Weering M, Jansen-Kosterink S, Frazer S, Vollenbroek-Hutten M. User Experience, Actual Use, and Effectiveness of an Information Communication Technology-Supported Home Exercise Program for Pre-Frail Older Adults. Front Med 2017; 4:208.

29. Silveira P, van de Langenberg R, van Het Reve E, Daniel F, Casati F, de Bruin ED. Tablet-based strength-balance training to motivate and encourage exercise in independently living older people: a phase II preclinical exploratory trial. J Med Internet Res. 2013; 15(8): e159.

30. Silveira P, van het Reve E, Daniel F, Casati F, de Bruin ED. Motivating and assisting physical exercise in independently living older adults: a pilot study. Int J Med Inform. 2013; 82(5): 325-334.

31. van Velsen L, Illario M, Jansen-Kosterink S, Crola C, Di Somma C, Colao A, Vollenbroek-Hutten M. A Community-Based, Technology-Supported Health Service for Detecting and Preventing Frailty among Older Adults: A Participatory Design Development Process. J Aging Res. 2015; 2015:216084.

32. Bousquet J, Bewick M, Cano A, Eklund P, Fico G, Goswami N, Guldemond NA, Henderson D, Hinkema MJ, Liotta G, Mair A, Molloy W, Monaco A, Monsonis-Paya I, Nizinska A, Papadopoulos H, et al. Building Bridges for Innovation in Ageing: Synergies between Action Groups of the EIP on AHA. J Nutr Health Aging 2017; 21:92-104.

33. Otago Exercise Programme to prevent falls in older adults. [Internet] 2007; [accessed on June 18, 2018], available from https://www.acc.co.nz/assets/injury-prevention/acc1162-otago-exercise-manual.pdf.

34. Janssen, B. & Szende, A. Population Norms for the EQ-5D. in Szende A, Janssen B, Cabase J. (Ed.) Self-Reported Population Health: An International Perspective based on EQ-5D. New York, NY: Springer 2015; pp. 18-30.

35. Iavarone A, Carpinelli Mazzi M, Russo G, D’Anna F, Peluso S, Mazzeo P, De Luca V, De Michele G, Iaccarino G, Abete P, Milan G, Garofalo E, Musella C, O’Caoimh R, Molloy W, De Joanna G, Manzo V, Ambra FI, Postiglione A, Illario M, and the Working Group. The Italian version of the quick mild cognitive impairment (Qmci-I) screen: normative study on 307 healthy subjects.
Aging and Experimental Research 2018; doi: 10.1007/s40520-018-0981-2.
36. Shephard RJ, Cox MH, Simper K. An analysis of "Par-Q" responses in an office population. Can J Public Health 1981; 72(1): 37-40.
37. Shephard RJ. PAR-Q, Canadian Home Fitness Test and exercise screening alternatives. Sports Med. 1988; 5(3): 185-195.
38. Jones CJ, Rikli RE. Measuring functional fitness of older adults. The Journal on Active Aging 2002; March April 2002, 24-30.
39. Rikli R, Jones J. Functional fitness normative scores for community-residing older adults, ages 60-94. Journal of Aging and Physical Activity 1999; 7:162-181.
40. Rikli R, Jones CJ. Senior Fitness Test Manual. Human Kinetics 2001Champaign, IL.
41. Rikli R, Jones J. Assessing physical performance in independent older adults: Issues and guidelines. Journal of Aging and Physical Activity 1997; 5: 244-261.
42. Rikli R, Jones J. Development and validation of a functional fitness test for community-residing older adults. Journal of Aging and Physical Activity 1999; 7:129-161.
43. Jones CJ, Rikli RE, Max J, Noffal G. The reliability and validity of a chair sit-and-reach test as a measure of hamstring flexibility in older adults. Res Q Exerc Sport 1998; 69(4):338-343.
44. Günther CM, Bürger A, Rickert M, Crispin A, Schulz CU. Grip strength in healthy caucasian adults: reference values. J Hand Surg Am. 2008; 33(4): 558-565.
45. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand Grip Strength: age and gender stratified normative data in a population-based study. BMC Res Notes 2011; 4:127.
46. Wong SL. Grip strength reference values for Canadians aged 6 to 79: Canadian Health Measures Survey, 2007 to 2013. Health Rep. 2016; 27(10):3-10.
47. Cramm JM, Twisk J, Nieboer AP. Self-management abilities and frailty are important for healthy aging among community-dwelling older people; a cross-sectional study. BMC Geriatr. 2014; 14:28.
48. von Faber M, Bootsma-van der Wiel A, van Exel E, Gussekloo J, Lagaa AM, van Dongen E, Knook DL, van der Geest S, Westendorp RG. Successful aging in the oldest old: who can be characterized as successfully aged? Arch Intern Med. 2001; 161(22):2694-2700.
49. Landi F, Russo A, Bernabei R. Physical activity and behavior in the elderly: a pilot study. Arch Gerontol Geriatr Suppl. 2004; 9:235-241.
50. Morey MC, Pieper CF, Crowley GM, Sullivan RJ, Puglisi CM. Exercise adherence and 10-year mortality in chronically ill older adults. J Am Geriatr Soc. 2002; 50(12):1929-1933.
51. Ammann R, Vandelanotte C, de Vries H, Mummery WK. Can a website-delivered computer-tailored physical activity intervention be acceptable, usable, and effective for older people? Health Educ Behav. 2013; 40(2): 160-170.
52. Gschwind YJ, Eichberg S, Marston HR, Ejupi A, Rosario Hd, Kroll M, Drobes M, Annegarn J, Wieching R, Lord SR, Aal K, Delbaere K ICT-based system to predict and prevent falls (iStopFalls): study protocol for an international multicenter randomized controlled trial. BMC Geriatr. 2014; 14(1):91.
53. Gusi N, Prieto J, Forte D, Gomez I, González-Guerrero JL. Needs, Interests, and Limitations for the Promotion of Health and Exercise by a Web Site for Sighted and Blind Elderly People: A Qualitative Exploratory Study. Educational Gerontology 2008; 34(6):449-461.
54. Hong Y, Goldberg D, Dahlke DV, Ory MG, Cargill JS, Coughlin R, Hernandez E, Kellstedt DK, Peres SC. Testing Usability and Acceptability of a Web Application to Promote Physical Activity (iCanFit) Among Older Adults. JMIR Hum Factors 2014; 1(1), e2.
55. Hermens H, op den Akker H, Tabak M, Wijsman J, Vollenbroek M. Personalized Coaching Systems to support healthy behavior in people with chronic conditions. J Electromyogr Kinesiol 2014; 24(6):815-826.
56. van het Reve E, de Bruin ED. Strength-balance supplemented with computerized cognitive training to improve dual task gait and divided attention in older adults: a multicenter randomized-controlled trial. BMC Geriatr. 2014; 14:134.
57. Landi F, Calvani R, Picca A, Tosato M, Martone AM, D’Angelo E, Serafini E, Bernabei R, Marzetti E. Impact of habitual physical activity and type of exercise on physical performance across ages in community-living people. PLoS One 2018; 13(1):e0191820.
58. Assessment: 30-Second Chair Stand. [Internet] 2017. [accessed on 10 July 2018]. Available from https://www.cdc.gov/steady/pdf/30_Second_Chair_S tand_Test-print.pdf