A Low-threshold ICT-based Fitness Programme for Homecare Service Users

Outcomes in Physical Activity and Balance

ICT-based Fitness Programme and Balance

Author(s): Susanne Ring-Dimitriou[1], Sonja Jungreitmayr[1], Marlene Blüher[2], Siegfried Eisenberg[2], Birgit Trukeschitz[2], & Cornelia Schneider[3]

Organisation(s): [1] Paris-Lodron University of Salzburg, Department of Sport Science & Kinesiology; [2] Vienna University of Economics and Business, Research Institute for Economics of Aging; [3] Salzburg Research Forschungsgesellschaft mbH, Mobile and Web-based Information Systems

Document Number: 8

Version/Date: 1.0/2018-10-31

Document Type: Working Paper

Dissemination Level: Public

Funded by the European Commission and Partner States within the Active and Assisted Living Programme

Table of Contents

List of Figures

List of Tables

Abstract

The enhancement of functional fitness to maintain a self-determined life is of major concern today. Accordingly various strategies were investigated to improve adherence to exercise programmes of older adults. Homebased exercise programmes were found beneficial with regard to improvements in physical fitness and health. However the effect of internet-based exercise programmes provided to older people is not clear. The aim of the controlled field study was to prove the effect of CARIMO, an 8-months lasting semi-supervised fitness-programme for end users in Austria and Italy.
239 women and men were assigned to a test group (TG, n=119) and a control group (CG, n=120). The included participants of both groups were tested for health enhancing physical activity level (HEPA, GPAQ item), sedentary behaviour (sitting time in min/d, GPAQ) and balance (uni-pedal stance time in s, UPS) as a marker of functional fitness before (t0), in between (t1, 6 month) and after (t2, 8 months) the CARIMO-test phase. Multi-variate and uni-variate testing was completed. Data were adjusted for possible confounders as sex, country and BMI or age at baseline. Significance level was set $p < .05$.
General linear model approach revealed a significant increase in HEPA (min/wk.), in sitting at the computer (min/d) and in balance (UPS, s) in the TG compared to the CG over the first six months ($p = .002$ and = .02, respectively). With CARIMO the TG improved the balance level over the cut-off norm of 16.7 s from 16 s to 19 s, whereas the CG remained at a low level of 12 s. After 8 months no group difference was found in HEPA and balance.
Our results are very promising with regard to the effectiveness of a low-threshold ICT-based exercise programme consisting of a 10 minutes lasting multi-component programme provided on a daily basis over eight months in community dwelling older adults.

Introduction

The following working paper summarizes the outcomes of the Care in Movement Project (CiM) regarding the tasks of the partner PLUS, which were the development and implementation of a “motion promotion service”. That service consisted of a multi-component exercise training programme that was integrated into an ICT-environment called CARIMO and described in detail elsewhere (Jungreitmayr & Ring-Dimitriou, 2016).

The aim of the CARIMO-motion promotion service was to improve physical activity level and functional fitness in community-dwelling older adults by completing a non-supervised short lasting video-based fitness programme at home combined with outdoor activities mediated by an activity tracker on a daily basis.

The low-threshold exercise training programme was developed by the CiM consortium for home care service users, the primary target group, aged 55 to 91 years without mental disorders, with low to moderate visual or acoustic impairments and with low to moderate nursing needs (for details on the target group see Trukeschitz and Blüher 2018). The care recipients were recruited from care organisations in Austria (Salzburg Hilfswerk) and Italy (ALDIA). Formal carers of the care services were instructed to encourage the care recipients to complete the video-based exercise programme, to use the CARIMO-activity tracker and to complete the exercise tip of the week. Further, formal carers were involved in the testing of functional fitness with the CARIMO-testing box, consisting of a tester manual and testing instruments. All participating formal carers were educated by the principal investigator (SJ) in a face-to-face on-site test instructor course. The test data were monitored and delivered to the CARIMO coordinator of each care service. The coordinator sent the data to the principal investigators (SJ, SRD).

The aim of this paper is to report the effects of the integrated exercise training concept of CARIMO on health-enhancing physical activity and balance.

In another paper the change in fitness literacy will be reported and adds further knowledge to the effects of CARIMO (Trukeschitz et al. 2018).

1 Rationale for a low-threshold fitness programme

1.1 Low-threshold health-enhancing exercise programme

A low-threshold health-enhancing exercise programme is characterized as a programme that can be implemented effortlessly into daily life and that fits to the needs of the target group. In care-in-movement we addressed community-dwelling women and men aged 55 to 91 years who live on their own at home and who got support by long-term care organisations in the regions of Salzburg/Austria and Lombardy/Italy. This population group lived independently, but faced some constraints in mobility, because of overweight, back pain, cardiovascular risk factors or disabilities in walking (TNS Opinion and Social 2018, Austria 2015). In that age-group the main motivation to be physically active is to maintain independence and mobility (Farrance, Tsofliou, and Clark 2016).

With regard to the delineated needs of our target group physical exercises are preferred that can be completed easily in the home setting and that are tailored to the individual physical performance level. Though, transport activities as walking for carrying out daily tasks like banking transactions, shopping at the grocery or pharmacy, as well as strength training with or without dumbbells or balance exercises are recommended (Nelson et al. 2007).

Like for adults in general the systematic analysis of the literature suggests the following exercise dosage that is the product of the frequency per week, duration and intensity per exercise bout in older people without doing harm: a moderate-to-vigorous physical activity equalling four to six kilocalories per kilogram body mass and per hour (i.e. 4 to 6 metabolic equivalents, METs) to improve physical function. A total of 150 minutes per week at moderate exercise intensity or at total of 75 min per week at vigorous intensity (>6 MET), separated at least into 10 minute-bouts, was found effective to improve health (Titze et al. 2010, Nelson et al. 2007).

However, formerly less active or even sedentary people face a lot of difficulties to change their physical activity behaviour from a sedentary to a more active lifestyle. Very often adults complain about the lack of time, a low motor skill level, the fear of getting injured when exercising or the lack of social support as barriers to be regularly active (TNS Opinion and Social 2018). To overcome such barriers people have to belief in their own situation specific capabilities, called self-efficacy (Fuchs 2003, Lee, Arthur, and Avis 2008). Beside coping strategies, like self-management training, the prescription of exercise training was also a target of research to improve self-efficacy and herewith the exercise adherence (Lee, Arthur, and Avis 2008).

With regard to the prescription the following components have to be considered when tailoring a self-efficacy- and an adherence-enhancing exercise programme:

- dosage;
- type of exercise;
- type of instruction;
- and duration of exercise intervention.

For instance, especially in older people it has been demonstrated that short lasting exercise bouts of 10 minutes increased the level of self-efficacy, whereas high intensive exercise boots led to a negative mood and a reduction in self-efficacy (Rudolph and Butki 1998). This finding was supported by DeBusk and collaborators, who showed that multiple short and moderate-to-intense bouts led to a higher adherence rate in 51 year old healthy men compared to long-lasting moderate bouts (DeBusk et al. 1990). Furthermore the fractionalization of a long-lasting bout, as a 30 min exercise session per day, into multiple short lasting exercise bouts (3x 10 min/d) was as effective in improving cardiorespiratory fitness and body composition (Woolf-May et al. 1999, Asikainen et al. 2003, Murphy and Hardman 1998). Concerning the exercise frequency per week a training programme consisting of less than two sessions per week was less accepted by older people resulting in lower adherence rates (McPhate, Simek, and Haines 2013). However metabolic effects especially in blood lipids, a risk marker of cardiovascular diseases, were improved significantly by exercise bouts lasting more than 20 minutes (Woolf-May et al. 1999).

As indicated before the type of exercise matters as well: strength and balance exercise are expected by older adults, whereas the prescription of flexibility exercises led to a drop in adherence rate (McPhate, Simek, and Haines 2013).

How the instructor behaves to the client or exercise class seem critical as well, indicating that an empowering communication style increases adherence rate significantly (Farrance, Tsofliou, and Clark 2016). However, fully supervised instruction is not as important as suspected as long-lasting lifestyle-modification programmes revealed. King and her collaborators completed a two years lasting controlled trial and found out that the home-based exercise training was as effective as supervised exercise concerning participation rate, improvement in cardiovascular fitness and metabolic health in women and men older than 50 years (King et al. 1995, Farrance, Tsofliou, and Clark 2016).

Very often it was reported that the longer the exercise intervention the smaller the effects in fitness due to a drop in adherence rate. With regard to that specific exercise programme descriptor a systematic review demonstrated that exercise interventions lasting more than 20 weeks were not much accepted by older people resulting in lower adherence rates (McPhate, Simek, and Haines 2013).

Descriptor	Exercise Prescription
Intervention duration	With regard to adherence the exercise intervention shall last no longer than 20 weeks.
Total Duration per week	150min/wk. moderate-to-vigorous physical activity (MVPA) or 75min/wk. vigorous physical activity (VPA), including all physical activities in the household, in transport (walking, cycling), in occupation or in leisure time. A multicomponent exercise training programme is part of that volume.
Duration per Session Intensity	10 min bouts/training sessions. Moderate-to-vigorous (MPA) = 4-6 kcal/kg/min (MET); Progressive increase over exercise intervention.
Frequency	At least 2x/week; preferably on most days.
Mode to complete the session, Fractionalisation	Continuous for 10 minutes (at least 5 min), i.e. not interrupted by longer rest periods (more than 2 minutes); Intermittent over the long run (2x 5 min /d; 7x 10min /week).
Session Structure	Warm-up, main topic, cool-down.
Type of exercise training (components)	Strength, balance/coordination, endurance; Involvement of large skeletal muscle groups.
Order of exercise over time	Muscle strengthening > Balance and coordination tasks > Endurance (walking)
Guidance	For a better outcome: semi-supervised, i.e. PEU complete the programme sometimes with the support of the formal or informal carer

Table 1. Descriptors of a low-threshold health-enhancing exercise programme (modified by Ring-Dimitriou, acc. to Jungreitmayr and Ring-Dimitriou 2016, p.8).

All in all to overcome the psychological barriers and to benefit the health of older people a low-threshold exercise training programme consists of at least 10 minutes bouts, completed several times per day and on multiple days per week with a moderate-to-vigorous intensity at home over 20 weeks. A detailed prescription is depicted in Table 1.

In summary an individualised multi-component exercise programme shall be provided to older people to achieve an improvement in functional fitness (Granacher et al. 2013, Bouaziz et al. 2016, Littbrand et al. 2006).

1.2 Functional fitness in old community dwelling people

With ageing, alterations in physical and mental functions are commonly expected. Hereby regular engagement in physical activity as walking or resistance exercise can counteract the detrimental reduction of physical function and maintain a self-determined mobility in daily life (Nelson et al. 2007, Sun, Norman, and While 2013, Ring-Dimitriou et al. 2018, Fried et al. 2001).

Most of the recommendations focus on endurance exercise, strength and balance training, because of the evidence found to reduce cardiovascular and metabolic risk as well as the risk of falling (Nelson et al. 2007). Accordingly a combination of physical exercises addressing the cardiorespiratory and motor function will have a profound impact on health in older people. The association between the loss of skeletal muscle mass (called *sarcopenia*) with a reduction in the level of physical fitness (cardiorespiratory fitness/endurance, motor fitness/strength), that further affects the ability to walk fast and to maintain a certain physical activity level, was introduced by Fried and collaborators (Fried et al. 2001). Emphasizing the vicious cycle of structure - muscle mass - and functional fitness in the heuristic model of Fried.

Accordingly functional fitness is defined as the ability to perform daily physical tasks easily, i.e. without difficulties in executing the tasks and getting tired when completing the tasks (Caspersen, Powell, and Christenson 1985, Rikli and Jones 2013). That means a certain motor skill level is important to fulfil the physical task in an everyday context with vigour, i.e. walking a distance of more than 400 m, crossing streets without fear of getting injured or stepping stairs without getting exhausted, hereby reducing the risk of falling (Ring-Dimitriou et al. 2018).

To overcome this kind of "functional barrier" a functional fitness programme shall consist of elementary exercises first to improve the movement skill level (i.e. balance, locomotion), followed by strength exercises and endurance exercises, both addressing the cardiorespiratory function, as introduced recently (Jungreitmayr 2018). Accordingly a multi-component exercise training programme is suggested to improve balance, a fundamental movement skill and prerequisite for engagement in regular exercise as strength and/or endurance training in older age (Becker & Blessing-Kapelke, 2011; Bouaziz et al., 2016; Kumar et al., 2016; Titze et al., 2010; Zaleski et al., 2016).

1.3 Smart exercise programmes

Nowadays new technology as activity trackers or mobile-phone based exercise workouts are very common to engage in new trend sport activities at the population level. However, it has been demonstrated that these devices as stand-alone products will not led to a significant increase in the health-enhancing physical activity behaviour.

To date, most of the studies reported that web-based and short lasting exercise interventions are effective with regard to adherence rate and significant improvements in fitness when accompanied by a personal support (empowerment) like practitioner, physicians or formal carer (Ring-Dimitriou et al. 2008, Meister, Becker, and Simon 2016, Kumar et al. 2016, Muellmann et al. 2018).

Based on behaviour change theories recommendations to tailor interventions that improve amount of engagement in physical exercises point towards a strategy, where the desired behaviour is addressed by multiple channels on a daily basis to facilitate an engagement ofat least 1.5 websites visits per week (Glanz, Rimer, and Viswanath 2008, Fuchs 2003, Muellmann et al. 2018). In practice this indicates that various functions of a smart ICT-based exercise programme serve as actions to improve physical activity level, for instance: a reminder function to be active (cognitive and affective level), an overview of fulfilled exercise sessions per week (cognitive and affective level), the exercise programme itself (action level) or the possibility to complete an exercise diary (cognitive level).

Therefore products are warranted that support people to become regularly active and improve their physical fitness by utilizing digital technologies consisting of evidence-based exercise training contents and programmes.

2 Research Questions

Based on the rationale delineated before, an information-communication-technology (ICT)-based exercise programme as part of CARIMO was developed to improve the physical activity and functional fitness level of adults aged 55 to 91 years living at home with the support of social services in Austria and Italy.

The aim of the empirical study was to test the effect of the ICT-based CARIMO programme on the level of physical activity and on balance, an indicator of the functional fitness level. The following research questions (RQ) were investigated in detail:

> RQ1) Was CARIMO effective in improving the health-enhancing physical activity level in care-dependent older women and men?
>
> RQ2) Was CARIMO effective in improving balance, a functional fitness indicator in care dependent older women and men?

3 Methods

3.1 Study design and sample

A prospective longitudinal controlled study was completed to investigate the effects of CARIMO on various outcomes, such as activity-related outcomes, fitness literacy, physical activity, and functional fitness.

In this paper we focus on the effects of CARIMO on self-assessed levels of physical activity and on objectively assessed functional fitness. Accordingly, we analysed the changes in the amount of physical activity and balance level in participants before (t0, April to May 2017), after six month (t1, in between, November 2017) and after eight months (t2, end intervention, February to March 2018).

With regard to the research questions, the test participation, multivariate and univariate testing before, in between and after the 8-months of CARIMO intervention data of 121 participants were available for analysis of changes in physical activity level and for changes in balance performance level over time. This sample consisted of 62 subjects assigned to the test group (TG) that were exposed to CARIMO and of 59 subjects that served as control group (CG) and who had no access to CARIMO.

The whole study design and methods were approved by the ethics committee of the University of Salzburg (EK-GZ 30/2016).

3.2 CARIMO exercise intervention

CARIMO, an ICT-based programme developed by a consortium of research and industrial partners under the lead of the Salzburg Research Forschungsgesellschaft consisted of three functions addressing the engagement in regular exercise to improve functional fitness: “fitness exercises (action -> initiating process)”, “physical activity overview (cognition -> reflexion and planning process)” and “tip of the week (cognition -> planning process)” (Jungreitmayr and Ring-Dimitriou 2016), and two additional functions addressing recreation activities, as reading daily news “Daily Newspaper” and playing games by surfing in the net “Games and Internet”, as well as another function addressing communication between end-user, formal carer and family members by the function “Activities and Notes” (Schneider and Rieser 2018).

The exercises of the CARIMO-fitness programme were tailored to the fitness level of the study participant (social service end-user of the test group). The fitness programme consisted of daily exercise sessions lasting 10 minutes. Each exercise session followed a typical order of exercises: warm-up, core part and cool-own, and consisted in total of about six to 10 exercises addressing the motor abilities balance, strength and flexibility. All exercises were provided as a video, depicting the whole moving pattern per repetition of the suggested exercise, and prescribed by a written text as well as a spoken text optionally. The end-user observed the video and completed the exercise as prescribed in the video. A counter of repetitions and seconds started, when the end-user pushed the start button. The completed exercises were counted, monitored and the information about the training progress was provided via the user-interface as a “physical activity overview” to the end-user. If an exercise was stopped to early, i.e. after eight seconds, the exercise was not counted. For more convenience, the service end-user could skip exercises.

Furthermore, the participants of the test group received an activity tracker to self-monitor their walking activities outdoors. The data of the tracker were transferred to CARIMO and the amount of completed outdoor physical activities in minutes was provided via the “physical activity overview”.

With support of the channel “tip of the week”, three times per week an exercise tip was communicated via the CARIMO-tablet to the test group like “today is a sunny day – good opportunity to walk outside”. The end-users had the opportunity to record the activities by their own or they monitored the activities with the help of the activity tracker. The information was sampled via the function “activities and notes” to provide an overview of all the completed exercise minutes in- and outdoors (Schneider and Rieser 2018).

The whole exercise intervention was tailored in that way, that participants of the test group were able to complete at least 150 minutes of moderate-to-vigorous activity per week or more to improve functional fitness level. Overall we used a low-threshold strategy to facilitate the engagement in daily physical activity. As indicated, the exercise programme was provided on a daily basis via a tablet and the activity tracker over eight months. The adherence of participants of the TG was tracked objectively and usage groups were formed based on that data where participants using CARIMO on more than seven days per months, i.e. at least on average two times per week, were defined as frequent users (Schneider and Rieser 2018).

3.3 Data collection, test procedures and measures

To investigate the effect of the exercise programme on health-enhancing physical activity level (HEPA) and on balance as part of CARIMO, we collected data by a self-administered questionnaire (further details see in Trukeschitz and Blüher 2018) and by the completion of a functional fitness test battery (Jungreitmayr and Ring-Dimitriou 2016).

The here reported data of study participants of the test and control group were collected before (t0), in between (t1, after six months) and after eight months in Austria and Italy by educated personnel.

To collect the objectively measured anthropometric data and the balance performance levels, we educated formal carers of the social services in a four hours lasting face-to-face workshop in Austria and Italy by one of the principal investigators (SJ) together with a native speaker (Jungreitmayr et al. 2018). Hereby the formal carers received the CARIMO test-box consisting of written standard-operating procedures for the functional fitness tests, a scale to measure body mass and body height, a tape to measure waist circumference, a dynamometer to measure hand grip, a stop watch to measure the repetitions in the 30s-chair rise test and to measure the seconds of the uni-pedal stance (Jungreitmayr and Ring-Dimitriou 2016, Jungreitmayr et al. 2018). In addition to educational actions on-site, a webinar, both in German and Italian, regarding all testing procedures was produced and provided to the formal carers throughout the test phase.

3.3.1 Anthropometric data

Body mass and body height were measured to the nearest of 0.1 kg and 0.1 cm by using a standardized scale and written standardized procedures according to the World Health Organization (Organization 1995). The end-user was barefoot and simply clothed when being assessed. The test criteria used to characterize the participants was body mass in kg at t0.

From these measures the body mass index (BMI, $kg{\cdot}m^{-2}$) was calculated to categorize the body mass of end-users into normal weight or overweight according to the WHO staging (Organization 1995). The test criteria used to analyse changes over time was BMI in $kg{\cdot}m^{-2}$ at t0, t1 and t2.

3.3.2 Physical activity and sedentary behaviour

It has been demonstrated, that the objective assessment method accelerometry has its limitations in monitoring a broad spectrum of physical activities. Especially in long-lasting intervention studies (> 20 weeks) survey data seem more reliable with regard to the diversity of physical activities and the compliance to wear the accelerometer (Sun, Norman, and While 2013). Further the investigation of sedentary behaviour by physical activity questionnaires is recommended, because until now it is difficult to differentiate between postures like standing, sitting and lying when utilizing an objective method like the accelerometry. Therefore we decided to measure the health-enhancing physical activity level per week (HEPA, min/wk) and the sitting time in various contexts per day (min/d) with items from the Global Physical Activity Questionnaire (GPAQ) as suggested by Bull and others (Bull, Maslin, and Armstrong 2009).

The items were part of the CARIMO self-administered questionnaire, that was distributed to all participants of the TG and CG by formal carers (further details in Trukeschitz and Blüher 2018). In the following the items are described in detail.

For assessing HEPA we used the single-item as introduced by Wanner et al. in the following (Wanner et al. 2013): "In the past week, on how many days have you done a total of 30 min or more of physical activity, which was enough to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places, but should not include housework or physical activity that may be part of your job." The item was cultural-sensitive translated and available in German and Italian (Wanner et al. 2013, Bull, Maslin, and Armstrong 2009). The test criterion was defined as HEPA in min/wk at t0, t1 and t2, where the quoted days per week were multiplied by 30 minutes.

To measure the sedentary behaviour we used the GPAQ-item "How much time do you usually spend sitting on a typical day?" (Bull, Maslin, and Armstrong 2009), slightly modified to the various contexts of sitting, as sitting when watching TV (1), when working at the computer/Laptop/ Tablet (2), when reading a book/newspaper/journal (3) or when sitting at the table with or without friends (4). The test criteria were defined as sitting time in min/d for each context.

3.3.3 Balance testing: Uni-pedal Stance Test

Uni-pedal stance time was measured to assess static balance ability (UPS, s). The test is easy to administer and requires a minimum of equipment. Subjects were barefooted, asked to fixate an imaginative point on eye level, to put their hands on the hips and to lift one leg on the count of 3-2-1-lift. The test ended when the subject either: (1) used his arms (i.e. lifted them off the hips) (2) used the raised foot (moved it towards or away from the standing limb or touched the floor), (3) moved the weight-bearing foot to maintain balance (i.e., rotated foot on the ground) or (4) a maximum of 60 seconds was exceeded.

The same procedure was then applied to the alternating leg. A total of six trials (three for each leg) was conducted and the best result in seconds (1 of 6) was used as test criteria.

3.4 Statistical methods

The continuous data of the sample were cleaned for outliers and general linear models were utilized to determine mean differences between groups (TG vs. CG) at baseline and over time. With regard to analyse a possible association between physical activity level and balance performance level the data sets were merged.

Hereby a multivariate approach was used at baseline to check for possible confounders. Further, we adjusted the mean differences between groups to sex and country, because it is evident that both determinants affect the outcome in the physical activity level and balance (Springer et al. 2007, Nelson et al. 2007, TNS Opinion and Social 2018). Mean differences between groups were adjusted for multiple testing with Bonferroni test.

Over time the interaction between group (TG, CG) and time (t0, t1, t2) was determined by an analyses of variance for repeated measures of the outcome variables HEPA (min/wk), sitting time (min/d) and balance (s). If an interaction effect was evident univariate analyses were performed to investigate the mean difference between groups at each time point. Because of three time points, we tested for sphericity over time with Mauchly´s Test, i.e. we tested if the variance of the orthonormalized transformed dependent variables were proportional to each other. In the case that the sphericity was violated we used the result of the Greenhouse-Geisser adjustment of the error variances of the ortho-normalized dependent variable. The significance level for all procedures was set p <.05.

4 Results

4.1 Sample size

In total, 239 older persons receiving care services in Austria and Italy were tested. As depicted in Figure 1 data of 121 subjects were available to test mean differences in physical activity level over all three time points and between groups equalling 51 % of the total sample. The changes in balance over all three time points were tested in 133 subjects (56 % of total sample).

The loss in data occurred because of missing data in the questionnaire and because participants did not attend all fitness test time points. Reasons for not attending the fitness test were because the participants were on holidays, ill or because they simply forgot to come to the appointment.

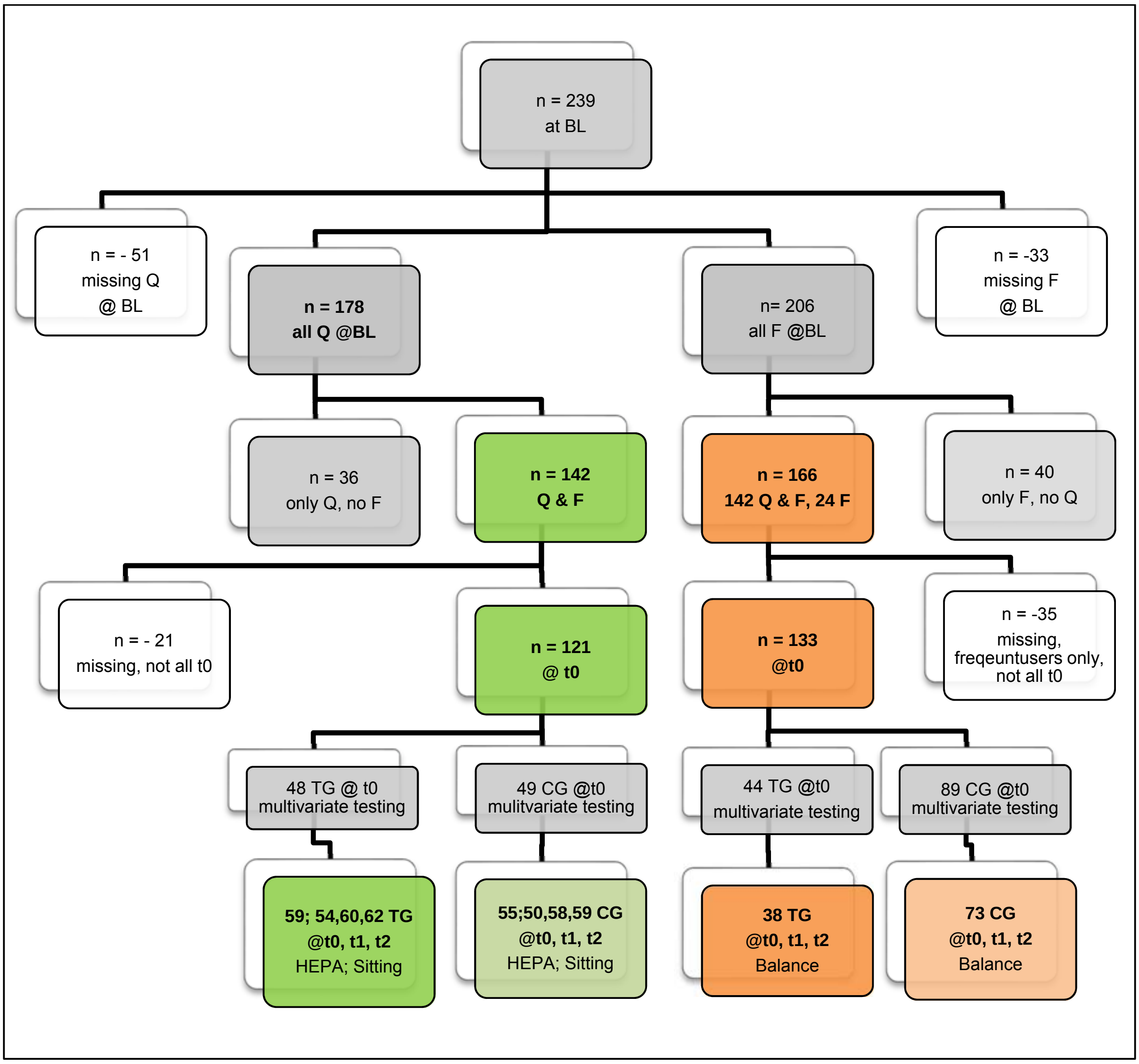

Figure 1. Participant flow of the sub-sample analysis for t0 (baseline), t1 (after 6 mon) and t3 (after 8 mon). *Notes:* BL, baseline t0; Q, self-administered questionnaire data HEPA (min/wk) and sitting (min/d; computer, TV, reading, table); F, fitness data as balance performance (s, 1 out of 6 trials). *Data sources:* survey data via WU/PLUS, CiM Effectiveness survey 2017/2018; physical activity and fitness data via CiM_PLUS_Survey1 and CiM_PLUS_ILPN1 (ref. see 5.2, Data files).

4.2 Changes in Physical Activity Level

4.2.1 Sample Characteristics at Baseline

As depicted in Table 1 on average the analysed participants were 75.5 years old, obese grade I in the TG and overweight in the CG. The percentage of females was 70 % in the whole sample. Based on usage data the sample consisted of 27 % frequent and 21 % less frequent users in the TG.

The self-administered survey data revealed that none of the participants reached the recommended HEPA-level of 150 min per week at baseline. Sitting in the context of TV viewing was a preferred sedentary activity and accounted for about 3.5 hours per day in both groups.

	Test group, TG		Control Group, CG		
	No.		*No.*		
n	48		49		-
Female, %	71		67		-
Adherence ≥ 8x/mon, frequent user, %	27		0		-
Adherence 1-7x/mon, user, %	14		0		-
Adherence 0x/mon, non-user, %	7		52		-
	M	*±SD*	*M*	*±SD*	*p*
Age, yr	75.0	7.1	76.1	7.2	n. s.
Body mass, kg	82.6	22.8	73.8	14.1	.02
Body height, cm	163.1	9.1	164.0	9.1	n. s.
BMI, kg/m²	31.0	7.7	27.5	5.3	.01
HEPA, min/week	53	63	41	61	n. s.
Sitting while watching TV, min/d	220	142	199	119	n. s.
Sitting at a computer, min/d	37	98	30	67	n. s.
Sitting while reading, min/d	91	71	82	53	n. s.
Sitting at a table	107	80	142	110	n. s.

Table 2. Baseline characteristics of the sample concerning physical activity level. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018, Notes: M = mean, SD = standard deviation, p = probability).

The multivariate analysis of the characteristics of participants at baseline (t0) revealed a significant group difference in BMI (see Table 1). Accordingly BMI was defined as a confounder variable and served as co-variate together with sex and country to adjust for differences at baseline in the interaction analyses.

4.2.2 Changes in HEPA over time

Analysis of variance with repeated measures showed only a trend for an interaction between group (CG, TG) and time (t0, t1, t2) indicated by an interaction (time*group) of $p = .06$, an effect size of *eta*².05 and an observed power of *1-beta* .55. With univariate testing HEPA was significantly higher in the TG with 63 ±68 min/wk. compared to the CG with 28 ±53 min/wk. (see Table 3).

	HEPA, min/Wk.				
	TG		CG		
	M	*±SD*	*M*	*±SD*	*p*
n	59		55		
BL, t0	47	62	35	61	n. s.
6 mon., t1	63	68	28	53	.002
8 mon., t2	52	66	30	58	n. s.

Table 3. Differences in HEPA (min/wk) within and between groups over time. Data source: Data source: WU/PLUS, CiM Effectiveness survey 2017/2018. *Note*: Abbreviations see Table 2.

In Figure 2 HEPA over time for the TG and CG is depicted as mean ±SE adjusted to sex, country and BMI revealing the increase over the first six month in the TG followed by a drop over the last two month.

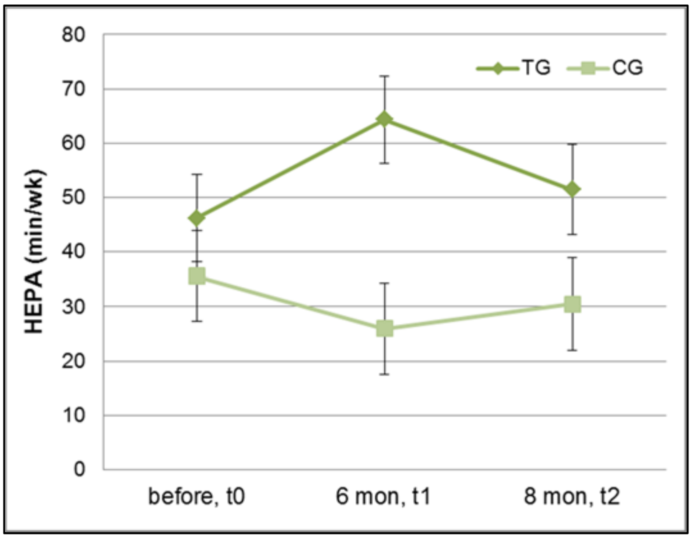

Figure 2. HEPA (min/wk.) over time in TG and CG as mean ±SE adjusted to covariates sex = 0.7105, country = 1.4474 and BMI = 29.180. Significant differences occurred between groups at t1 by univariate testing. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018.

4.2.3 Changes in sitting over time

In the following the analysis of variance with repeated measures for sitting in various contexts will be shown.

The analysis of variance with repeated measures revealed a significant interaction between groups and over time in sitting at a computer, because sitting time increased significantly in the TG and differed significantly between TG and CG after six and eight months (see Table 4, Figure 3). Further, we found a significant interaction (time*group) with p = .004, an effect size of *eta²* .11 and an observed power of $1-\beta$ .87.

Sitting Computer, min/d					
	TG		CG		
	M	*±SD*	*M*	*±SD*	*p*
N	54		50		
BL, t0	34	93	29	66	n. s.
6 mon., t1	82	87	24	54	.0001
8 mon., t2	88	87	34	93	.002

Table 4. Differences in sitting time (min/d) *while working on the computer, laptop or tablet* within and between groups over time. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018..

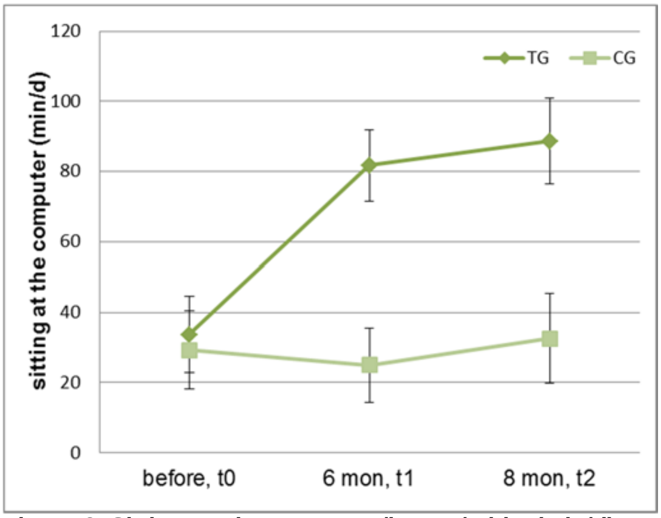

Figure 3. Sitting on the *computer/laptop/tablet* (min/d) over time in TG and CG as mean ±SE adjusted to covariates sex = 0.7105, country = 1.4474 and BMI = 29.180. Significant differences between groups occurred at t1 and t2 by univariate testing. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018..

No significant interaction between groups and over time was found for sitting while watching TV, while reading a book or sitting at a table (see Table 5, Table 6, Table 7). Univariate testing showed a significant difference between TG and CG in sitting at a table at baseline, where the CG quoted a higher amount of 2h25min compared to 1h47min in the TG.

Sitting TV, min/d					
	TG		CG		
	M	*±SD*	*M*	*±SD*	*P*
n	62		59		
BL, t0	216	135	206	133	n. s.
6 mon., t1	201	117	216	127	n. s.
8 mon., t2	197	111	229	125	n. s.

Table 5. Differences in sitting (min/d) while *watching TV* over time within and between groups. **Data source: WU/PLUS, CiM Effectiveness survey 2017/2018**.

Sitting reading, min/d					
	TG		CG		
	M	*±SD*	*M*	*±SD*	*P*
N	60		58		
BL, t0	94	67	85	49	n. s.
6 mon., t1	79	58	88	67	n. s.
8 mon., t2	74	64	89	104	n. s.

Table 6: Differences in sitting (min/d) while *reading a book* over time within and between groups. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018.

Sitting Table, min/d					
	TG		CG		
	M	*±SD*	*M*	*±SD*	*P*
n	*60*		*57*		
BL, t0	107	77	145	125	.02
6 mon., t1	127	106	131	86	n. s.
8 mon., t2	115	79	129	116	n. s.

Table 7: Differences in sitting (min/d) while *sitting at a table* alone or with friends over time within and between groups. Data source: WU/PLUS, CiM Effectiveness survey 2017/2018.

4.3 Balance Performance Level

In the following the balance performance level of study participants, as a marker of functional fitness, was investigated. Hereby we analysed the data of participants who were measured at t0 and at all three time points. Only frequent users of the TG, i.e. those who used CARIMO fitness programme at least twice a week were included in the repeated measures.

4.3.1 Sample Characteristics at Baseline

Baseline data of 133 participants revealed no significant difference between groups in anthropometric characteristics after analysis of variance by multivariate testing. On average the sub-samples were overweight because of a BMI ≥25 kg/m². The age of the sub-samples and the percentage of females with 72 % were comparable with participants investigated for physical activity level (see Table 8).

	Test group, TG		Control Group, CG		
n	44		89		-
Female, %	73		71		-
	M	*±SD*	*M*	*±SD*	*p*
Age, yr	74.3	7.0	76.5	7.2	.08
Body mass, kg	76.8	21.3	73.9	16.4	n. s.
Body height, cm	161.9	9.6	163.8	8.4	n. s.
BMI, kg/m²	29.0	6.7	27.6	6.0	n. s.
Balance, s	16.2	18.8	12.4	18.2	n. s.

Table 8. Baseline characteristics in baseline data of the sub-sample concerning balance. *Data source*: CiM_PLUS_ILPN1.

However the average balance level of 16.2 s in the TG and 12.4 s in the CG were below the normative cut-off levels of 16.7 s (SD 15.0 s) for females and 25.0 s (SD 18.1 s) for males in that age-group (Springer et al. 2007).

Because of a trend for an age difference between groups, with the participants of the CG being slightly older, we adjusted the group-mean over time for age.

4.3.2 Changes in Balance Performance

In line with the analysis of the changes in physical activity level, the changes over time in balance performance were adjusted to sex, country and age.

Over time analysis of variance with repeated measures revealed a significant interaction between time and group with $p = .006$, an effect size of eta^2 .09 and an observed power of $1-\beta$ .83. The interaction remained after Greenhouse-Geisser adjustment for no sphericity of the error variances of the ortho-normalized dependent variable with $p = .045$, an effect size of eta^2 .03 and an observed power of $1-\beta$ .57. Levene´s test at each time point revealed equality of error variances between groups ($p > .10$).

Because of an age-standardized normative cut-off value for balance of 16.7 s for females and 25.0 s for males, the uni-pedal stance test revealed that both groups showed a balance performance below the norm at baseline (see Table 9). However, compared to the CG the CARIMO test-group increased the balance level significantly over the first six months (see Table 9).

Balance Uni-pedal Stance, s					
	TG		CG		
	M	*±SD*	*M*	*±SD*	*p*
n	38		73		
BL, t0	16.3	18.4	13.8	19.6	n. s.
6 mon., t1	19.4	18.6	11.5	17.4	.02
8 mon., t2	13.9	15.1	12.2	16.7	n. s.

Table 9: Differences in balance (s) measured as uni-pedal stance (s) over time within and between groups. *Data source*: CiM_PLUS_ILPN1.

Thereafter a drop in performance level to the baseline in the TG was found with no difference compared to the CG. The level in the CG decreased over six month and remained below the cut-off until the end of the CARIMO test phase (see Table 9 and Figure 4).

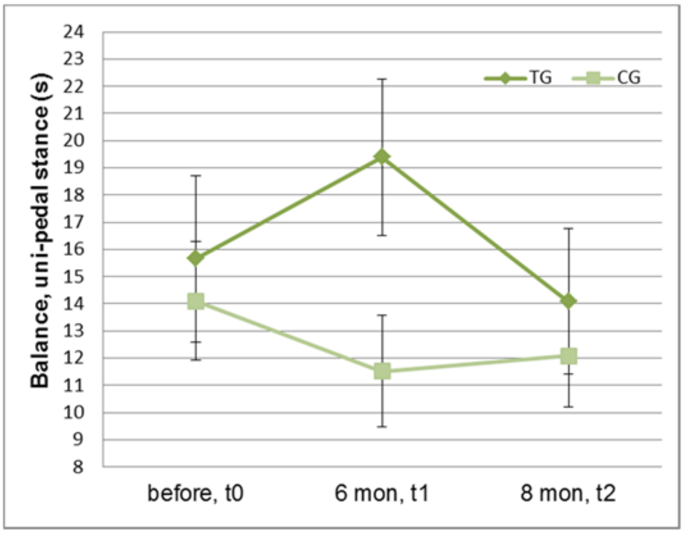

Figure 4. Balance performance measured by uni-pedal stance (s) over time in TG and CG as mean ±SE adjusted to covariates sex = 1.7207, country = 1.414 and age 75.5. Significant differences occurred between groups at t1 by univariate testing. *Data source*: CiM_PLUS_ILPN1.

5 Discussion

To date empirically investigated ICT-based exercise promotion programmes in an older community-dwelling population are rare (Muellmann et al. 2018).

With this working paper we report for the first time the outcome of a low-threshold ICT-based exercise programme consisting of three functions (fitness exercises, outdoor activities / activity tracker, reminder tip of the week) as part of the CARIMO system. Each participant of the TG received the CARIMO web-based system on a tablet and was introduced into the usage of all functions by educated care workers of the care organisations in Austria (Hilfswerk Salzburg) and in Italy (ALDIA).

The special finding of the CARIMO study is that almost one third of the TG used the exercise functions on a frequently basis, i.e. two times or more per week for more than half a year (Schneider and Rieser 2018)! The reported recommendation was 1.5 ±0.6 weekly visits to improve subjectively measured HEPA by web-based interventions (Muellmann et al. 2018). According to that we could show a trend for a pronounced increase in the HEPA-level over the first six month in the TG from 30min to 1h20min per week of moderate-to-vigorous activity (MVPA) compared to the CG that remained at a level of 20 to 30 min/week.

Although the here self-reported health-enhancing physical activity levels (HEPA-values) are far away from the recommended amount of 2h30min per week (Titze et al. 2010), the results of the TG are encouraging, especially when keeping in mind the short-lasting exercise bouts of 10 minutes provided on a daily basis and the age of the sample. In general, only 10 % of older people achieve the recommended HEPA-level measured as self-reported 30 min MVPA data (Sun, Norman, and While 2013). Every increase in physical activity level in that age group is a step towards a more active lifestyle. The drop of HEPA in the TG after six months was possible affected by a seasonal effect, as the last two months coincided with the winter months December to February accompanied by festivals like Christmas and New Year in both countries. The recently learned behaviour seems not as stable to external stimuli as festivals. Often a relapse to the "old habit" can be observed in such special situations (Fuchs, Göhner, and Seelig 2007, Lee, Arthur, and Avis 2008).

Although the results are encouraging, the impact of the ICT-based programme consisting of other functions as "reading news" or "playing games" seem to compensate for the activity behaviour with an increase in sedentary behaviour, because we found a significant increase in sitting time while working on the computer/laptop/tablet in the TG from 30 min to 1h25min compared to the CG with a stable value of around 25 min over eight months. Further studies are warranted to investigate the compensation behaviour in such interventions. However, our results are in line with the usage data of CARIMO as reported by Schneider and Rieser (2018) and opens questions towards the effectiveness of the programme concerning functional fitness? In the end animprovement of functional fitness is important to increase mobility, quality of life and to reduce the risk for cardiovascular mortality and morbidity in older people (Ekelund et al. 2016, Janssen, Heymsfield, and Ross 2002, Middleton, Fritz, and Lusardi 2015).

Despite the increase in sitting time in the TG we could demonstrate, that the usage of CARIMO led to a significant increase in balance performance measured with uni-pedal stance (dominant leg, eyes open) over the first six month from 16 s to 19 s. During the same time the CG decreased their performance level on average from 14 s to 12 s (repeated measures). Interesting was the finding that again over the last two month a dramatic fall in balance from 19 s to 15 s was found in the TG compared to a maintenance of the balance performance level in the CG at 12 s. Again we speculate that a seasonal effect (Christmas Time) accounted for the drop in the TG compared to the CG. With regard to our sample consisting of about two third of women the cut-off for a normal balance performance is 16.7 s (25 s in men). Uni-pedal stance time below the cut-off level was highly associated with the risk of falling and cardio-metabolic disorders (Springer et al. 2007, Ekelund et al. 2018, Granacher et al. 2013, Janssen, Heymsfield, and Ross 2002)Because the TG significantly improved the balance performance level over six months above the cut-off level of 16.7 s, a reduction in risk of falling can be assumed. .

This means: Although the TG increased sitting at the computer by using CARIMO, the engagement in physical activity level by using the activity tracker and by utilizing the 10 minutes homebased exercise-programme provided via tablet on a frequent basis improved the balance performance significantly over half a year and most likely reduced the risk of falling.

In conclusion these results are promising with regard to the effectiveness of a low-threshold ICT-based exercise programme consisting of a 10 minutes lasting multi-component programme provided on a daily basis over eight months in community dwelling older subjects. We think the CARIMO concept provides promising strategies in health promotion of people in the third age concerning the adherence rate and the quality of the physical activity programme to improve functional fitness.

Limitations

Collecting field-data of such a complex and long-lasting study is always crucial with regard to the measured outcomes. Because we wanted to combine survey data on physical activity and sedentary behaviour with functional fitness missing data has to be expected in the analysis. The observed power of our outcome was moderate with 1-β of .55 for HEPA (min/wk), good with 1- β of .87 for sitting at a computer (min/d) and moderate with 1- β of .57 for uni-pedal stance (s).

Another problem was that sex was not well distributed, because >70 % of our sample comprised females. Although females tend to have a lower HEPA- and balance performance-level, the adherence rate was equal or better compared to the males in our study and is in line with the observation of others (Farrance, Tsofliou, and Clark 2016).

Finally, the impact of addressing sedentary behaviour as well with an ICT-based exercise programme has to be investigated further with regard to compensation mechanism and the impact on functional fitness.

Acknowledgement

We thank for the intensive contribution of the care workers of Hilfswerk Salzburg in Austria and ALDIA in Italy as well as *Daniele Pintus* concerning translation activities as well as the collection of anthropometric data and balance data.

Further we thank Salzburg Hilfswerk and especially *Federica Bosco* of ALDIA for coordinating the interaction between formal carers and end user with regard to the data collection process and the usage of CARIMO. Without their effort the study would not be possible.

Finally we thank all the participants in Austria and Italy, who helped us to develop the CARIMO-exercise programme.

References

5.1 Literature

Asikainen, T. M., S. Miilunpalo, K. Kukkonen-Harjula, A. Nenonen, M. Pasanen, M. Rinne, K. Uusi-Rasi, P. Oja, and I. Vuori. 2003. "Walking trials in postmenopausal women: effect of low doses of exercise and exercise fractionization on coronary risk factors." *Scand J Med Sci Sports* 13 (5):284-92.

Austria, Statistik. 2015. "Österreichische Gesundheitsbefragung 2014." *Hauptergebnisse des Austrian Health Interview Survey (ATHIS) und methodische Dokumentation, Wien*.

Bouaziz, W., P. O. Lang, E. Schmitt, G. Kaltenbach, B. Geny, and T. Vogel. 2016. "Health benefits of multicomponent training programmes in seniors: a systematic review." *Int J Clin Pract* 70 (7):520-36. doi: 10.1111/ijcp.12822.

Bull, F. C., T. S. Maslin, and T. Armstrong. 2009. "Global physical activity questionnaire (GPAQ): nine country reliability and validity study." *J Phys Act Health* 6 (6):790-804.

Caspersen, C. J., K. E. Powell, and G. M. Christenson. 1985. "Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research." *Public Health Rep* 100 (2):126-31.

DeBusk, R. F., U. Stenestrand, M. Sheehan, and W. L. Haskell. 1990. "Training effects of long versus short bouts of exercise in healthy subjects." *Am J Cardiol* 65 (15):1010-3.

Ekelund, U., W. J. Brown, J. Steene-Johannessen, M. W. Fagerland, N. Owen, K. E. Powell, A. E. Bauman, and I. M. Lee. 2018. "Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants." *Br J Sports Med*. doi: 10.1136/bjsports-2017-098963.

Ekelund, U., J. Steene-Johannessen, W. J. Brown, M. W. Fagerland, N. Owen, K. E. Powell, A. Bauman, I. M. Lee, Committe Lancet Physical Activity Series 2 Executive, and Group Lancet Sedentary Behaviour Working. 2016. "Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women." *Lancet* 388 (10051):1302-10. doi: 10.1016/S0140-6736(16)30370-1.

Farrance, C., F. Tsofliou, and C. Clark. 2016. "Adherence to community based group exercise interventions for older people: A mixed-methods systematic review." *Prev Med* 87:155-166. doi: 10.1016/j.ypmed.2016.02.037.

Fried, Linda P, Catherine M Tangen, Jeremy Walston, Anne B Newman, Calvin Hirsch, John Gottdiener, Teresa Seeman, Russell Tracy, Willem J Kop, and Gregory Burke. 2001. "Frailty in older adults: evidence for a phenotype." *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 56 (3):M146-M157.

Fuchs, R., W. Göhner, and H. Seelig. 2007. "Aufbau eines körperlich-aktiven Lebensstils." In *Sportpsychologie*, edited by B. Strauß, W. Schlicht, J. Munzert and R. Fuchs. Göttingen, Bern, Wien, Paris et al.: Hogrefe.

Fuchs, Reinhard. 2003. *Sport, Gesundheit und public health*. Edited by B. Strauß, Schlicht, W., Munzert, J., & Fuchs, R., *Sportpsychologie, Bd. 1.* Göttingen, Bern, Toronto, Seattle: Hogrefe

Glanz, K., B. K. Rimer, and K. Viswanath. 2008. *Health Behavior and Health Education. Theory, Research and Practice.* San Francisco: Jossey-Bass.

Granacher, U., A. Gollhofer, T. Hortobagyi, R. W. Kressig, and T. Muehlbauer. 2013. "The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: a systematic review." *Sports Med* 43 (7):627-41. doi: 10.1007/s40279-013-0041-1.

Janssen, Ian, Steven B Heymsfield, and Robert Ross. 2002. "Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability." *Journal of the American Geriatrics Society* 50 (5):889-896.

Jungreitmayr, S. 2018. "Krafttraining im Alter." *Sportphysiotherapie* (6):161-170. doi: https://doi.org/10.1055/a-0642-8120.

Jungreitmayr, S., and S. Ring-Dimitriou. 2016. Training Concepts Report. Genearl Approach. In *Deliverable D5*. Salzburg.

Jungreitmayr, S., S. Ring-Dimitriou, Birgit Trukeschitz, Cornelia Schneider, Siegfried Eisenberg, and Harald Rieser. 2018. Effects of an ICT-based functional fitness programme on physical fitness of female home care recipients. edited by Sport Science & Kinesiology University of Salzburg. Salzburg.

King, A. C., W. L. Haskell, D. R. Young, R. K. Oka, and M. L. Stefanick. 1995. "Long-term effects of varying intensities and formats of physical activity on participation rates, fitness, and lipoproteins in men and women aged 50 to 65 years." *Circulation* 91 (10):2596-604.

Kumar, A., K. Delbaere, G. A. Zijlstra, H. Carpenter, S. Iliffe, T. Masud, D. Skelton, R. Morris, and D. Kendrick. 2016. "Exercise for reducing fear of falling in older people living in the community: Cochrane systematic review and meta-analysis." *Age Ageing* 45 (3):345-52. doi: 10.1093/ageing/afw036.

Lee, L. L., A. Arthur, and M. Avis. 2008. "Using self-efficacy theory to develop interventions that help older people overcome psychological barriers to physical activity: a discussion paper." *Int J Nurs Stud* 45 (11):1690-9. doi: 10.1016/j.ijnurstu.2008.02.012.

Littbrand, H., E. Rosendahl, N. Lindelof, L. Lundin-Olsson, Y. Gustafson, and L. Nyberg. 2006. "A high-intensity functional weight-bearing exercise program for older people dependent in activities of daily living and living in residential care facilities: evaluation of the applicability with focus on cognitive function." *Phys Ther* 86 (4):489-98.

McPhate, L., E. M. Simek, and T. P. Haines. 2013. "Program-related factors are associated with adherence to group exercise interventions for the prevention of falls: a systematic review." *J Physiother* 59 (2):81-92. doi: 10.1016/S1836-9553(13)70160-7.

Meister, S., S. Becker, and U. Simon. 2016. "Digitale Gesundheit - Unterstützung der Adipositastherapie durch digitale Technologien." *Adipositas* 10 (1):38-42.

Middleton, Addie, Stacy L Fritz, and Michelle Lusardi. 2015. "Walking speed: the functional vital sign." *Journal of aging and physical activity* 23 (2):314-322.

Muellmann, S., S. Forberger, T. Mollers, E. Broring, H. Zeeb, and C. R. Pischke. 2018. "Effectiveness of eHealth interventions for the promotion of physical activity in older adults: A systematic review." *Prev Med* 108:93-110. doi: 10.1016/j.ypmed.2017.12.026.

Murphy, M. H., and A. E. Hardman. 1998. "Training effects of short and long bouts of brisk walking in sedentary women." *Med Sci Sports Exerc* 30 (1):152-7.

Nelson, M. E., W. J. Rejeski, S. N. Blair, P. W. Duncan, J. O. Judge, A. C. King, C. A. Macera, C. Castaneda-Sceppa, Medicine American College of Sports, and Association American Heart. 2007. "Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association." *Circulation* 116 (9):1094-105. doi: 10.1161/CIRCULATIONAHA.107.185650.

Organization, World Health. 1995. Physical status: The use of and interpretation of anthropometry, Report of a WHO Expert Committee.

Rikli, R. E., and C. J. Jones. 2013. "Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years." *Gerontologist* 53 (2):255-67. doi: 10.1093/geront/gns071.

Ring-Dimitriou, Susanne, Sonja Jungreitmayr, Birgit Trukeschitz, and Cornelia Schneider. 2018. "Sarkopenie vorbeugen durch Bewegung im betreuten Wohnen." In *Gesund altern*, 203-224. Springer.

Ring-Dimitriou, Susanne, Serge P von Duvillard, Monika Stadlmann, Hannu Kinnunen, Oliver Drachta, Erich Müller, Raija Laukkanen, Jena Hamra, Sandy Weeks, and Kayla Peak. 2008. "Changes in physical fitness in moderately fit adults with and without the use of exercise telemetry monitors." *European journal of applied physiology* 102 (5):505.

Rudolph, D. L., and B. D. Butki. 1998. "Self-efficacy and affective responses to short bouts of exercise." *Jorunal of Applied Sport Psychology* (10):268-280.

Schneider, Cornelia, and Harald Rieser. 2018. “To use or not to use?” Analysis of Usage Data of the Active and Assisted Living System 'CARIMO', Unpublished Discussion Paper No. 6 of the AAL-project CareInMovement (CiM). Salzburg: Salzburg Research Forschungsgesellschaft mbH.

Springer, B. A., R. Marin, T. Cyhan, H. Roberts, and N. W. Gill. 2007. "Normative values for the unipedal stance test with eyes open and closed." *J Geriatr Phys Ther* 30 (1):8-15.

Sun, F., I. J. Norman, and A. E. While. 2013. "Physical activity in older people: a systematic review." *BMC Public Health* 13:449. doi: 10.1186/1471-2458-13-449.

Titze, S, S Ring-Dimitriou, PH Schober, C Halbwachs, G Samitz, HC Miko, P Lercher, KV Stein, C Gäbler, and R Bauer. 2010. "Arbeitsgruppe Körperliche Aktivität/Bewegung/Sport der Österreichischen Gesellschaft für Public Health." *Österreichische Empfehlungen für gesundheitswirksame Bewegung. Wien: Bundesministerium für Gesundheit, Gesundheit Österreich GmbH, Geschäftsbereich Fonds Gesundes Österreich*.

TNS Opinion, and Social. 2018. Special Eurobarometer 472 - December 2017, "Sport and Physical Activity". In *Special Eurobarometer*.

Trukeschitz, Birgit, and Marlene Blüher. 2018. Measuring the effectiveness of the fitness app 'CARIMO': study protocol and data collection. In *Discussion Paper of the AAL-project CareInMovement (CiM) No. 2/2018 and Discussion Paper No. 2/2018 of the Research Institute for Economics of Aging, Vienna University of Economics and Business (WU), Vienna*.

Trukeschitz, Birgit, Siegfried Eisenberg, Marlene Blüher, Ulrike Schneider, Harald Rieser, Susanne Ring-Dimitriou, and Cornelia Schneider. 2018. The effects of 'CARIMO', an ICT-supported fitness and entertainment program for home care service users: Evidence from a quasi-experiment in Austria and Italy In Unpublished *Discussion Paper No. 8/2018 and Unpublished Discussion Paper of of the AAL-project CareInMovement (CiM) No. 5/2018* Vienna: WU Research Institute for Economics of Aging, Vienna University of Economics and Business.

Wanner, Miriam, Nicole Probst-Hensch, Susi Kriemler, Flurina Meier, Adrian Bauman, and Brian W Martin. 2013. "What physical activity surveillance needs: validity of a single-item questionnaire." *Br J Sports Med*:bjsports-2012-092122.

Woolf-May, K., E. M. Kearney, A. Owen, D. W. Jones, R. C. Davison, and S. R. Bird. 1999. "The efficacy of accumulated short bouts versus single daily bouts of brisk walking in improving aerobic fitness and blood lipid profiles." *Health Educ Res* 14 (6):803-15.

5.2 Data files – PLUS Material

CiM_PLUS_ILPN1 (2018). Data material stored as SPSS data files “Masterfile_ ILPN05092018_(24102018sj).spv”

WU/PLUS, CiM Effectiveness survey 2017/2018 (2018). Survey data material stored as SPSS data file.