Effects of interventions on physical activity in nursing home residents

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Abstract The aim of this review was to evaluate current evidence regarding the effects of interventions on physical activity in the subgroup of nursing home residents as well as to critically review the assessment methods used in this regard. Published studies through January 2015 were searched in The Cochrane Library, PubMed, CINAHL, Web of Knowledge, PsycInfo, Psynex, Psycarticles, CC Med, and DissOnline; and by manual search. For randomized controlled trials (RCTs) to be included, an intervention had to be conducted with nursing home residents aged 65 years and above and physical activity had to be assessed using standardized, quantitative methods. Study quality was evaluated using an established Cochrane rating tool for RCTs. Eight studies met the inclusion criteria. Only one intervention study with main focus on a modification of physical activity behavior could be identified. Physical activity assessments used in the studies were partly limited regarding objectivity or psychometric

quality. Hence, the documentation of effects of interventions is restricted. Six studies reported significant increases of physical activity in nursing home residents and thus positive intervention effects, which points at the feasibility and high potential of intervention programs to promote physical activity in this setting. Enhanced individual contact as well as physical exercise combined with behavioral interventions and the inclusion of nursing staff seems to be most effective in this regard. As only one study involved post-intervention follow-up assessments, sustainability of effects remained unclear.

Keywords Nursing home residents · Physical activation · Intervention · Older people

Introduction

In most countries, the percentage of older people receiving long-term institutional care has remained stable despite demographic change towards an aging population (Rodrigues et al. 2012). One main reason for this is that current policy measures emphasize the strengthening of home care rather than of institutional care (Rodrigues et al. 2012). Even though home care is the predominant care setting in Europe (Rodrigues et al. 2012), the number of dependent older persons living in care institutions such as nursing homes (NH) will remain high in Europe (European Commission [Directorate-General for Economic and Financial Affairs and Economic Policy Committee (Ageing Working Group)] 2009). Hence, measures to raise healthy life years should focus on institutionalized older people as well.

One major means to promote health in institutionalized and non-institutionalized older people is to maintain or

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even increase physical activity (PA) (Crocker et al. 2013; Foster et al. 2005). Positive effects of PA interventions on physical and cognitive function have been reported in the general older population as well as older people with dementia, some of which were residing in long-term care institutions (Potter et al. 2011). It can be expected that PA interventions may also lead to improvements in disability status in the group of NH residents. However, studies show that without regular motivation or prompts fostering PA, most NH residents stay inactive (Scherder et al. 2010). Respective studies demonstrate that compared to non-institutionalized seniors, NH residents are considerably less active (Bates-Jensen et al. 2004; MacRae et al. 1996) and far from meeting the widely acknowledged guidelines issued by the World Health Organization (WHO). The guidelines recommend at least 150 min of moderate intensity PA per week—i.e., 30 min a day, five days a week for older adults aged 65 and above (WHO 2010). It is questionable whether these general guidelines apply for multi-morbid, frail nursing home residents. Until now more specific recommendations taking into account the characteristics of this specific population do not exist. NH residents show pronounced individual restrictions and deficits (e.g., sensory losses, depression, dementia-related disorders, motor impairment, multi-morbidity) (Phillips et al. 2004; Slaughter et al. 2011), they face restrictive environmental factors (e.g., limited outdoor accessibility) and have specific attitudes and experiences (e.g., attitude towards aging or PA); all these conditions making it difficult to meet such general recommendations (van der Bij et al. 2002). Moreover, although steps have been undertaken to refrain from custodial measures like physical restraints (e.g., the “Expert Standard for Fall and Fracture Prevention”; German Network for Quality Development in Care 2006), they are still common practice in nursing facilities. Aiming to prevent falls or other adverse events (de Vries et al. 2004), they also lead to an aggravation of immobility and inactivity. At the psychological level, many NH residents experience difficulties in living a self-determined, active, and stimulating life (Riedl et al. 2012). In particular, their sedentary lifestyle and thus the absence of PA participation may weaken self-efficacy (McAuley and Blissmer 2000), resulting in even more passive behavior, which may lead to a vicious circle overall.

Reviewing the existing body of research on PA and old age, many studies addressing PA in older adults focused on community-dwelling older adults (van der Bij et al. 2002) or older people with dementia (Potter et al. 2011). Some studies even have purposefully excluded NH residents (Foster et al. 2005). Considering the examined outcomes, reviews on interventions with NH residents focused on deficits in (Instrumental) Activities of Daily Living (ADL/IADL) (Crocker et al. 2013) or functional performance

(Rydwik et al. 2004). We are not aware of any review targeting PA changes as outcome of PA interventions in the NH setting.

In NH residents, there are some specific challenges with regard to the accurate measurement of PA. Due to impaired cognitive status and complex constellations of multi-morbidity, in most residents accuracy of recall and self-report are limited (Hauer et al. 2011). Subjective assessments such as questionnaires and interviews partially involve subjective judgement, which may lead to imprecision and limited reliability (Allet et al. 2010; de Bruin et al. 2008). Objective technical assessments often have the problem that activity clusters in frail older persons are usually characterized by short activity episodes that are somewhat complicated to identify. Due to these challenges and difficulties regarding PA assessment an evaluation of the quality of the PA measurements used in the studies being included in the analysis of the identified studies.

Study objectives

Given the beneficial effects of PA on a range of physical as well as psychological outcomes in older people, the identification of effective interventions to enhance PA is of high relevancy. This applies especially to the population of NH residents as they show a pronounced sedentary lifestyle. Therefore, the aim of this review is to investigate existing evidence regarding the effects of interventions on PA in NH residents and to critically review the assessment methods used to measure PA.

Methods

The literature search comprised the following bibliographic databases from the starting year of each database’s index through January 2015: The Cochrane Central Register of Controlled Trials (The Cochrane Library 2015, Issue 1), PubMed, CINAHL, PsycInfo, Psycarticles, Psynindex, Web of Knowledge, Current Contents Medizin (CC Med), and DissOnline. Due to the language capacity of the authors, the search was limited to English and German titles, abstracts, and vocabulary thesauruses (e.g., “MeSH” or CINAHL Headings Thesaurus). In order to detect a maximum number of relevant studies, an extensive search was conducted and adjusted to each electronic database. In addition, reference lists of related articles were manually scanned and experts in the field were contacted. As an example, the search conducted in PubMed is presented in Table 1.

The inclusion criteria were (1) study type: RCTs; (2) outcome: PA; (3) setting: NH; and (4) study population:

Table 1 Overview of search terms used in PubMed

LTC setting	Physical activity
#1 “nursing home”[tiab]	#18 “Sedentary Lifestyle”[Mesh:NoExp]
#2 “nursing homes”[tiab]	#19 “Human Activities”[Mesh:NoExp]
#3 Institutional* [tiab]	#20 “Movement”[Mesh:NoExp]
#4 “long-term care”[tiab]	#21 “Locomotion”[Mesh:NoExp]
#5 “residential home”[tiab]	#22 “Motor Activity”[Mesh:NoExp]
#6 “rest home”[tiab]	#23 “active living” [tiab]
#7 “special-care home”[tiab]	#24 “active lifestyle” [tiab]
#8 “home for the elderly”[tiab]	#25 “activity exercise” [tiab]
#9 Pflegeheim[tt]	#26 “activity promotion”[tiab]
#10 Altersheim[tt]	#27 aktivier*[tt]
#11 Seniorenheim[tt]	#28 aktivit*[tt]
#12 Altenheim[tt]	#29 activat*[tiab]
#13 “Nursing Homes”[Mesh]	#30 “spontaneous activity”[tiab]
#14 “Institutionalization”[Mesh]	#31 “spontaneous activities”[tiab]
#15 “Long-Term Care”[Mesh]	#32 “activity level”[tiab]
#16 “Homes for the Aged”[Mesh]	#33 “sedentary lifestyle”[tiab]
#17 OR (#1-#16)	#34 “motor activity”[tiab]
	#35 “motor activities”[tiab]
	#36 “human activity”[tiab]
	#37 “human activities”[tiab]
	#38 movement[tiab]
	#39 locomotion[tiab]
	#40 “daily activity”[tiab]
	#41 “activity habits”[tiab]
	#42 “habitual activity”[tiab]
	#43 “habitual activities”[tiab]
	#44 “physical activity”[tiab]
	#45 “physical activities”[tiab]
	#46 OR (#18-#45)
	#47 (#17 AND #46)
	#48 #47

Combination of the synonyms

NH residents aged 65 and older. Identified articles were processed in a reference management program (see Fig. 1). After removing duplicate papers, the remaining studies were assessed by title and corresponding abstracts. Papers out of scope were excluded. The remaining potentially relevant studies were assessed for eligibility by screening their abstracts—and in case of ambiguity—the full paper. Papers presumably meeting the inclusion criteria were retrieved, examined in detail, and included in the review if the inclusion criteria were fully met. Additionally, quality of studies was evaluated using a standardized rating tool. Each step of study selection, data extraction, and quality rating was performed independently by two review authors (CPJ and KC). Any disagreements were resolved by consensus or third party adjudication (KH and HWW).

Study quality rating

Each original RCT was evaluated based on a rating system for RCTs developed by the Cochrane Bone, Joint and Muscle Trauma Group (for more detailed description see Latham et al. 2003). Scoring range lies within 0 and 16 (highest quality) points. For each of the eight criteria, a score of two, one, or zero points could be obtained. Two points were given if provided information fully met the criterion; one point was given if the criterion was not fully met (e.g., due to situations such as a small but possible chance of disclosure of assignment; unblinding of some of the assessors; small confounding of treatment and control group; inadequate definitions). Zero points were given if the criterion was not met (e.g., non-randomized trial; inadequate detail that did not allow the reviewer to check

Fig. 1 Flowchart of literature search and study selection

or carry out an intention-to-treat analysis; no attempt to blind assessors to the assignment of treatment; statistically significant differences between the groups without adjustment made in the analysis or the lack of description of the treatment groups at baseline) or if there was insufficient or unclear information provided.

Data extraction

In accordance with the study objectives, the following data were extracted from the studies: the type of interventions conducted as well as the effects of those interventions on PA; the outcome measurements used as well as their psychometric quality; important characteristics of the study populations. In addition, effect sizes were calculated if required information was presented in the paper.

Results

Eight studies fully met the inclusion criteria and were included in final data extraction (see Fig. 1). Descriptive data of included studies regarding study design, interventions, outcome measurements, type, and effects of interventions are presented in Table 2.

Study quality

Table 3 shows the results of the study quality rating tool. We acknowledge that some of the rated studies may have been underrated due to a possible lack of presentation of

methodological issues. The eight RCTs were evaluated by the rating tool described above and had an average rating score of 10.8 (range 8–15).

The highest rated study (Galik et al. 2014) fulfilled 83 % and the lowest rated study (Lobo et al. 2010) fulfilled 50 % of the rating criteria. Several studies shared methodological weaknesses or did not provide the required information to allow rating of intention-to-treat analysis (Chin A Paw et al. 2006; Lobo et al. 2010; Schnelle et al. 2010; Simmons and Schnelle 2004), outcome assessor blinding (Fitarone et al. 1994; Lobo et al. 2010; Schnelle et al. 2010), and treatment concealment (Lobo et al. 2010). Moreover, only Galik et al. (2014) provided sufficient information about whether the care programs—other than the trial options—were identical across participating NHs. Lobo et al. (2010) stated that their trial was not a true RCT due to recruitment implications in the different institutions. However, as the eight participating NHs in this study were randomly selected, this study was nevertheless included in the review.

Study design and major study characteristics

Studies were published between 1995 (Schnelle et al.) and 2014 (Grönstedt et al.); five of the studies came from the U.S., three from Europe (Table 2). Mean sample size was 129 participants, ranging from $N = 76$ to $N = 266$. Mean age of participants across studies varied between 75 and 89 years. Inclusion criteria differed between studies. Several studies excluded residents with walking limitations or other physical limitations (Chin A Paw et al. 2006; Fitarone et al. 1994; Lobo et al. 2010; Schnelle et al. 1995);

Table 2 Study characteristics, intervention, outcome measurements, main findings (concerning PA), and quality-rating score

Study	Design: no. (N); age: mean (SD); cognitive status (MMSE score), measurement times (times), followup	Intervention: no. of IGs (description); no. of CGs (description); duration (Dur); frequency (Freq)	PA as prim. or sec. outcome: description	PA outcome measurement ^a	Main findings (effects of intervention)	RCT rating	ES (d _{corr} ; Klauer 2001)
<i>RCTs</i>							
Chin A Paw 2006 NED	N = 157. Age 81 (6) Cognitive status NA Times baseline, 6 months Followup NA	3; IG I: resistance training, IG II functional-skills training, IG III both interventions. CG: 1; educational program Dur and Freq 26 weeks, 2 days/week	Sec. habitual PA	Accelerometer MTI model 7164 (3 days)	n.s. diff. between groups. Decline of moderate intensity PA* in IG I	12	NA
Fiatarone 1994 USA	N = 94. Age 87 (1) Cognitive Status IG I: 20.9; IG II: 22.7; IG III: 23.1; CG: 22.2 Times baseline, 1 week, 10 weeks Followup NA	3; IG I high-intensity progressive resistance training, IG II nutritional supplement, IG III both. CG: 2 groups; CG I: placebo activities, CG II: nutritional supplement Dur and Freq 10 weeks, 3 (IG I)/7 (IG II) days/week	Prim. PA level	Activity monitors (GMM) (72 h)	Diff in PA between IG I and III versus CG I and II*	10	NA
Galik 2014 USA	N = 103. Age 83.7 (9.9) Cognitive status 8.7 Times baseline, 3 months, 6 months Followup NA	1; function-focused care intervention. CG: function-focused care education only Dur and Freq 6 months, 10 h/week (IG); 1 30-min in-service (CG)	Prim. PA	Accelerometer (ActiGraph; 24 h), observational survey (PAS-LTTC)	Diff. in PA between groups after 6 months for both measures*	15	NA
Grönstedt 2012 SWE, NOR, DEN	N = 266. Age 85 Cognitive status IG: 19, CG: 19 Times baseline, 3 months Followup NA	1; individually tailored physical and daily activities. CG 1; usual care Dur and Freq 12 weeks, 7 days/week	Sec. PA level	Nursing home life-space diameter (NHLSD) rating scale	Diff in PA level between groups*	13	NA
Lobo 2010 POR	N = 137. Age IG: 75-82; CG: 78 Cognitive status ≥24 Times baseline, 12 months Followup 3 months	3; IG I: aerobic training, IG II strength training, IG III health education program CG 1; waiting control Dur and Freq 52 weeks, 2 days/week	NS daily PA	Accelerometer MTI Actigraph (7 days, counts/h)	Diff in PA levels between IG I and II vs. CG; n.s. at follow-up*	8	IG I vs. CG: 0.992 IG II vs. CG: 0.846
Schnelle 1995 USA	N = 76. Age 85 (8) Cognitive status: 11.6 Times baseline, 8 weeks Followup NA	1; prompted voiding plus functional incidental training CG: 1; prompted voiding Dur and Freq 8 weeks, 5 days/week, 4×/day	NS PA	Motion sensors Caltracs (3 × 8 hrs), staff observations	Diff in PA within both groups (IG and CG), n.s. between*	9	NA

Table 2 continued

Study	Design: no. (N); age; mean (SD); cognitive status (MMSE score), measurement times (times), followup	Intervention: no. of IGs (description); no. of CGs (description); duration (Dur); frequency (Freq)	PA as prim. or sec. outcome: description	PA outcome measurement ^a	Main findings (effects of intervention)	RCT rating	ES (d _{Korr} ; Klauer 2001)
Schnelle 2010 USA	N = 112. Age IG: 86 (10.5); CG: 86 (9.4) Cognitive status: IG: 9.6; CG: 12.9 × Times baseline, 3 months Followup NA	1; toileting assistance, exercise, and choice of food snacks and fluids CG 1; usual care Dur and Freq 3 months, 5 days/week	NS PA	Movement device (2 days, 8 h)	Diff. in PA between groups*	9	NA
Simmons ^b 2004 USA	N = 89. Age IG: 88 (7), CG: 89 (6) Cognitive status IG: 12.1, CG: 15.4 × Times Baseline, 8 weeks, 32 weeks. Followup NA	1; scheduled toileting, encouragement to walk/wheelchair and to repeat sit-to-stands, upper body resistance training, and encouragement to drink fluid. CG 1; usual care. Dur and Freq 32 weeks, 5 days/week, 4 ×/day	NS daily PA	Motion sensors Caltracs (3 × 8 h), staff observations	Diff. in PA between groups for both measurements*	10	1.038

CG control/comparison group; ES effect sizes; IG intervention group; LTC long-term care; NA not available; n.s. statistically not significant; NS not stated whether PA was primary or secondary outcome; PA physical activity; PAS-LTC physical activity survey for long-term care

^a No study reported significant baseline group differences regarding PA outcomes ($p < .05$)

^b Two more papers were published on the same RCT: Kapasi et al. (2003); Schnelle et al. (2002)

* Statistically significant ($*p < .05$); × statistically significant at baseline

Lobo et al. (2010) excluded cognitively impaired persons; however, most of the studies included cognitively impaired subjects or mentioned cognitive impairment as inclusion criteria (Galik et al. 2014). Most participants were described as being at risk of functional and cognitive decline. Cognitive status was assessed in seven studies by the Mini-Mental State Examination (see MMSE scores in Table 2) and had a mean range from 8.7 to ≥ 24 . Following the MMSE cut-off ranges as classified by Eschweiler et al. (2010), two studies reported severe dementia (Galik et al. 2014; Schnelle et al. 2010; 0–10 points), three studies reported moderate dementia (Schnelle et al. 1995; Simmons and Schnelle 2004; 10–19 points), and one study reported mild dementia (Fiatarone et al. 1994; 20–26 points).

Study duration varied between eight weeks and 15 months, in which baseline and final assessments were performed (Table 2). One study (Lobo et al. 2010) conducted post-intervention follow-up assessments three months after the intervention.

In-depth analysis of intervention programs

Although seven studies shared that exercise interventions were implemented, interventions were very heterogeneous (Table 2). They consisted of resistance training (Chin A Paw et al. 2006; Fiatarone et al. 1994; Lobo et al. 2010; Simmons and Schnelle 2004), aerobic training/walking (Lobo et al. 2010), functional skills training (Chin A Paw et al. 2006), repeated sit-to-stands and walking (Schnelle et al. 2010), functional incidental training (Schnelle et al. 1995), function-focused care (FFC) for nursing staff (Galik et al. 2014), and individually tailored activities. Four studies used behavioral interventions that included prompted voiding (Schnelle et al. 1995), scheduled toileting (Schnelle et al. 2010; Simmons and Schnelle 2004), encouragement to be more active (Simmons and Schnelle 2004), and a health education program (Lobo et al. 2010). Additionally, two studies involved other interventions, such as nutritional supplement (Fiatarone et al. 1994) and a periodical offering of snacks and fluids (Schnelle et al. 2010). Five studies used multi-component-type interventions, i.e., a multiple exercise program (Chin A Paw et al. 2006); a combination of behavioral programs and exercise (Schnelle et al. 2010; Simmons and Schnelle 2004); programs combining exercise and nutritional supplement strategies (Fiatarone et al. 1994), and exercise and prompted voiding (Schnelle et al. 1995). In one study, a staff-based intervention with the intention to change the philosophy of nursing care towards PA optimization in residents was implemented (Galik et al. 2014).

The exercise programs were performed for 30–60 min per session, varying from one to seven days per week

Table 3 Scores of the study quality rating

Item	Score							
	Chin A Paw	Fiatarone	Galik	Grönstedt	Lobo	Schnelle et al. 1995	Schnelle et al. 2010	Simmons
Was the assigned treatment adequately concealed prior to allocation?	1	1	1	1	0	1	1	1
Were the outcomes of patients who withdrew described and included in the analysis?	1	1	2	2	0	1	0	1
Were the outcome assessors blinded to treatment status?	2	0	2	2	0	1	0	1
Were the treatment and control group comparable at entry?	2	2	2	2	2	0	2	1
Were care programs, other than the trial options, identical across NHs?	0	0	2	0	0	0	0	0
Were the inclusion and exclusion criteria clearly defined?	2	2	2	2	2	2	2	2
Were the interventions clearly defined?	2	2	2	2	2	2	2	2
Were the outcome measures used clearly defined?	2	2	2	2	2	2	2	2
Sum	12	10	15	13	8	9	9	10

(calculated mean = 4.4). Training periods varied between eight weeks and one year. In three studies, short (five min) bouts of interventions were conducted up to four times a day (Schnelle et al. 1995, 2010; Simmons and Schnelle 2004). Adherence rates varied from 60 % (Lobo et al. 2010) to 97 % (Fiatarone et al. 1994); one study gave no information on adherence (Simmons and Schnelle 2004). Control group activities consisted in all instances of the continuation of usual care and other activities (see Table 2).

Effects of interventions

The main findings regarding effects of interventions on PA are displayed in Table 2. Six of eight studies reported significant between-group differences in PA of intervention groups compared to control groups (Fiatarone et al. 1994; Galik et al. 2014; Grönstedt et al. 2012; Lobo et al. 2010; Schnelle et al. 2010; Simmons and Schnelle 2004). For two of these studies (Lobo et al. 2010; Simmons and Schnelle 2004) effect sizes were calculated as shown in Table 2 (according to Klauer 2001), with both showing large effects ($d > 0.8$; see Cohen 1988). Two studies did not report significant between-group differences in PA (Chin A Paw et al. 2006; Schnelle et al. 1995). In the study by Schnelle et al. (1995), a significant increase of PA in the intervention as well as the control group was reported.

Except for Galik et al. (2014), all of the studies included some sort of exercise component in their intervention that led to significant differences in PA between groups in five of seven cases. These consisted of resistance/strength

training, aerobic training, or functional exercises. In both studies that applied a combination of exercise and behavioral interventions, significant increases of PA were achieved. In these, scheduled toileting (with assistance) and encouragement to drink were implemented in addition to exercises. Effects of interventions on PA seemed not to be dependent on study quality. Drop-out rates were variable, ranging from 6 % (Fiatarone et al. 1994) to 30 % (Chin A Paw et al. 2006).

Outcome measurements

In four of the studies, PA was explicitly indicated as a primary outcome (Fiatarone et al. 1994; Galik et al. 2014) or secondary outcome (Chin A Paw et al. 2006; Grönstedt et al. 2012). The remaining four studies did not provide information in that respect. PA was assessed using objective technical devices, questionnaires or surveys (Tables 4, 5), or both. One study did not use objective technical assessment methods at all. Objective technical assessment was performed using motion sensors such as the Actigraph, the Caltrac Motion Sensor, or the GMM activity monitor (Table 4). One study did not provide information about type and model of the movement device used (Schnelle et al. 2010). Motion sensors recorded either movement counts per time, estimated energy expenditure, or time spent in activities. None of the devices provided a more detailed quantitative analysis including parameters such as time/frequency of activities as classified by walking, standing, lying, sitting, transitions, or even qualitative gait analysis as provided in recent high technical assessments.

PA assessment devices were worn during daytime for at least eight h on two days. Only Fiatarone et al. (1994) had daytime and nighttime data after recording activity for 72-h periods. The devices were worn on hip, thigh, or ankle. None of the studies provided a life space assessment documenting location and area of activities.

The only questionnaire used was the LASA Physical Activity Questionnaire (LAPAQ; Chin A Paw et al. 2006). Observations consisted of one min, time-sampled observations (Schnelle et al. 1995; Simmons and Schnelle 2004), the Physical Activity Survey for Long-Term Care (PAS-LTC; Galik et al. 2014), the Nursing Home Life Space Diameter (NHLSD; Grönstedt et al. 2012), and one observation not described in detail (Schnelle et al. 2010). Overall, validity and reliability were scarcely addressed (see Tables 4, 5). In two studies, information was provided; four studies at least stated where information on validity and reliability is provided.

Discussion

We used a broad literature search strategy that identified only a limited number of adequate studies to report on effects of interventions on PA in NH populations. This indicates a lack of research in this field.

We found positive effects of interventions on PA in NH residents. Most of the included studies support or at least partially support this finding. Effect sizes calculated for two studies showed large effects.

All studies were analyzed and evaluated with our main focus on PA, although it has to be pointed out that most studies were not designed to promote and assess PA as a primary outcome. However, with PA as a secondary study focus, the significant increases in PA emphasize the potential and feasibility of interventions for this highly vulnerable population of NH residents. Consequently, effects might be substantially increased in future studies with primary focus on PA promotion.

On average most of the study samples were cognitively impaired according to a MMSE score. With the exception of one, all of the studies that included cognitively impaired subjects found positive effects of interventions on PA. However, no study distinguished between cognitively impaired and non-impaired subjects—hence, no conclusions on the association between cognitive impairment and intervention effects can be drawn.

Regarding the kind of interventions undertaken, the six studies that found significant increases of PA can be split up in three studies using exercise interventions, two studies combining exercise and behavioral intervention components, and one study implementing a staff intervention. As types of exercise and behavioral programs differ, programs show few

commonalities, hampering their comparison. The fact that the two studies using a combination of exercise and behavioral interventions clearly showed significant increases of PA underlines the potential of this combination. In these two multi-component intervention studies, interventions were characterized by multiple short time, face-to-face interactions between residents and staff members or research staff/therapists. Thus, one explanation for the positive effect may be that, on one hand, the physical component (exercise) enables NH residents to regain or improve the abilities needed to be physically active. On the other hand, the enhanced individualized contact may be crucial for encouraging residents to use the abilities gained through the physical component, and consequentially lead to more physically active behavior. This assumption is supported by the fact that the four other studies also included individual supervision and care in some way. In fact, the results and conclusions in five of eight studies imply that exercise linked with individual contact may be the most powerful tool in promoting PA in NH residents. However, the studies do not clarify to which extent each intervention component leads to increases in PA. In the study not reporting any increase of PA, authors trace the absence of effect back to insufficient compliance of residents (Chin A Paw et al. 2006).

With respect to study quality ratings, it has to be acknowledged that all studies achieved at least half of the maximum score of 16. However, there were methodological weaknesses that may have influenced the evidence of intervention effects. A large variety of heterogeneous PA assessments were used, which impedes an overall interpretation of results. Additionally, psychometric quality of assessments was inappropriately addressed, as only three of the studies provided sufficient information on reliability and validity of PA measures. This might be due to the fact that high-quality PA assessments were either not available or not validated in this population at the time of publication. Hence, caution is in place when interpreting results of these measures.

Regarding objective technical measurement, studies using the most extensively validated uni-axial accelerometer “Actigraph” showed both supportive and non-supportive findings of interventions. This device has repeatedly been shown to significantly correlate with energy expenditure (EE; Plasqui and Westerterp 2007); however, depending on the kind of regression equations used to calculate EE, it has also been shown to underestimate the objective Metabolic Equivalent of Task (MET; Bassett et al. 2000). The same is also true for the Caltrac motion sensor that tends to underestimate EE in most types of activities except walking (Bassett et al. 2000). No detailed information could be found on the GMM activity monitor used by Fiatarone et al. (1994) as well as the device used by Schnelle et al. (2010), which was not named by the authors. Considering that the studies were published

Table 4 Methods of PA Assessment as Reported in Identified Studies: Objective Technical Assessment

Device	Author	Unit	Reliability	Validity
Actigraph	Chin A. Paw et al.	Counts	–	–
	Galik et al.		Test–retest: $r = 0.98$	$r = 0.35^*$ (sedentary activity) $r = 0.46^*$ (physical activities) $r = 0.71^*$ (heart rate) $r = 0.73^*$ (oxygen uptake)
	Lobo et al.		–	Source mentioned
	Schnelle et al. (1995)		–	–
Caltrac	Simmons and Schnelle	kcal/h	–	–
GMM activity monitor	Fiatarone et al.	Counts	–	–
Not specified	Schnelle et al. (2010)	–	$r = 0.67^+$	Previous work

+ Pearson correlation between two observers, * significant correlation

between 1995 and 2014, differences and weaknesses of objective technical PA measurements cannot be excluded even though motion sensors represent a rather recent method of PA assessment. This may also explain why most of these assessment tools have not been validated in NH residents, although the devices used were state of the art at the time of their application.

Observation and questionnaire-based data showed heterogeneous results and most methods lacked validity data. Moreover, they were not stated to be developed for and validated in cognitively impaired subjects, although these were included in most studies. The LASA Physical Activity Questionnaire used by Chin A Paw et al. (2006) was found to moderately correlate with a pedometer (Stel et al. 2004). The Nursing Home Life Space Diameter (NHLSD), used by Grönstedt et al. (2012), gives information on extent and frequency of mobility. According to its developers, it represents a simple assessment of mobility that holds potential to be an universal measure of activity level (Tinetti and Ginter 1990). Generally speaking, elaborated PA assessment methods are required to be

highly sensitive and unobtrusive, especially in NH residents. Hitherto, no standard on the assessment of PA has been established and too many different parameters aiming to describe PA are used. Objective technical PA assessments seem to be the method of choice given the problems associated with subjective assessments in cognitively impaired subjects.

Limitations

Several limitations of this review should be noted. The term “physical activity” is not easy to grasp, and although numerous relevant synonyms of the term had been used, some studies using different terms may have been overlooked. Thus our broad literature search may not have been able to identify all relevant studies. Additionally, null findings or inconsistent outcomes may not have been published (filedrawer problem), resulting in publication bias. The fact that only one study with main focus on a modification of PA behavior could be identified implies

Table 5 Methods of PA assessment as reported in identified studies: observation/questionnaire

Method	Study	Specification	Reliability	Validity	Standardization
Observation	Galik et al.	PAS-LTC	$r = 0.82\text{--}0.94^*$	$r = 0.55\text{--}0.60^+$	Yes
	Grönstedt et al.	NHLSD	Source mentioned	Source mentioned	Yes
	Simmons and Schnelle	1-min., time-sampled observations	–	–	Yes
	Schnelle et al. (1995)		–	–	Yes
Questionnaire/ Survey	Chin A. Paw et al.	LAPAQ	–	Source mentioned	Yes

NHLSD nursing home life-space diameter, LAPAQ LASA physical activity questionnaire

– no information provided in the paper; * inter-observer/inter-rater reliability as mentioned in the paper, + criterion-referenced validity based on bivariate correlations (with Actigraph)

that conclusions have to be drawn on outcomes that were not the main focus of the other studies. Moreover, as only one study included post-intervention follow-up measurement, the information on sustainability of effects was too limited to warrant any conclusions.

In general, studies showed large heterogeneity regarding type of interventions and methodology, particularly regarding PA assessment. Hence, it was not suitable to conduct a meta-analysis. It should also be mentioned that results on participation and engagement—which involve PA but are defined on a more general level of “activity”—were excluded from this review. Note in this context that our search also retrieved five Non-RCTs fulfilling all other inclusion criteria and several studies on sleep or rest activity rhythm. However, these studies addressed PA in terms of sleep patterns or rest activity rhythms instead of PA; i.e., the outcome measures they used did not exactly fit the inclusion criteria of this review. Therefore, these studies were excluded.

Conclusions

Positive effects of interventions on PA in NH residents were found. Thus, an implementation of interventions involving different forms of activities, exercise, and behavioral interventions seems feasible and valuable in the very frail NH population, regardless of cognitive status. Interventions including enhanced individualized contact may be the most powerful tool in eliciting remaining physical and motivational resources as well as in promoting PA in sedentary NH residents. Therefore, the inclusion of staff into the process of PA behavior modification may be very useful. With the exception of one study, results were derived from RCTs in which activity promotion was not the major focus. Therefore, we recommend concentrating on such a behavioral perspective in future studies.

Considering assessment tools, sufficient psychometric quality is indispensable. Moreover, a consensus on PA measurements is required to allow comparison of results, as of now there are various parameters used to describe PA. Technically advanced PA assessment devices have recently been developed to provide detailed objective and quantitative as well as qualitative analysis or even life space assessment, documenting location, and area of activities. Such assessments may also be used to gather longitudinal data in order to document the natural course of PA behavior in NH residents. This could help designing effective long-term interventions with the aim to promote PA in the NH setting.

Overall, results indicate a high potential of multi-component intervention programs to enhance PA in NH settings. Extensive individual contact and attention combined

with physical exercise and behavioral programs on the residents' part as well as the inclusion of nursing staff seem to be the most effective components of interventions aimed at PA modification.

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