A systematic review — physical activity in dementia: The influence of the nursing home environment

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ABSTRACT
Most older persons with dementia living in nursing homes spend their days without engaging in much physical activity. This study therefore looked at the influence that the environment has on their level of physical activity, by reviewing empirical studies that measured the effects of environmental stimuli on the physical activity of nursing home residents suffering from dementia. The electronic databases PubMed, PsycINFO, EMBASE, CINAHL and the Cochrane Library were used for the search. The search covered studies published between January 1993 and December 2012, and revealed 3187 abstracts. 326 studies were selected as potentially relevant; of these, 24 met all the inclusion criteria. Positive results on the residents’ level of physical activity were found for music, a homelike environment and functional modifications. Predominantly positive results were also found for the small-scale group living concepts. Mixed results were found for bright or timed light, the multisensory environment and differences in the building footprint.

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1. Introduction

The design of our physical living environment influences our performances by supporting our abilities (Lawton, 1974). Especially for older persons with dementia, who have cognitive, physical and sensory limitations, the physical environment potentially supports or hinders a satisfactory life (Cohen-Mansfield and Werner, 1998). Thus, understanding the influence of the environment on their behaviour is of utmost importance for the teams that design nursing homes and comprise of architects, interior designers, care professionals and policymakers. In the literature, these environments are referred to as, for example, “healing environments” (Dijkstra et al., 2006) or “therapeutically designed environments” (Day et al., 2000).

Many studies have investigated the health and behaviour-related effects of the nursing home environment on older persons with dementia (for reviews see: Day et al., 2000; Day and Calkins, 2002; Maslow and Ory, 2001; Calkins, 2009). The majority of these intervention studies aimed to moderate residents’ disruptive behaviours (e.g. wandering, agitation or aggression) by reducing the environmental stimuli (Mahoney et al., 2000). However, too little stimulation implies the stimulus deprivation of and little activity by older persons with dementia during the day (Cohen-Mansfield and Werner, 1998). Nearly half of the residents in nursing homes suffer from dementia-related diseases, for example, Alzheimer’s, vascular dementia or Huntington’s (Silverstein and Flaherty, 2003), and this group appears to be the least active: 90% of all nursing home residents with dementia suffer from passive behaviour (Kolanowski et al., 2005).

The research interest has shifted from limiting disruptive behaviours by reducing environmental stimuli, towards providing enriched environments that elicit positive behaviours (Calkins, 2009). Moreover, recent studies have shown that stimulating older persons with dementia might actually reduce disruptive behaviours (Volicer et al., 2006; Aman and Thomas, 2009). More specifically, the physical and mental activation of older persons suffering from dementia is important to prevent them from being...
bored, restless and apathetic (Morgan and Stewart, 1999; Lawton, 2001). In the literature, boredom and loneliness are associated with cognitive decline (Conroy et al., 2010; Wilson et al., 2007). There is also emerging evidence for the beneficial effects of physical activity on physical flexibility, coordination and strength (Warburton et al., 2006), as well as on cognitive functioning, especially of older persons with and without cognitive impairment (Colcombe and Kramer, 2003).

Considering the growing consensus about the beneficial effects of physical activity on cognition, physical health, behaviour and older persons’ mood, the goal of the present review was to address studies that measured the effects of environmental stimuli on the level of physical activity of older persons with dementia residing in a nursing home environment. Physical activity is defined as “any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase over resting energy expenditure” (Pate et al., 1995). The recommended amount of physical activity for older persons is described in Text box 1.

As all non-apathetic behaviour is desirable, and possibly contributes to meeting the ACSM/AHA recommendations (Nelson et al., 2007), several physical activity outcomes were included in this review, that is, performance on (i) ADLs, attending leisure activities, total amount of daily activity and reducing apathy.

2. Method

2.1. Search strategy

We performed literature searches in five electronic databases: PubMed, PsycINFO, EMBASE, CINAHL and the Cochrane Library. For the searches, we used the following four sets of search terms: (1) dementia, (2) physical environmental stimuli, (3) physical activity and (4) nursing home environment. The search terms included medical subject headings (MeSH) in PubMed and controlled terms (Emtree) in EMBASE, and both were combined with free text terms.

The first set of terms consisted of dementia [MesH], dementia and Alzheimer*. The set of terms related to physical environmental stimuli included homelike, design, colour, light, sound, music, visual, auditory, olfactory, building layout, outdoor, interior, ambient, grid and pattern. The search terms related to physical activity included motor activity [MesH:NoExp], activities of daily living [MesH], activity level, functional ability, mobility, rest-activity, self-maintenance, sedentary, walking and self-efficacy. The last set of terms included residential facilities [MesH], housing for the elderly [MesH], nursing home, SCU, assisted living, toilet, kitchen, resident room, activity area, wandering area and garden. The search covered studies published between January 1, 1993 and December 31, 2012. Upon request, the first author can provide the complete search strategy.

2.2. Inclusion criteria

Inclusion criteria for studies relevant for this review were: (1) studies that involved patients who were diagnosed with dementia; (2) studies that exclusively intervened with a physical element in the architectural building layout, interior design or ambience of the nursing home environment; (3) studies that reported on outcome measures assessing performance on (i) ADLs, attending leisure activities, total amount of daily physical activity and reducing apathy; (4) studies with a pre- and post-test, (quasi) experimental, cross-sectional design and randomized controlled trials (RCTs); and (5) studies written in English and published in a peer-reviewed journal between January 1, 1993 and December 31, 2012. Due to the comparative nature of a systematic review, environmental stimuli that were evaluated by only one study were not included in this review. The severity of the patients’ dementia was not a selection criterion, but it is reported in Tables 1–3 as follows: a Minimal Mental State Examination (MMSE) score of 20–27 is considered mild dementia, a score of 10–19 is considered moderate dementia and a score of 0–9 is considered severe dementia. Two researchers reviewed the abstracts independently to improve the objectivity and accuracy of evaluating the studies. The first author reviewed all of the abstracts, whereas two persons, for practical reasons, i.e. a PhD candidate and a senior researcher, have done the second review. Differences in opinion were discussed and in the case of doubt, the paper was selected as potentially relevant.

3. Results

3.1. Search results

The search revealed 3187 abstracts, of which 326 studies were selected as potentially relevant; of these, 24 met all the inclusion criteria. The structure of this review was based on the dimensions of the physical environment described by Harris et al. (2002): (1) ambient features (the least permanent features, such as music and lighting); (2) interior design features (the less permanent features of the building, such as the furnishings); and (3) architectural features (the relatively permanent features, such as the spatial layout of the building). Nine of the selected studies intervened with ambient features (see Table 1), seven with interior design features (see Table 2) and eight with architectural features (see Table 3). The first two authors reviewed the 24 selected papers on their study designs as classified by the NIMR evidence hierarchy (National Health and Medical Research Council, 2000) and appraised the methodological quality (Pluye et al., 2009). These results are presented in Tables 1–3.

3.2. Ambient features

3.2.1. Light

Six studies reported the effects of light on the residents’ activity levels. Two of these studies intervened with extra bright light (Riemersma-van der Lek et al., 2008; Shochat et al., 2000) and four with timed light, that is, bright light in the morning and dim light in...
# Table 1
Ambient features.

<table>
<thead>
<tr>
<th>First author, year</th>
<th>Study type, N</th>
<th>NHMRC evidence hierarchy</th>
<th>Estimated methodological quality (%)</th>
<th>Control group Y/N, placebo</th>
<th>Severity of dementia d</th>
<th>Setting</th>
<th>Intervention</th>
<th>Type of outcome</th>
<th>Measuring method(s)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light</strong></td>
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<tr>
<td>Bright light</td>
<td>RCT, 189 II</td>
<td>100</td>
<td>Y, (1) light (2) melatonin</td>
<td>2</td>
<td>AL</td>
<td></td>
<td>Four groups: whole day bright (±1000 lux) or dim (±300 lux) light combined with or without extra melatonin intake</td>
<td>Physical activity, Actigraphy, ADL</td>
<td>NI-ADL</td>
<td>Increase of 1.8 points/yr (95% CI, 0.61–2.92; P = .003) on NI-ADL</td>
</tr>
<tr>
<td>Riemersma-van der Lek et al. (2008)</td>
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<tr>
<td><strong>Timed light</strong></td>
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<tr>
<td>Ancoli-Israel et al. (2002)</td>
<td>RCT, 77 II</td>
<td>67</td>
<td>Y, dim light</td>
<td>2</td>
<td>NH</td>
<td></td>
<td>2 h evening bright light, 2 h evening dim light, or daytime sleep restriction; for 18 days</td>
<td>Physical activity, Actilume</td>
<td></td>
<td>Morning bright light delayed peak of activity rhythm and improved mean activity level</td>
</tr>
<tr>
<td>Ancoli-Israel et al. (2003)</td>
<td>RCT, 93 II</td>
<td>67</td>
<td>Y, dim light</td>
<td>3</td>
<td>NH</td>
<td></td>
<td>Morning bright light, morning dim red light or evening bright light</td>
<td>Physical activity, Actilume</td>
<td></td>
<td>No improvements in mean activity levels</td>
</tr>
<tr>
<td>Dowling et al. (2005)</td>
<td>RCT, 70 II</td>
<td>33</td>
<td>Y, usual indoor light</td>
<td>3</td>
<td>L-TC</td>
<td></td>
<td>Morning or afternoon 1 h bright light (≥2500 lux), non-fri for 10 wks</td>
<td>Physical activity, Actigraphy</td>
<td>Apathy</td>
<td>No improvements in mean activity levels</td>
</tr>
<tr>
<td>Dowling et al. (2007)</td>
<td>RCT, 70 II</td>
<td>33</td>
<td>Y, usual indoor light</td>
<td>3</td>
<td>L-TC</td>
<td></td>
<td>Morning bright light or afternoon bright light</td>
<td>Physical activity, Actigraphy</td>
<td>Apathy</td>
<td>No significant improvements on apathy scores</td>
</tr>
<tr>
<td><strong>Music</strong></td>
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<tr>
<td>Holmes et al. (2006)</td>
<td>Pseudorandomised controlled trial, 32 III-1</td>
<td>67</td>
<td>Y, silence</td>
<td>2</td>
<td>RC, NH</td>
<td></td>
<td>Sequence of live music, recorded music, silence periods of 30 min each, presented randomized</td>
<td>Activity engagement</td>
<td>DCM</td>
<td>Engagement improved compared to baseline (12.5%) sig. to life music (69%) and positive but not sig. to recorded music (25%)</td>
</tr>
<tr>
<td>Gotell et al. (2008)</td>
<td>Non-randomised experimental study, 9 III-2</td>
<td>83</td>
<td>Y, usual care</td>
<td>3</td>
<td>NH</td>
<td></td>
<td>Two experimental groups: caregiver singing and background music</td>
<td>Activity engagement</td>
<td>Observation</td>
<td>Improved sense of vitality</td>
</tr>
<tr>
<td>Sixsmith and Gibson (2007)</td>
<td>Case series, 26 IV</td>
<td>83</td>
<td>N, u</td>
<td></td>
<td>Independent, RC</td>
<td></td>
<td>No intervention</td>
<td>Activity engagement</td>
<td>Observation</td>
<td>Improved participation in activities that are stimulating and personally meaningful</td>
</tr>
</tbody>
</table>

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* NHMRC (2000).
* Pluye et al. (2009).
* 0 — healthy, 1 — mild, 2 — moderate, 3 — severe, and u — unspecified.
* RC — residential care, AC — assisted living, NH — nursing home, and L-TC — long-term care.
* Nurse-informant adaptation.
* Wrist mounted monitor which records both illumination and activity data.
* Neuropsychiatric inventory-nursing home version.
* Dementia care mapping.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Study type, N</th>
<th>NHMRC evidence hierarchy</th>
<th>Estimated methodological quality (%)</th>
<th>Control group Y/N, placebo</th>
<th>Setting</th>
<th>Intervention</th>
<th>Type of outcome</th>
<th>Measuring method(s)</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td><strong>Homelike environment</strong></td>
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<tr>
<td>Cioffi et al. (2007)</td>
<td>Pre-test/post-test, 35/36</td>
<td>IV</td>
<td>83</td>
<td>N</td>
<td>u</td>
<td>SCU</td>
<td>Dining room adjoined to kitchen, family pictures, decorating private room, unrestricted garden use, large windows, and multisensory room</td>
<td>ADL, Physical activity</td>
<td>Focus groups</td>
</tr>
<tr>
<td><strong>Multisensory environment</strong></td>
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</tr>
<tr>
<td>van Weert et al. (2005)</td>
<td>Pseudorandomised controlled trial, 61</td>
<td>III-1</td>
<td>67</td>
<td>Y, usual care</td>
<td>2,3</td>
<td>NH</td>
<td>Individual 24 h snoezel program, based on family history and stimulus preference. Caregivers were trained.</td>
<td>Apathy</td>
<td>INTERACT</td>
</tr>
<tr>
<td>Milev et al. (2008)</td>
<td>RCT, 21</td>
<td>II</td>
<td>100</td>
<td>Y, no treatment</td>
<td>3</td>
<td>LT-C</td>
<td>Two experimental groups; (1) 1× snoezelen/wk, (2) 3× snoezelen/wk</td>
<td>Apathy</td>
<td>DOS</td>
</tr>
<tr>
<td>Baker et al. (2001)</td>
<td>RCT, 50</td>
<td>II</td>
<td>67</td>
<td>Y, Activity group</td>
<td>2,3</td>
<td>Day care</td>
<td>Eight 30-min. sessions over a 4-wk period</td>
<td>Apathy</td>
<td>INTERACT</td>
</tr>
<tr>
<td><strong>Functional modifications</strong></td>
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<tr>
<td>Connell et al. (2002)</td>
<td>Case series, 5</td>
<td>IV</td>
<td>67</td>
<td>N</td>
<td>1,2</td>
<td>NH</td>
<td>Pictures, magnified mirrors, coloured cups, consistent layout to support performance of oral care</td>
<td>ADL</td>
<td>AAI, Observation</td>
</tr>
<tr>
<td>Chard et al. (2009)</td>
<td>Case series, 6</td>
<td>IV</td>
<td>67</td>
<td>N</td>
<td>Unspecified</td>
<td>AL</td>
<td>Labelling of drawers and closet doors, visible workstations, providing ADL equipment, removing distractions</td>
<td>ADL</td>
<td>AMPS</td>
</tr>
</tbody>
</table>

a: NHMRC (2000).
b: Pluye et al. (2009).
c: 0 = healthy, 1 = mild, 2 = moderate, 3 = severe, and u = unspecified.
d: RC = residential care, AC = assisted living, NH = nursing home, and L-TC = long-term care.
e: Assessment tool for occupation and social engagement, daily observation scale, abilities assessment inventory, and assessment of motor and process skills.
3.2.1. Bright light. One of the two interventions with bright light used a melatonin prescription (Riemersma-van der Lek et al., 2008); for this review, we looked at the control group that was exposed to bright light only. Both intervention studies reported positive results of bright light, but differed in duration and outcome measures. A 15-month RCT (Riemersma-van der Lek et al., 2008) showed that exposure to bright light slowed down the decline in ADLs (activities of daily living) performance by 53% compared to residents exposed to dim light. During a cross-sectional study (Shochat et al., 2000), both the illumination and the activity levels were measured throughout the day. Although some influence was found, the results were less convincing. No overall improved physical activity was measured, but the study did show that the peak in light levels preceded the peak in activity levels. The authors suggest two explanations for this: the alerting effects of bright light enhanced the residents' activity, whereas the circadian rhythms of sitting outside followed by afternoon activities caused the positive relation (Shochat et al., 2000). Both studies conclude by suggesting that nursing homes should provide bright light throughout the day, and stating that this will have no long-term adverse effects.

3.2.2. Timed light. The effects of timed light on physical activity were reported in four studies. Two studies, both RCTs (Ancoli-Israel et al., 2002, 2003) with a similar setup, showed different results in the residents’ mean activity levels. The authors suggested that the residents’ MMSE score of 5.7 in the earlier study compared to the mean MMSE score of 12.8 in the later study, might be related to the absence of significant improvements in the first study (Ancoli-Israel et al., 2002). In line with this suggestion, two more RCT studies did not show significant improvements of timed light on mean activity levels (Dowling et al., 2005) or apathetic behaviour (Dowling et al., 2007) of residents in a severe stage of dementia. These results are not surprising: the severe impairment in patients’ cognition could explain the lack of effect of bright light on physical activity.

3.2.3. Music

Three studies evaluated the effects of background and live music on the residents’ level of physical activity and apathetic behaviour (Holmes et al., 2006; Göttel et al., 2008; Sixsmith and Gibson, 2007). During an RCT, 30-min periods of either live or background music, or silent periods were randomly presented to subjects with moderate to severe dementia to reduce apathy (Holmes et al., 2006). During both musical periods, the subjects’ engagement in a creative activity improved, but not significantly, whereas the results were the most promising for live music, during which the engagement improved significantly. Specific information about the nature of the creative activity was lacking. In line with these results, interviews with older persons with dementia revealed their appreciation for music and music-related activities in everyday life (Sixsmith and Gibson, 2007). According to the residents, music enables them to participate in enjoyable activities that are personally meaningful and support their ADLs (Sixsmith and Gibson, 2007). Music also appeared to contribute to the interaction between persons with dementia and the caregivers during morning care sessions in a quasi-experimental study (Göttel et al., 2008). More specifically, background music or singing by the caregiver seemed to improve the residents’ ADLs, and their interaction was characterized by the carers as “mutual vitality infused by playfulness” (Göttel et al., 2008).

3.3. Interior design features

3.3.1. Homelike environment

Two studies evaluated residents’ self-initiated activities and their attendance of group activities after implementing a homelike interior design (Morgan-Brown et al., 2012; Cioffi et al., 2007). Studies that combined a homelike atmosphere with reducing the facility’s scale are discussed in Section 3.4.1. The two studies discussed here did not change the size of the facilities, which accommodated 18 residents (Morgan-Brown et al., 2012) and 21 residents (Cioffi et al., 2007), respectively. A qualitative study evaluated the redesigned facility, which now offers residents private rooms, bathrooms, the freedom to decorate, better garden access and layout, big windows and a multisensory room (Cioffi et al., 2007). The results of focus groups with staff and relatives revealed their appreciation of the environmental changes (both the staff and the relatives had also experienced the old units). Relatives and staff mentioned the unrestricted nature of the new facility and the ability to freely engage in activities. Unfortunately, possible changes in the residents' activity adherence were not measured (Cioffi et al., 2007). The second study also reported improvements in residents’ activity adherence after the conversion of a traditional nursing home into a more homelike environment (Morgan-Brown et al., 2012). The new design encouraged spontaneous interactions and self-initiated activities; both quantitative measures almost doubled. The residents spent more time in the communal areas, where they were more socially engaged, more interactive with their environment and did more activities for themselves.

3.3.2. Multisensory environment

Most intervention studies with a multisensory environment (MSE) measured its influence on the residents’ agitated behaviour, whereas in this review we included only those studies that also reported on the level of physical activity or ADLs. Three studies reported on the effects of the MSE or ‘Snoezelen’ on the levels, or lack of physical activity of nursing home residents (van Weert et al., 2005; Milev et al., 2008; Baker et al., 2001). The MSE combines interior design features with ambient features to create a multisensory experience (Chung and Lai, 2009). Because these MSE rooms are placed permanently within the nursing home environment, we considered them an interior design concept. An RCT study among 50 patients who were diagnosed with moderate to severe dementia, compared a multisensory stimulation group (MSS group) with a control group that participated in puzzle activities (Baker et al., 2001). Both groups improved on the outcome measures related to physical activity: initiating more activities, enjoying themselves, more active or alert, and less bored. However, the MSS group did not show significantly more improvements than the control group. In addition, no long-term effects were found: the improvements declined sharply during the one-month follow-up period. More promising results were found in another RCT study with 18 patients with severe dementia observed on either active or passive behaviour during a 24-week Snoezelen programme (Milev et al., 2008). Two treatment groups showed significant improvements in apathetic behaviour compared to the control group; they also showed more improvement when they were given three sessions per week rather than only one. The positive effects lasted for 12 additional weeks after cessation of the multisensory treatment sessions. More positive effects on apathetic behaviour were found during a pre- and post-test quasi-experimental study among 61 patients with moderate to severe dementia (van Weert et al., 2005).
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Study type, N</th>
<th>NHMRC evidence hierarchy(^a)</th>
<th>Estimated methodological quality(^b) (%)</th>
<th>Control group Y/N, placebo</th>
<th>Severity of dementia(^c)</th>
<th>Setting(^d)</th>
<th>Intervention</th>
<th>Type of outcome</th>
<th>Measuring method(s)</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>Small-scale/group living concepts</td>
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<tr>
<td>Warren et al. (2001)</td>
<td>Two single arm, 54</td>
<td>III-3</td>
<td>100</td>
<td>Y, RC ((N = 36))</td>
<td>u</td>
<td>RC, SCU</td>
<td>Designed cluster environment (E-shape). Staff: emphasis on ADL and freedom, no physical restraints</td>
<td>ADL</td>
<td>FIM + FAM(^e)</td>
<td>The functional decline over time did not differ. Scores on independence/choice was sig. higher for RC. RC residents were more active than SCU residents.</td>
</tr>
<tr>
<td>Verbeek et al. (2010)</td>
<td>Non-randomised experimental trial, 124</td>
<td>III-2</td>
<td>67</td>
<td>Y, NH</td>
<td>2</td>
<td>Small-scale living facility</td>
<td>Six to eight residents, homelike character, emphasis on family situation, in group, staff is part of household, bottom-up influence</td>
<td>Apathy, ADL</td>
<td>NPI-NH</td>
<td></td>
</tr>
<tr>
<td>Schwarz et al. (2004)</td>
<td>Pre-test/post-test, unspecified</td>
<td>IV</td>
<td>67</td>
<td>N</td>
<td>u</td>
<td>Dementia care unit</td>
<td>Decentralized dining, bathing for smaller groups. Improved ambiance</td>
<td>Physical activity</td>
<td>Behavioural Mapping</td>
<td>More involvement in programmed activities, but did not meet the expectations. Sig. Improvements in something to do at the Dutch facility, not sig., but positive results for the Belgium facility. More involvement in overall and preferred activities.</td>
</tr>
<tr>
<td>De Rooij et al. (2012)</td>
<td>Pseudorandomised controlled trial, 179</td>
<td>III-1</td>
<td>100</td>
<td>Y, NH</td>
<td>3</td>
<td>Small-scale living facility</td>
<td>Small-scale group living concepts (not specified) in both The Netherlands and Belgium</td>
<td>Activity Engagement</td>
<td>QUALIDEM</td>
<td></td>
</tr>
<tr>
<td>Smit et al. (2012)</td>
<td>Pseudorandomised controlled trial, 1327</td>
<td>III-1</td>
<td>100</td>
<td>Y, NH</td>
<td>u</td>
<td>Small-scale living facility</td>
<td>Small-scale with: (1) living rooms with homelike atmosphere, (2) dinner is prepared in group-kitchen, (3) housekeeping is done by the staff, (4) freedom when to go out of bed</td>
<td>Activity engagement</td>
<td>Activity pursuit patterns from the RAI-MDS</td>
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<td>Building footprint</td>
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<tr>
<td>Zuidema et al. (2010)</td>
<td>Cross-sectional, unspecified</td>
<td>IV</td>
<td>100</td>
<td>N</td>
<td>2,3</td>
<td>NH</td>
<td>Walking circuit, number of patients/unit or living room (and staff/patient ratio and hours spent on direct care)</td>
<td>Apathy</td>
<td>NPI-NH</td>
<td>No changes in any of the NPI outcomes. Only apathy occurred less frequently when nurses spent more time on patient care.</td>
</tr>
<tr>
<td>Milke et al. (2009)</td>
<td>Five single arm, unspecified</td>
<td>III-3</td>
<td>83</td>
<td>N</td>
<td>2</td>
<td>RC</td>
<td>Five homes, based on Woodside Place; differences in physical environment were measured with the TESS-2(^i)</td>
<td>Physical activity, ADL</td>
<td>Activity behaviour mapping</td>
<td>The differences in activity patterns were large and enduring. Between the sites, significant differences were found in the activities: ADLs, walking, and work.</td>
</tr>
</tbody>
</table>
The Snoezelen group showed less apathetic behaviour compared to the control group, which received the usual nursing home care.

3.3.3. Functional modifications

Two studies, both with a quasi-experimental design, investigated the effects of an environment that was modified to meet personal needs in order to support the residents’ ability to perform ADLs (Connell et al., 2002; Chard et al., 2009). In both studies, the intervention was a combination of environmental modifications and verbal cueing by the caregivers. In one study, five nursing home residents with dementia were helped to perform oral care independently (Connell et al., 2002). The environmental modifications were adjusted to the personal limitations of each of the five residents. The modifications included the provision of informative pictures, and the use of colour and contrast to improve concentration on the task. Four of the five residents showed improved independence on oral care tasks. In the second study, the emphasis of the intervention was on verbal cueing, supported by environmental modifications to improve residents’ ADLs (Chard et al., 2009). The environmental modifications included the labelling of drawers and closet doors, workstations with visible items, providing ADL equipment and removing distractions. The interventions improved significantly the ADL process abilities (i.e. time management) of all five participants; in two participants, ADL motor abilities (i.e. pick up and hold objects) also improved.

3.4. Architectural features

3.4.1. Small-scale group living concepts

An emerging trend is the replacement of traditional large nursing homes, which typically have 100–120 beds, with small-scale living environments. Although there is not yet a consensus on the ideal number of residents for a small-scale living cluster, the range is often 6–12 residents (Regnier and Denton, 2009; Warren et al., 2001; Schwarz et al., 2004). Besides the restricted number of residents per group, the selected studies also reported on a more homelike atmosphere in which residents can personally decorate their private rooms, communal household facilities and activities, and trained staff who provide resident-centred care. Five studies investigated the effects of small-scale living concepts on ADLs or involvement in other activities (Verbeek et al., 2010; Warren et al., 2001; Schwarz et al., 2004; De Rooij et al., 2012; Smit et al., 2012).

A longitudinal quasi-experiment (Verbeek et al., 2010) found that residing in an 8-person small-scale living concept did not reduce apathetic behaviour compared to living in the traditional larger wards. However, two studies that reported on the effects of 12-person living concepts revealed more promising results (Warren et al., 2001; Schwarz et al., 2004). A quasi-experimental study compared a 12-person with a 6-person concept. The residents did not differ in functional decline, but were more active in the 12-person setting compared to that of 6 persons. Although the total number of falls was higher in the smaller setting, the number of falls with injuries was higher, but not significantly so, in the larger setting.

A pre-and post-test designed study evaluated the effects of modified facilities on quantitative and qualitative measures of residents’ behaviour (Schwarz et al., 2004). Two floors of the facility were divided into three groups of 10–12 residents with a kitchen, dining area and living room. Place-centred behaviour mapping showed improved involvement in group activities, probably due to the easily accessible activity areas. The authors did not describe the programmed activities. The lack of consensus on the ideal number of members of a small-scale living group might be explained by the influences of also the environmental design, staff skills and institutional organization on residents’ behaviour.
Two more recent studies selected the small-scale living concept not on the number of residents, but on the group living characteristics as discussed above. A quasi-experiment measured the residents’ quality of life (QoL) with ‘something to do’ as one of the parameters (De Rooij et al., 2012). In this study, a Dutch and a Belgian facility were evaluated, and significant improvements in ‘something to do’ were found for the Dutch facility. The effects in the Belgian facility were not significant, as was the case for the long-lasting effects for both facilities. More promising results were found in a comprehensive cross-sectional study that included 136 long-term care facilities, accommodating a total of 1327 older persons suffering from dementia, in the Netherlands (Smit et al., 2012). This study showed that residents living in facilities with more characteristics of group living were more involved in overall and preferred activities. More specifically, the activities that were attended significantly more in the group living facilities were task-related activities, outdoor activities, leisure activities, physical exercise and interaction with others.

3.4.2. Building footprint

Three studies addressed the effects of the spatial layout of nursing homes on the residents’ level of physical activity (Milke et al., 2009; Zuidema et al., 2010; McAllister and Silverman, 1999). In these studies, the investigators changed the building footprint according to the architectural model of Woodside Place (DiMotta et al., 1993), or in a similar manner. Typical of this architectural design are several 12-resident clusters with an open floor plan to invite residents to walk around the entire facility without getting lost. One study that compared this clustered building footprint with a traditional nursing home showed promising results (McAllister and Silverman, 1999). Although they did not mention the Woodside Place building model, the building floor plan that was evaluated in this cross-sectional study was comparable. By observing the residents’ activity patterns, they found higher participation in ADLs.

Two studies that compared several of these clustered building footprints reported remarkably contradictory results; whereas one concluded that small differences in designs could have large and long-term effects on residents’ behaviour (Milke et al., 2009), the second study observed no effects on residents’ behaviour of large differences in floor plans (Zuidema et al., 2010). It is difficult to explain these contradictory results. The first study compared residents’ day-long activity patterns in five nursing homes, all built according to the Woodside Place model, but with small differences in specific design characteristics (Milke et al., 2009). The overall physical activity levels were surprisingly high compared to former studies (Ice, 2002; Bates-Jensen et al., 2004), and significant differences across the nursing homes were found in ADLs and walking (Milke et al., 2009). However, the causal relationship between specific design characteristics and the improved physical activity remains unclear. With a cross-sectional cohort study, the effects of several environmental differences between 56 SCUs were evaluated on the residents’ apathetic behaviour (Zuidema et al., 2010). Neither the presence of a walking circuit nor the number of residents correlated with apathy.

4. Conclusions

- Due to the limited number of studies that scored high on the NHMRC evidence hierarchy (National Health and Medical Research Council, 2000), we also included studies with less rigorous study designs. However, almost all studies scored relatively high on the quality assessment for mixed methods reviews by Pluye et al. (2009).

- Studies on the effects of timed bright light, and MSE on the levels of physical activity had the most rigorous study designs according to the NHMRC hierarchy (National Health and Medical Research Council, 2000), but the methodological quality differed, from 33% to 100% on the quality assessment of Pluye et al. (2009). The studies of music and small-scale living concepts covered almost all levels of the NHMRC evidence hierarchy, but scored overall high on methodological quality, from 67% to 100%. The two studies with whole-day bright light differed strongly in scientific rigor, i.e. a cross-sectional and RCT study, but both scored well on methodological quality, namely 67% and 100%. Studies that evaluated building footprint, functional modifications and the homelike environment scored in the lowest two levels of the NHMRC evidence hierarchy, whereas all studies scored relatively high on methodological quality, i.e. from 67% to 100%.

- The number of patients included in the studies varied strongly amongst the environmental elements. The qualitative studies that evaluated functional modifications included rather low numbers of residents ($N_{total} =$ 11). Higher numbers of participants can be found for elements that are evaluated with both quantitative and qualitative studies: building footprint ($N_{total} =$ 93; two studies that did not specify the number of participants), homelike environment ($N_{total} =$ 54), and music ($N_{total} =$ 67). The highest numbers of participants can be found with the elements that were (predominately) evaluated quantitatively: timed ($N_{total} =$ 310) and all day bright light ($N_{total} =$ 257), multisensory environment ($N_{total} =$ 132), and small-scale living environments ($N_{total} =$ 1684; one study did not specify the number of participants).

- As the search strategy shows, we search the databases on more environmental elements than are evaluated in this review. Physical elements of the nursing home environment that we searched but that were not studied (sufficiently) on its effect on physical activity are: colour, sound and noise (other than music), way finding and spatial orientation, visual and tactual stimuli, smell and fragrance, furnishing, outdoor and gardens, decoration and patterns. Future studies to the effects of these elements on the residents’ level of physical activity would provide useful knowledge to make the nursing home environment more stimulating.

- It is remarkable that the known positive effects of timed bright light on, for example, physical activity have not resulted in improved lighting in nursing homes: the illumination levels in today’s nursing homes are often low (Lepeleire et al., 2007). The studies that evaluated the MSE and small-scale living concepts also showed predominantly positive influences on the residents’ level of physical activity; we therefore recommend adapting these concepts to the nursing home environment.

- We should consider the results for music with caution, as the studies differed strongly in scientific rigor. However, as the results were unanimously positive, including background, or preferably live music in the daily care for residents might be advisable for physical activation.

- Because of the lack of evidence for the influence of the homelike environment, functional modifications and the building footprint on the residents’ level of physical activity, we cannot provide design guidelines for these environmental characteristics.

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