

Effects of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers: a systematic review

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Executive summary

Background

A range of studies found that spending time outdoors in daylight provided substantial benefits for the psychosocial well-being of older people. Good psychosocial well-being is essential in maintaining overall health as people age and often contributes to adequate physical functioning.

Objectives

The overall objective of this study was to undertake a systematic review on the effects of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers.

Inclusion criteria

Types of participants

This review considered studies that included older people aged 55 years or more, including those living in a community or residential accommodation setting. In addition, this review considered family carers, who were defined as unpaid relatives or friends of an older person, who helped that individual with their activities of daily living.

Types of intervention(s)

The intervention of interest was spending time outdoors in daylight.

Types of studies

All experimental and epidemiological study designs including randomized controlled trials and non-randomized controlled trials published in the English language were included in this review.

Types of outcomes

This review considered studies that included objective and/or subjective measures of psychosocial well-being for older people and their family carers.

Search strategy

The search aimed to find published and unpublished studies through electronic databases, reference lists, key reports and the World Wide Web. An extensive search was undertaken for the following databases: MEDLINE, CINAHL, Wiley Online Library, ProQuest Central, Scopus, and the Cochrane Library. Databases were searched up to December 2013.

Methodological quality

Methodological quality was assessed independently by three reviewers using the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) checklists. Disagreements that arose between the reviewers were resolved through discussion.

Data collection

Quantitative data were extracted from papers included in the review using the standardized data extraction tool from JBI-MAStARI. The data was individually extracted by two reviewers. Disagreements that arose between the reviewers were resolved through discussion. All results were subject to double data entry.

Data synthesis

For this review statistical pooling of the data was not possible due to the heterogeneity of the studies; therefore, the findings are presented in narrative form.

Results

A total of 13 studies were included in the final review. In the four studies that evaluated the effects of exposure to daylight on behavioral disturbances, there was no evidence of effect of daylight hours on physical and verbal aggression. There was some evidence to indicate that exposure to daylight for a period of time resulted in fewer depressive symptoms. Increasing the frequency of going outdoors was associated with better cognitive preservation over a one year period. Similarly exposure to daylight resulted in improved social functioning and improved quality of life. There were no studies that evaluated the effect of spending time outdoors in daylight on the psychosocial well-being of family carers, including carer satisfaction or carer stress.

Conclusions

There is insufficient high-quality evidence from which conclusions can be drawn for the effect of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers. More robust research is required to evaluate the effectiveness of interventions to improve time spent outdoors in daylight for older people and their family carers.

Implications for practice

There is some evidence to support the effects of exposure to daylight on mood, cognition and social functioning levels. With only small changes in routines for nursing staff there is potential for exposure to sunlight to have a significant impact on psychosocial well-being for older adults living in residential accommodation.

Implications for research

Future studies should be undertaken using more rigorous research designs, such as randomized controlled trials with sufficiently powered sample sizes. A focus on accurately measuring time spent outdoors in daylight should be a priority. Additionally, by investigating a comprehensive range of psychosocial outcomes with validated tools, researchers could more accurately deduce the effect of spending time outdoors on the psychosocial well-being of older people and family carers.

Keywords

aged, elderly, older adult, sunlight, daylight, behaviour, cognition, quality of life, satisfaction, well-being, psychosocial

Background

A range of studies has found that spending time outdoors in daylight provides substantial benefits for the psychosocial well-being of older people. Good psychosocial well-being is essential in maintaining overall health as people age and often contributes to adequate physical functioning.¹ Psychosocial well-being encompasses behavioral disturbances, cognition, mood, quality of life (QoL), self-rated health, social interaction and satisfaction of service provision if a person is living in a residential aged care facility (RACF). Spending time outdoors in daylight is often difficult for older people as a result of increasing frailty, environmental barriers and poor health. Psychological limitations include a fear of falling or skin cancer.² Therefore, the ability of older people to be outdoors is lessened and research commonly reports that older people do not spend enough time outdoors in the daylight.^{3,4}

In research to date, there is an over-reliance on the use of electric “bright light” phototherapy. However, some research shows that natural daylight is more beneficial to human health than artificial light as it is generally stronger and brighter.⁵ In addition, spending time outdoors in the daylight includes exposure to a range of other natural elements such as fresh air and green space. These factors are linked to additional benefits across a range of clinical and psychosocial outcomes, when compared to general light exposure.^{6,7} The psychosocial benefits of spending time outdoors extends to participating in socially-related activities, whereby studies have associated the use of outdoor natural spaces, such as parks with improved social networks among the older community.^{8,9}

It has been established that a well-designed outdoor built environment is fundamental in promoting active and independent lives for older people. However, the philosophy of “build it and they will come” has not proved successful in getting older people to spend adequate time outdoors in the daylight. An Australian study demonstrated that despite a large majority of older people understanding that getting outdoors in the daylight can provide health benefits, more than a third of respondents preferred to partake in indoors activities.²

Behavioral disturbances encompass a range of symptoms such as agitation, wandering, sundowning and nocturnal delirium.¹⁰ Behavioral disturbances are generally associated with older adults living with a dementia related disease. For older people living with dementia, increasing the amount of time spent outdoors in daylight is associated with lessened behavioral disturbances.¹¹⁻¹³ These outcomes were associated with the ability of daylight to regulate the body’s circadian rhythm.¹⁴

Older people with cognitive impairment are likely to spend less time outdoors in daylight. Research showed that older people who have few reasons to spend time outdoors show a more rapid decrease in cognitive function over time.¹⁵ Additionally, research suggests that time spent outdoors in the daylight can predict better cognitive outcomes in older people.¹⁵⁻¹⁷ These results were related to improvements in vitamin D status¹⁷ and social factors. Spending time outdoors in green space provided a restorative effect on cognition, including concentration.¹⁸

Reduced levels of daylight are consistently linked to depressive symptoms in a phenomenon called seasonality.¹⁹ However, research surrounding seasonality has largely overlooked older adults and has resulted in inconsistent findings. Increased light exposure, including spending time outdoors in daylight, is related to improved mood in older adults.²⁰ Outdoor exercise programs in older adults have shown positive beneficial effects on mood, even after controlling for exercise, indicating that being outdoors provides beneficial factors beyond physical activity.²¹ Elevation in mood was associated with a favorable effect on perceived well-being in older people. Some researchers found no association between daylight and mood, and argued that others overestimated the impact of seasonality.¹⁹

Most of us, including older people, would agree that spending time outdoors in daylight is enjoyable and improves our psychosocial well-being. While the definition of QoL is contentious, essentially it is a multi-layered concept that involves objectively measuring health and physical functioning, and subjectively measuring satisfaction with life.²² Correlations between light exposure and QoL have been documented qualitatively²³ and quantitatively.²⁰ Older people who perceive barriers in the outdoor environment were shown to have a lower QoL.²⁴

Outdoor activities improved self-rated health in older people. Self-rated health can be measured as an outcome using valid and reliable tools. This area of research was limited with the available findings indicating that outdoor activities did not statistically significantly improve self-rated health.²⁵ A study that assessed the effects of a natural green space on self-rated health in residential accommodation outlined the main hindrances related to spending time outdoors, including a lack of assistance and uncomfortable weather conditions.²⁶ It was concluded that increasing the accessibility and attractiveness of the outdoor area could result in more frequent outdoor use and consequently improved self-rated health.²⁶

The opportunities for older people to spend time outdoors in daylight were more severely limited when they lived in residential accommodation.²⁷ This could be a consequence of an individual's physical inability or a lack of outdoor areas conducive to spending time outdoors in daylight.²⁸ Therefore residential accommodation services should provide an individualized care approach to focus on the unique needs of individuals, including the ability of their living environment to provide for their tailored needs.

Spending time outdoors in daylight provided an opportunity for social interaction for older adults. While it was argued that social interaction could happen anywhere, outdoor spaces were associated with the formation of greater social networks among a community.⁸ Social interaction is an imperative component of the lives of older people and is associated with overall health and functional status.²⁹ Performing physical activity in outdoor locations provided psychosocial benefits from social interactions and a greater commitment to the activity being performed. A recent report released by National Seniors Productive Ageing Centre (2013) showed that in a one-month period only 25% of older Australian adults engaged in outdoor social activities with friends and only 15% of respondents participated in outdoor social activities with family members. These figures are particularly low, especially considering that almost 73% of respondents agreed that they socialized as much as they desired.

A large body of literature found that providing care to an older person is a very stressful experience for a family carer^{30,31} with an overall impact on many factors. A meta-analysis has associated caregiver burden with physical and psychological health outcomes³¹ where it was determined that if a care receiver had poorer physical health and greater behavioral disturbances, the burden experienced by a carer was significantly greater. A review of the effects of spending time outdoors in daylight on the psychosocial well-being of older people and family carers has national and international relevancy as it is a phenomenon without geographical boundaries. Currently no reviews exist on this topic; therefore the purpose of this study was to present all the available evidence relating to the effects of spending time outdoors in daylight on the psychosocial well-being of older adults and family carers.

Objectives

The overall objective of this study was to undertake a systematic review of the effects of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers. The specific question addressed was: What is the effect of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers?

Inclusion criteria

Types of participants

This review considered studies that included all older people aged 55 years or more, including those living in a community or residential accommodation setting. The age of 55 or more was selected as the age range criterion to ensure all relevant literature was located as studies used different definitions to describe the age range of older adults in their sample. No other specific criteria were applied when searching the literature. The review considered family carers to be unpaid relatives or friends caring for an older person and who help with activities of daily living.

Types of intervention(s)

The intervention of interest was spending time outdoors in daylight. "Outdoors in daylight" is a broad term that encompasses all outdoor environments where participants are exposed to daylight in a natural setting while participating in any type of outdoor activity. For this review, the definition of outdoor activity is simply "being outdoors" in order to capture all types of engagement with outdoor environments. The comparisons made were:

- Outdoor activity compared to indoor activity with no exposure to daylight
- Being outdoors compared to not being outdoors.

Studies were excluded if they utilized artificial "bright" light sources, or modified the indoor environment to improve light exposure. No other criteria were applied to locate relevant studies.

Types of studies

This systematic review considered experimental and epidemiological study designs including randomized controlled trials (RCTs), non-randomized controlled trials, quasi-experimental, before and after studies, prospective and retrospective cohort studies, case control studies and analytical cross sectional studies for inclusion. Studies published only in the English language were included in this review.

Types of outcomes

This review considered studies that included objective and/or subjective measures of the following outcomes:

For older people:

- psychosocial well-being:
 - behavioral disturbances
 - cognition
 - mood levels
 - quality of life
 - satisfaction with service provision
 - social interaction.

For family carers:

- carer satisfaction
- carer stress.

Search strategy

The search aimed to find published and unpublished studies through electronic databases, reference lists, key reports and the World Wide Web. A three-step search strategy was utilized in this review. Initial key terms were developed using MeSH terms in four broad search categories (**Error! Reference source not found.**):

- Population: (MH) aged, elderly, older adult, older person, geriatric.
- Phenomena of interest: (MH) sunlight, daylight, sunshine, sun, natural light, outdoor, (MH) light.
- Family carer health: (MH) caregivers, carer and (MH) satisfaction, and carer and (MH) stress.
- Psychosocial well-being: (MH) behaviour, (MH) cognition, (MH) mood disorders, (MH) quality of life, satisfaction, service provision and social interaction.

Databases were searched as far back as possible. The initial phase of database searching consisted of using the initial search terms in CINAHL and MEDLINE. Terms within each category were used in combination using the Boolean term "OR". Then, a search combined each category using the Boolean term "AND".

A second more extensive search was undertaken using appropriate headings and key terms for the following databases:

- CINAHL Plus (includes Nursing and Allied Health Collection), (2013)
- MEDLINE (includes PubMed), years 1950
- Cochrane Library, 2014
- Proquest Central, 2014
- Scopus (includes Science Direct), 2014
- Wiley Online Library, 2014.

Resources from the following web sites were searched using the initial key terms:

- National Institute of Clinical Studies Australian Centre for Evidence Based Clinical Practice (<http://www.acebcp.org.au>)
- National Health and Medical Research Council (NHMRC) guidelines
- Internet search using the Google search engine (<http://google.com>).

The third stage involved hand searching the reference lists of the articles retrieved.

Studies were restricted to those published in the English language in the absence of a translation service. Date limits were not set to capture all related published studies.

Method of the review

Papers selected for retrieval were individually assessed by three independent reviewers for methodological validity, prior to inclusion in the review using standardized critical appraisal instruments. The Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) checklists (**Error! Reference source not found.**) were used to assess quantitative papers. Disagreements that arose between the reviewers were resolved through discussion. In order to include only high quality studies a threshold value was produced. For this review the mean score of all studies and its Standard Deviation (SD) was calculated. Studies that scored above the mean minus 1.5xSD were included.³²

Data collection

Quantitative data were extracted from papers included in the review using the standardized data extraction tool from JBI-MAStARI (**Error! Reference source not found.**). The data extracted from all papers included specific details about the interventions, populations, setting, study methods, limitations of the study, and outcomes of significance to the review question and specific objectives, and author conclusions. The data was individually extracted by two reviewers. Disagreements that arose between the reviewers were resolved through discussion. All results were subject to double data entry.

Data synthesis

For this review, statistical pooling of the data was not possible due to the heterogeneity of the studies; therefore, the findings are presented in narrative form.

Results

Description of studies

Approximately 6500 papers were identified from the search strategy (Figure 1). Following removal of duplicates, the majority were excluded based on a review of the title and abstract of the citation against the inclusion criteria. A total of 14 studies were deemed potentially eligible for the review and full text of these studies was obtained (Table 1). The 14 studies were critically appraised (Table 2) for methodological quality using the JBI critical appraisal tools (**Error! Reference source not found.**). Based on the criteria for quality assessment the calculated mean quality score was 23.0 (SD \pm 3.08; range 16 – 27). The quality threshold score was calculated to be 18. Based on this score one study was excluded (Table 3)³³ as it fell lower than 1.5 SD below the mean score. A total of 13 studies were included in this review. The characteristics of each study are described (Appendix V) with summaries of relevant information for each study included using the JBI-MAStARI data extraction tool (**Error! Reference source not found.**).

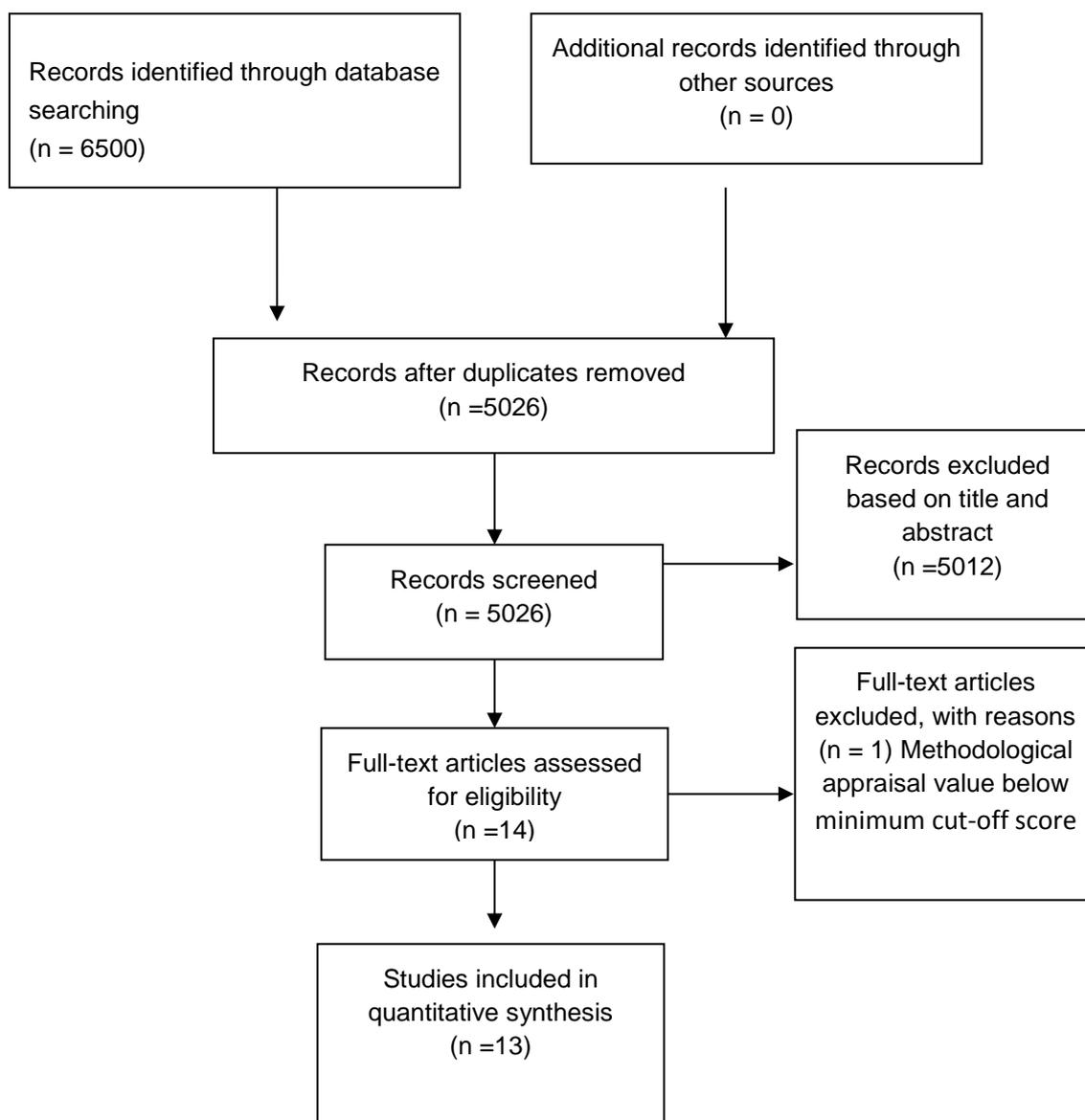


Figure 1: Flowchart for the search and study selection process

Table 1: Number of studies found and retrieved

Number of studies found	Number selected for retrieval
5026	14

Thirteen studies evaluated the effect of spending time outdoors in daylight on the psychosocial well-being of older people. No studies evaluated the effect of time spent outdoors in daylight on the family carers. The publication dates of the included studies ranged from 1999–2012. Of the 13 included studies, five were randomized/pseudo-randomized controlled trials,^{11,21,34-36} with the number of participants ranging from 17–118. Eight studies were of descriptive/case series design with the number of participants ranging from 53–599.^{4,15,17,19,20,37-39} The participants in this review were aged 55 years or more (mean age ranging from 67.7–86.5). Two studies did not report mean age.^{15,21} Four

studies included older people living with dementia.^{11,34,35,38} The studies were undertaken in the USA,^{11,20,34,35,37,39} Japan,^{4,36} England,³⁸ Turkey,¹⁷ Korea,²¹ Greece³⁶ and the Netherlands.³⁸ Nine studies were undertaken in community^{4,15,17,19-21,36,37,39} and four in residential accommodation^{11,34,35,38} settings.

Methodological quality

The method of randomization involved random numbers tables³⁴ and block randomization.¹¹ The method of randomization was not reported in one trial.³⁵ Two trials did not utilize randomization.^{21,36} More than 80% of the participants were followed up in four trials.^{11,34-36} The criteria for inclusion in the sample were clearly described in all studies.

Description of interventions

Exposure to daylight was undertaken in various ways including structured activities during summer, being or exercising outdoors in daylight, attending appointments and visiting family and friends. Exposure to daylight by older people was measured in various ways: (1) level of solar radiation experienced, as measured by meteorological data; (2) frequency of going outdoors, as measured by self-reported questionnaires; and (3) levels of light exposure, as measured by light meters, generally worn as a part of Actillum devices to measure physical movement, generally related to circadian activities.

Solar radiation is the measurement of outdoor environmental light, including insolation (which is hours of daylight per day) which is quantifiable meteorological data. These measurements do not take into account how long the individuals spend outdoors in daylight. Frequency of going outdoors was defined as any measure that quantified the number of times an individual went outdoors. Light exposure was defined as the intensity of light an individual is exposed to per day. Light exposure is generally captured via a light meter worn by participants. However as all environmental light is captured by the meter the contribution of light exposure can only be estimated.

Due to the nature of interventions, blinding of the patient, care provider and assessor was not possible in all of the trials.^{11,21,34-36}

Outcome assessment

Outcomes were measured in a reliable way in all studies. The studies evaluated different aspects of psychosocial well-being including behavioral disturbances (n=3),^{11,35,38} cognition (n=3),^{15,17,39} mood (n=6),^{4,19-21,36,37} QoL (n=1)³⁹ and social interaction (n=1).³⁴ Behavioral disturbances were measured using the Present Behavioral Examination tool³⁸ and Cohen-Mansfield Agitation Inventory;^{11,35} cognition was measured by the Mini Mental State Examination (MMSE),¹⁵ clock-drawing task¹⁷ and trail making test;³⁹ mood levels were measured by the Geriatric Depression Scale,^{4,19} self-reported questionnaires,^{20,36,37} Centre for Epidemiological Studies Depression (CES-D) scale short form³⁹ and the Profile of Mood States questionnaire;²¹ and quality of life was measured by self-reported questionnaire²⁰ and the Perceived Quality of Life Scale.³⁹ Significant results will be reported (p value) and non-significant results will be referred to as NS.

Table 2: Results of quality appraisal (MAStARI)

* 3 awarded for Yes, 2 awarded for No, 1 awarded for Unsure, 0 awarded for Not Applicable.

JBI critical appraisal checklist for randomized control/pseudo randomized trial											
Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Overall appraisal value*
Alessi CA, Martin JL, Webber AP, Cynthia Kim E, Harker JO, Josephson KR, 2005	3	2	2	3	2	3	3	3	3	3	27
Calkins M, Szmerekovsky J, Biddle S, 2008	2	2	2	3	2	2	3	3	3	3	25
Connell BR, Sanford J, Lewis D, 2007	3	2	2	3	2	3	3	3	3	3	27
Matsouka O, Kabitsis C, Harahousou Y, Trigonis I, 2005	2	2	2	2	2	1	3	3	3	3	23
Shin Y, 1999	2	2	2	2	2	3	3	3	3	3	25
JBI critical appraisal checklist for descriptive/case series											
Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9		Overall appraisal value
Aydin ZD, Ersoy IH, Baştürk A, Kutlucan A, Göksu SS, Güngör G, et al., 2011	2	3	2	3	1	1	1	3	3		19
de Craen AJM, Gussekloo J, van der Mast RC, le Cessie S, Lemkes JW, Westendorp RGJ, 2005	3	3	2	3	0	3	3	3	3		23
Grandner MA, Kripke DF, Langer RD, 2006	3	3	3	3	0	3	2	3	3		23
Kerr J, Marshall S, Godbole S, Neukam S, Crist K, Wasilenko K, et al., 2012	3	3	3	3	3	3	2	3	3		26
Kono A, Kai I, Sakato C, Rubenstein LZ, 2004	2	3	3	3	0	3	3	3	3		23
Kripke DF, Jean-Louis G, Elliott JA, Klauber MR, Rex KM, Tuunainen A, et al., 2004	2	3	2	3	2	3	2	3	3		23
Sheehan B, Keene J, 2002	3	3	2	3	0	3	0	3	3		20
Suzuki T, Murase S, 2010	2	3	2	3	0	3	3	3	3		22
Excluded study											
Sugiyama T, Thompson CW, 2005	2	2	3	3	0	0	0	3	3		16

Table 3: Number of studies included and excluded

Number of studies included	Number of studies excluded
13	1

Results

Exposure to daylight and behavioral disturbances

Four studies evaluated the effects of exposure to daylight on behavioral disturbances.^{11,34,35,38} Exposure was measured using solar radiation and actigraphy.

Exposure measured using solar radiation (N=1)

One study of 100 individuals living with dementia evaluated the relationship between solar radiation and behavioral disturbances in older people.³⁸ Behaviour problems were rated using the Present Behavioral Examination interview and average daily daylight for the month that the interview was conducted was obtained utilizing meteorological data. Data were collected every four months for five years. The study found no statistically significant association between sunlight hours and verbal aggression ($p>0.05$), resistiveness ($p>0.05$), or depression. A trend towards significance was found for the association between ratings of physical aggression and sunlight hours ($p=0.05$). Therefore, limited support was found for the hypothesis that daylight levels inversely affect the levels of behavioral disturbances in individuals living with dementia.

Exposure measured using actigraphy (N=3)

Three studies evaluated how increased time spent outdoors in daylight effected behavioral disturbances in individuals living with dementia in residential accommodation.^{11,34,35} All three studies used wrist actigraphy with inbuilt light meters to measure exposure to environmental light, including daylight. A repeated measures design study was undertaken to evaluate the effect of an outdoor activity program on levels of agitation using the Cohen-Mansfield Agitation Inventory (CMAI).¹¹ Seventeen individuals living with dementia were observed during winter and summer, with and without structured activities, of which only the summer activity program was held outdoors. Participation in the program was limited. A mixed or immeasurable effect on agitation was reported despite a significantly greater average light level for the summer, outdoors activity group compared with the three other conditions.

The CMAI measure of agitation was also used in a study using direct observation to evaluate the effect of time spent outdoors on behavioral disturbances.³⁵ Twenty older people were offered participation in: (i) an outdoor or (ii) an indoor activity program for one hour a day for ten days. For the outdoor group only, average light exposure was significantly higher during the intervention phase compared to baseline ($p<0.001$). A significant improvement was noted for verbal agitation in the group participating in the outdoor activity program ($p=0.05$), but not for other aspects of agitation, such as physical agitation.

A multidimensional, non-pharmacological intervention was undertaken which included 30 minutes a day of exposure to daylight for five consecutive days in 118 older people living in residential

accommodation.³⁴ Behavioral disturbances were quantified using observation from research staff. A non-significant trend towards a reduction in the reporting of daily observable verbal and/or physical agitation was observed.

Exposure to daylight and mood

Five studies evaluated the effects of exposure to daylight on mood.^{19,20,37,4,39} Exposure was measured using solar radiation and actigraphy, and by the frequency of going outdoors.

Exposure measured using solar radiation (N=1)

One study evaluated the relationship between mood and a measure of solar radiation. Seasonal mood variations, or “seasonality”, is a condition in which mood is predicted by different seasons. Changes in mood were evaluated using the Geriatric Depression Scale (GDS) in a cohort of 599 community dwelling Dutch older people (≥ 85 y).¹⁹ In contrast to younger cohorts, no significant changes in depression were found between seasons ($p=0.44$) nor did the duration of daylight have any effect on depression ($p=0.08$).

Exposure measured using actigraphy (N=2)

Two studies evaluated the relationship between mood and light exposure. These studies included a cohort of 450 post menopausal women from the Womens Health Initiative study to evaluate how depression (using the Center for Epidemiologic Studies Depression scale [CESD]) was linked to light exposure as measured by wrist actigraphy with a light meter.^{20,37} Fewer depressive symptoms were associated with higher levels of light exposure ($p<0.05$), but this relationship could be driven by other factors associated with quality of life.²⁰ In another study, utilizing the same cohort, an investigation into mood and light exposure showed a modest, non-significant correlation between environmental light and depressive symptoms.³⁷

Exposure measured according to the frequency of going outdoors (N=2)

Two studies evaluated the relationship between the frequency of going outdoors and measures of mood. When a group of 137 ambulatory older people who went outdoors >4 times a week were compared to those who went outdoors less than <1 a week, there was no statistical reduction in GDS scores.⁴ The second study compared the effect of time spent being or exercising outdoors in daylight with that of exercising indoors on depressive symptom scores (CESD short-form) of older people.³⁹ The depressive symptom scores were significantly different for outdoor time ($p = 0.012$) and exercise time ($p = 0.03$). Participants who spent 30 or more minutes outdoors were more likely to have fewer depressive symptoms as did those who spent 30 or more minutes exercising.

Exposure to daylight and cognition

Three studies evaluated the effects of exposure to daylight on cognition.^{15,17,39} Exposure was measured according to the frequency of going outdoors.

Exposure measured according to the frequency of going outdoors (N=3)

Three studies evaluated the relationship between the frequency of going outdoors in daylight and measures of cognition.^{15,17,39} In a cohort of 125 older people presenting to an outpatient clinic, those who reported spending more time in daylight during the summer performed significantly better on a clock-drawing task (CDT) (odds ratio=1.73, 95%, CI=1.16-2.57).¹⁷ An observational study which

evaluated the frequency of going outdoors in older people with cognitive impairment using infrared sensors in the homes of participants showed that when the Mini Mental State Examination (MMSE) was used to measure cognitive functioning, individuals with lower MMSE scores had gone outdoors in daylight less frequently than those with better cognitive function (8.8 vs. 17.3, $p < 0.01$).¹⁵ Additionally, increasing the frequency of going outdoors was associated with better cognitive preservation over one year ($p < 0.05$). Time spent exercising outdoors in daylight made no statistically significant difference to the cognitive function measured by the Trail-Making Test (TMT) but a trend was evident for improved cognitive function.³⁹

Exposure to daylight and quality of life

Two studies evaluated the effects of exposure to daylight on quality of life.^{37,39} Exposure was measured using actigraphy and by frequency of going outdoors.

Exposure measured using actigraphy (N=1)

One study evaluated the relationship between quality of life and light exposure, in the cohort of 450 community dwelling post menopausal women from the Womens Health Initiative study. Results from this study demonstrated that increased light exposure improved quality of life, as measured by wrist actigraphy with a light meter and a self-reported quality of life measure ($p < 0.005$).²⁰

Exposure measured according to the frequency of going outdoors (N=1)

One study compared the effect of time spent being or exercising outdoors in daylight with exercising indoors on quality of life as measured by the Perceived Quality of Life Score. Those who spent 30 or more minutes outdoors ($p = 0.07$) were more likely to report higher quality of life scores.³⁹

Exposure to daylight and social functioning

Two studies evaluated the effects of exposure to daylight on social functioning.^{20,34} Exposure was measured using actigraphy.

Exposure measured using actigraphy (N=2)

Two studies evaluated the relationship between social interaction and light exposure. In the first study, increased light exposure, as measured by wrist actigraphy, improved self-reported social functioning ($p < 0.005$)²⁰ and exposure to 30 minutes a day of daylight improved social activities ($p = 0.001$) and social conversation ($p = 0.03$).³⁴

Exposure to daylight on family carers

There were no studies that evaluated the effect of spending time outdoors in daylight on family carers, including carer satisfaction or carer stress.

Discussion

This systematic review was undertaken to investigate the effects of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers and summarized the best available evidence at the time of the report. A systematic search of the literature resulted in 13 published studies that were eligible for inclusion in this review. It is somewhat surprising that despite the importance of family carers, no studies evaluated the effect of spending time outdoors in daylight on family carers, including carer satisfaction or carer stress.

Although only three RCTs were included in the review, the overall methodological quality of the included studies was generally good. The trials involved both males and females. It is surprising that few studies were found evaluating the effect of spending time outdoors in daylight on the psychosocial well-being of older people, particularly when considering its versatility as an intervention and its far-reaching but complex implications on human health. The heterogenous nature of the studies in terms of exposure to daylight and measurement of outcome precluded the data from being aggregated into a meta-analysis.

The study that used solar radiation as a measure of exposure to light reported limited support for the hypothesis that daylight levels inversely affect the levels of behavioral disturbances and mood in older individuals. This could be due to the fact that the use of solar radiation as a measure of daylight exposure is unlikely to be of relevance to older people as older people, in particular individuals living with dementia in residential accommodation, rarely spend time outdoors in daylight³⁵ and go outdoors as infrequently as only once per week.

In the literature reviewed, the few studies that quantified light exposure through tools such as light meters seemed to provide an effective way of capturing time spent outdoors in daylight for older people. Despite the paucity and limitations of this research, including the limited ability of light meters to distinguish indoor and outdoor lighting, some insights can be extrapolated in relation to the psychosocial well-being of older people. This research consistently showed more positive effects of spending time in daylight on behavioral disturbances, mood, quality of life and social interaction than studies that measured the frequency of going outdoors or solar radiation. This could also be reflective of the more accurate description of spending time outdoors in daylight in these studies. The results of these studies are promising and warrant follow-up in more rigorously designed studies. With respect to non-pharmacological multifaceted interventions to improve psychosocial outcomes in individuals living with dementia, it must be possible in future to isolate the effect of daylight alone, as confounding effects, such as socializing, could be interfering with the aforementioned associations.

Similarly participants who spent 30 or more minutes outdoors per day were more likely to have fewer depressive symptoms and improved cognition as did those who spent 30 or more minutes exercising. It was argued that simply measuring the frequency of going outdoors is unlikely to adequately capture time spent outdoors in daylight, as this technique also includes getting out of the house to participate in indoors activities, such as shopping. Although these measurements can give us some idea of how getting outdoors effects psychosocial well-being in older people, it is unlikely to reflect the time spent in daylight, as previous research suggests older people rarely utilize outdoor spaces.¹¹ In addition, as studies were included in which participants were involved in any type of activity, other factors such as

the role of physical activity on the outcome measures were not accounted for. This should be considered when interpreting the results of the studies.

Many recent studies aimed at improving time spent outdoors in daylight for older people living in residential accommodation focused on manipulating the design of buildings to improve light exposure.⁴⁰ In fact, in sunny countries such as Australia, optimizing the use of daylight is a requirement when developing the built environment in residential accommodation.⁴¹ In a country as sunny as Australia, it could be argued that the focus should be shifted from improving the built environment to increase daylight exposure for those who are not immobile, to encouraging spending time outdoors in daylight, which could provide additional benefits to psychosocial well-being through being in close proximity to green space and fresh air.⁶ However, time and education of nursing staff could be a limiting factor in this transition. Staff could be unaware of the benefits for older people of being outdoors and as a result encouraging older people to be outdoors is a low priority. This solution showed that it is not simply a case of “build it and they will come”.^{35(p.199)}

There is an urgent need for appropriate health messages regarding adequate levels of sun exposure in Australia and other countries, which emphasize the benefits associated with spending time in daylight for older people. It should be noted that the World Health Organization estimated that excessive daylight exposure accounts for a loss of approximately 1.6 million disability-affected life years.⁴² However, this number is shadowed by the 3.3 billion disability-affected life years estimated to be caused by low daylight exposure,⁴² primarily relating to falls and Vitamin D deficiency. Therefore, there needs to be an appropriate response from the health sector, incorporating policy, research, and primary care, to address the increased risk of low daylight exposure in older people.

While it is widely believed that spending time outdoors in daylight benefits human health, relevant information regarding exposure to daylight and health is relatively unknown.⁴³ There is a larger focus on the benefits for daylight on physical health outcomes, such as osteoporosis and falls. However, its effect on psychosocial well-being needs to be further communicated. The effects of spending time outdoors on the psychosocial well-being of older people and family carers need to be emphasized and more research is needed to develop safe strategies to harness this limitless and “untapped” resource.

Conclusion

There is insufficient high-quality evidence from which we can draw conclusions in relation to the effect of spending time outdoors in daylight on the psychosocial well-being of older people and their family carers. Further and more robust research is required to evaluate the effectiveness of interventions to increase time spent outdoors in daylight for older people and their family carers.

Implications for practice

The limited evidence obtained from the review does not provide a concrete base for the development of recommendations for clinical practice. However, there is some evidence to support exposure to daylight on improved mood, levels of cognition and social functioning in both residential and community settings. Currently, there is insufficient evidence either to support or dispute the effects of daylight exposure on the quality of life for older people. With only small changes in routines for nursing staff there is potential for significant impacts on the psychosocial well-being of older adults living in residential accommodation.

Implications for research

Future studies should be undertaken using more rigorous research designs, such as RCTs with sufficiently powered sample sizes. Qualitative research must become a priority in this field to identify why older people are not spending time outdoors and investigate how this can be overcome. A focus on accurately measuring time spent outdoors in daylight should be a priority. Previous research was hampered by short lengths of time spent outdoors and low participation in outdoor activity programs. Therefore, research should concentrate on improving adherence to study protocols and encouraging life-long participation in outdoor activities for older people. Additionally, by investigating a comprehensive range of psychosocial outcomes with validated tools, researchers could more accurately deduce the effect of spending time outdoors on psychosocial well-being in older people and family carers.

Conflict of interest

None to report.

Acknowledgements

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Appendix I: Search strategy

MEDLINE

Search ID#	Search Terms
S1	(MH "Sunlight+")
S2	TX daylight
S3	TX sunlight
S4	TX sunshine
S5	(AB sun) OR (TI sun)
S6	TX "solar exposure"
S7	TX "natural light"
S8	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7
S9	TX ("green space*" OR greenspace*)
S10	TX "open air"
S11	TX "open space*"
S12	(AB outdoor*) OR (TI outdoor*)
S13	TX (outdoor* AND space*)
S14	S9 OR S10 OR S11 OR S12
S15	(MH "Light+")
S16	TX light*
S17	S15 OR S16
S18	S14 AND S17
S19	(MH "Exercise+")
S20	(MH "Leisure Activities+")
S21	(MH "Walking+")
S22	(MH "Environment+")
S23	(MH "Recreation+")
S24	(AB activit*) OR (TI activit*)
S25	(AB exercise*) OR (TI exercise*)

- S26 (AB walk*) OR (TI walk*)
- S27 (AB leisure*) OR (TI leisure*)
- S28 (AB environment*) OR (TI environment*)
- S29 (AB recreation*) OR (TI recreation*)
- S30 S19 OR S20 OR S21 OR S23 OR S24 OR S25 OR S26 OR S27 OR S29
- S31 S14 AND S30
- S32 S8 OR S31 OR S14
- S33 (MH "Aged+")
- S34 TX aged
- S35 TX elderly
- S36 TX "older adult**"
- S37 TX "older person**"
- S38 TX "older people"
- S39 TX geriatric
- S40 (MH "Middle Aged")
- S41 TX "Middle Aged"
- S42 S33 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41
- S43 (MH "Melatonin")
- S44 (MH "Serotonin+")
- S45 (MH "Vitamin D+")
- S46 TX melatonin
- S47 TX serotonin
- S48 TX "vitamin D"
- S49 S43 OR S44 OR S45 OR S46 OR S47 OR S48
- S50 (MH "Activities of Daily Living+")
- S51 (MH "Mobility Limitation")
- S52 TX ("activities of daily" OR ADL)
- S53 TX "personal care"

- S54 (AB mobility) OR (TI mobility)
- S55 TX ("functional abilit*" OR "motor function*")
- S56 S50 OR S51 OR S52 OR S53 OR S54 OR S55
- S57 (MH "Motor Activity+")
- S58 TX "physical activit*"
- S59 S57 OR S58
- S60 (MH "Sleep+") OR (MH "Photoperiod")
- S61 (AB sleep) OR (TI sleep) OR (TX "Circadian rhythm*")
- S62 S60 OR S61
- S63 S49 OR S56 OR S59 OR S62
- S64 S32 AND S42 AND S63
- S65 (MH "Behaviour+")
- S66 (AB (Behaviour* OR behaviour*)) OR (TI (Behaviour* OR behaviour*))
- S67 (MH "Cognition+")
- S68 (AB cogniti*) OR (TI cogniti*)
- S69 (MH "Mood Disorders+")
- S70 (AB mood*) OR (TI mood*)
- S71 (MH "Quality of Life")
- S72 TX ("Quality of Life" OR qol)
- S73 (MH "Interpersonal Relations+")
- S74 TX "Interpersonal Relation*"
- S75 TX "social interaction*"
- S76 TX "social support*"
- S77 TX (well-being OR "well-being")
- S78 (MH "Residential Facilities+")
- S79 TX "residential facilit*"
- S80 TX "service provision*"
- S81 TX "nursing home*"

- S82 TX "aged care"
- S83 TX "residential accommodation*"
- S84 (MH "Geriatrics")
- S85 S78 OR S79 OR S80 OR S81 OR S82 OR S83 OR S84
- S86 (MH "Personal Satisfaction")
- S87 (MH "Patient Satisfaction+")
- S88 (AB satisfaction) OR (TI satisfaction)
- S89 S86 OR S87 OR S88
- S90 S85 AND S89
- S91 S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77 OR S90
- S92 S32 AND S42 AND S91
- S93 (MH "Caregivers")
- S94 (AB carer*) OR (TI carer*) OR (AB famil*) OR (TI famil*)
- S95 (AB caregiver*) OR (TI caregiver*)
- S96 S93 OR S94 OR S95
- S97 (MH "Personal Satisfaction")
- S98 (MH "Stress, Psychological+")
- S99 (AB satisfaction) OR (TI satisfaction)
- S100 (AB stress) OR (TI stress)
- S101 S97 OR S98 OR S99 OR S100
- S102 S96 AND S101
- S103 S32 AND S102
- S104 (PT "Clinical Trial") OR (PT "randomized controlled trial")
- S105 (MH "Cluster Analysis+")
- S106 TX ("randomi* control* stud*" OR "randomi* control* trial*" OR "randomi* stud*" OR "randomi* trial*")
- S107 TX ("quasi randomi*" OR "quasi-randomi*" OR "quasi experiment*" OR "quasi-experiment*" OR "pseudo randomi*" OR "pseudo-randomi*" OR "pseudo experiment*" OR "pseudo-experiment*")

- S108 TX ("clustered trial*" OR "clustered stud*" OR ((cluster* OR group* OR place) AND ("randomi* control* stud*" OR "randomi* control* trial*" OR "randomi* stud*" OR "randomi* trial*")))
- S109 (S104 AND S105) OR S108
- S110 S104 OR S106 OR S107 OR S109
- S111 (MH "Qualitative Research")
- S112 TX ("Qualitative Research" OR "Qualitative stud*")
- S113 TX ("interpretive research" OR "interpretive stud*")
- S114 TX ("critical research" OR "critical stud*")
- S115 S111 OR S112 OR S113 OR S114
- S116 TX (("prospective" AND "cohort*") OR ("retrospective" AND "cohort*"))
- S117 TX ("case control*" OR "case-control*")
- S118 TX ("descriptive research*" OR "descriptive stud*")
- S119 (MH "Epidemiologic Studies+")
- S120 TX ("cohort stud*" OR "cohort research*")
- S121 TX ("longitudinal stud*" OR "longitudinal research*")
- S122 TX ("cross-sectional stud*" OR "cross-sectional research*" OR "cross sectional stud*" OR "cross sectional research*")
- S123 S116 OR S117 OR S118 OR S119 OR S120 OR S121 OR S122
- S124 (MH "Expert Testimony")
- S125 TX ("expert testimon*" OR "expert opinion" OR "expert text" OR narrative)
- S126 S124 OR S125
- S127 S64 AND S110
- S128 S64 AND S115
- S129 S64 AND S123
- S130 S64 AND S126
- S131 S92 AND S110
- S132 S92 AND S115
- S133 S92 AND S123
- S134 S92 AND S126

S135 S103 AND S110

S136 S103 AND S115

S137 S103 AND S123

CINAHL

Search terms

Search

ID#

- S1 (MH "Sunlight+")
- S2 TX daylight
- S3 TX sunlight
- S4 TX sunshine
- S5 (AB sun) OR (TI sun)
- S6 TX "solar exposure"
- S7 TX "natural light"
- S8 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7
- S9 TX ("green space*" OR greenspace*)
- S10 TX "open air"
- S11 TX "open space**"
- S12 (AB outdoor*) OR (TI outdoor*)
- S13 TX (outdoor* AND space*)
- S14 S9 OR S10 OR S11 OR S12
- S15 (MH "Light+")
- S16 TX light*
- S17 S15 OR S16
- S18 S14 AND S17
- S19 (MH "Exercise+")
- S20 (MH "Leisure Activities+")
- S21 (MH "Walking+")
- S22 (MH "Environment+")

- S23 (MH "Recreation+")
- S24 (AB activit*) OR (TI activit*)
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- S26 (AB walk*) OR (TI walk*)
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- S38 TX "older people"
- S39 TX geriatric
- S40 (MH "Middle Age")
- S41 TX "Middle Aged"
- S42 S33 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41
- S43 (MH "Melatonin")
- S44 (MH "Serotonin+")
- S45 (MH "Vitamin D+")
- S46 TX melatonin
- S47 TX serotonin
- S48 TX "vitamin D"
- S49 S43 OR S44 OR S45 OR S46 OR S47 OR S48
- S50 (MH "Activities of Daily Living+")

- S51 (MH "Physical Mobility")
- S52 TX ("activities of daily" OR ADL)
- S53 TX "personal care"
- S54 (AB mobility) OR (TI mobility)
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- S57 (MH "Motor Activity+")
- S58 TX "physical activit*"
- S59 S57 OR S58
- S60 (MH "Sleep+") OR (MH "Circadian rhythm")
- S61 (AB sleep) OR (TI sleep) OR (TX "circadian rhythm*")
- S62 S60 OR S61
- S63 S49 OR S56 OR S59 OR S62
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- S66 (AB (Behaviour* OR behaviour*)) OR (TI (Behaviour* OR behaviour*))
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- S70 (AB mood*) OR (TI mood*)
- S71 (MH "Quality of Life")
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- S76 TX "social support*"
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- S103 S32 AND S102
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- S105 (MH "Cluster Analysis+")

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- S107 TX ("quasi randomi*" OR "quasi-randomi*" OR "quasi experiment*" OR "quasi-experiment*" OR "pseudo randomi*" OR "pseudo-randomi*" OR "pseudo experiment*" OR "pseudo-experiment*")
- S108 TX ("clustered trial*" OR "clustered stud*" OR ((cluster* OR group* OR place) AND ("randomi* control* stud*" OR "randomi* control* trial*" OR "randomi* stud*" OR "randomi* trial*")))
- S109 (S104 AND S105) OR S108
- S110 S104 OR S106 OR S107 OR S109
- S111 (MH "Qualitative Studies+")
- S112 TX ("Qualitative Research" OR "Qualitative stud*")
- S113 TX ("interpretive research" OR "interpretive stud*")
- S114 TX ("critical research" OR "critical stud*")
- S115 S111 OR S112 OR S113 OR S114
- S116 TX (("prospective" AND "cohort*") OR ("retrospective" AND "cohort*"))
- S117 TX ("case control*" OR "case-control*")
- S118 TX ("descriptive research*" OR "descriptive stud*")
- S119 (MH "Nonexperimental Studies+")
- S120 TX ("cohort stud*" OR "cohort research*")
- S121 TX ("longitudinal stud*" OR "longitudinal research*")
- S122 TX ("cross-sectional stud*" OR "cross-sectional research*" OR "cross sectional stud*" OR "cross sectional research*")
- S123 S116 OR S117 OR S118 OR S119 OR S120 OR S121 OR S122
- S124 TX ("expert opinion" OR "expert text" OR narrative)
- S125 S64 AND S110
- S126 S64 AND S115
- S127 S64 AND S123
- S128 S92 AND S110
- S129 S92 AND S115
- S130 S92 AND S123

- S131 S103 AND S110
 S132 S103 AND S115
 S133 S103 AND S123
 S134 S64 AND S124
 S135 S92 AND S124
 S136 S103 AND S124

Cochrane Library

- | ID | Search |
|-----|---|
| #1 | MeSH descriptor: [Sunlight] explode all trees |
| #2 | daylight |
| #3 | sunlight |
| #4 | sunshine |
| #5 | (AB sun) or (TI sun) |
| #6 | "solar exposure" |
| #7 | "natural light" |
| #8 | #1 or #2 or #3 or #4 or #5 or #6 or #7 |
| #9 | ("green space*" or greenspace*) |
| #10 | "open air" |
| #11 | "open space" |
| #12 | (AB outdoor*) or (TI outdoor*) |
| #13 | (outdoor* and space*) |
| #14 | #9 or #10 or #11 or #12 |
| #15 | MeSH descriptor: [Light] explode all trees |
| #16 | light* |
| #17 | #15 or #16 |
| #18 | #14 and #17 |
| #19 | MeSH descriptor: [Exercise] explode all trees |
| #20 | MeSH descriptor: [Leisure Activities] explode all trees |
| #21 | MeSH descriptor: [Walking] explode all trees |
| #22 | MeSH descriptor: [Environment] explode all trees |
| #23 | MeSH descriptor: [Recreation] explode all trees |
| #24 | (AB activit*) or (TI activit*) |
| #25 | (AB exercise*) or (TI exercise*) |
| #26 | (AB walk*) or (TI walk*) |
| #27 | (AB leisure*) or (TI leisure*) |
| #28 | (AB environment*) or (TI environment*) |
| #29 | (AB recreation*) or (TI recreation*) |
| #30 | #19 or #20 or #21 or #23 or #24 or #25 or #26 or #27 or #29 |
| #31 | #14 and #30 |
| #32 | #8 or #31 or #14 |
| #33 | MeSH descriptor: [Aged] explode all trees |
| #34 | aged |
| #35 | elderly |

- #36 "older adult"
- #37 "older person"
- #38 "older people"
- #39 geriatric
- #40 MeSH descriptor: [Middle Aged] explode all trees
- #41 "Middle Aged"
- #42 #33 or #35 or #36 or #37 or #38 or #39 or #40 or #41
- #43 MeSH descriptor: [Melatonin] this term only
- #44 MeSH descriptor: [Serotonin] explode all trees
- #45 MeSH descriptor: [Vitamin D] explode all trees
- #46 melatonin
- #47 serotonin
- #48 "vitamin D"
- #49 #43 or #44 or #45 or #46 or #47 or #48
- #50 MeSH descriptor: [Activities of Daily Living] explode all trees
- #51 MeSH descriptor: [Mobility Limitation] explode all trees
- #52 ("activities of daily" or ADL)
- #53 "personal care"
- #54 (AB mobility) or (TI mobility)
- #55 ("functional abilit*" or "motor function*")
- #56 #50 or #51 or #52 or #53 or #54 or #55
- #57 MeSH descriptor: [Motor Activity] explode all trees
- #58 "physical activit*"
- #59 #57 or #58
- #60 MeSH descriptor: [Sleep] explode all trees
- #61 MeSH descriptor: [Photoperiod] explode all trees
- #62 (AB sleep) or (TI sleep) or (TX "Circadian rhythm*")
- #63 #60 or #61 or #62
- #64 #49 or #56 or #59 or #63
- #65 #32 and #42 and #64 from 1979 to 2012
- #66 MeSH descriptor: [Behaviour] explode all trees
- #67 (AB (Behaviour* or behaviour*)) or (TI (Behaviour* or behaviour*))
- #68 MeSH descriptor: [Cognition] explode all trees
- #69 (AB cogniti*) or (TI cogniti*)
- #70 MeSH descriptor: [Mood Disorders] explode all trees
- #71 (AB mood*) or (TI mood*)
- #72 MeSH descriptor: [Quality of Life] this term only
- #73 ("Quality of Life" or qol)
- #74 MeSH descriptor: [Interpersonal Relations] explode all trees
- #75 "Interpersonal Relation"
- #76 "social interaction*" or "social support"
- #77 (well-being or "well-being")
- #78 MeSH descriptor: [Residential Facilities] explode all trees
- #79 "residential facilit*"
- #80 "service provision"
- #81 "nursing home"
- #82 "aged care"
- #83 "residential accommodation"
- #84 MeSH descriptor: [Geriatrics] explode all trees
- #85 #78 or #79 or #80 or #81 or #82 or #83 or #84

- #86 MeSH descriptor: [Personal Satisfaction] this term only
 #87 MeSH descriptor: [Patient Satisfaction] explode all trees
 #88 (AB satisfaction) or (TI satisfaction)
 #89 #86 or #87 or #88
 #90 #85 and #89
 #91 #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 or #74 or #75 or #76 or #77 or #90
 #92 #32 and #42 and #91 from 1979 to 2012
 #93 MeSH descriptor: [Caregivers] this term only
 #94 (AB carer*) or (TI carer*) or (AB famil*) or (TI famil*)
 #95 (AB caregiver*) or (TI caregiver*)
 #96 #93 or #94 or #95
 #97 MeSH descriptor: [Personal Satisfaction] this term only
 #98 MeSH descriptor: [Stress, Psychological] explode all trees
 #99 (AB satisfaction) or (TI satisfaction)
 #100 (AB stress) or (TI stress)
 #101 #97 or #98 or #99 or #100
 #102 #96 and #101
 #103 #32 and #102 from 1979 to 2012

Proquest Central

((all("Aged" OR "elderly" OR "older" OR "older adult" OR "older person" OR "older people" OR "geriatric" OR "caregiver*" OR "carer") AND ftany(yes) AND peer(yes)) AND (all("Sunlight" OR "daylight" OR "sunshine" OR "sun" OR "natural light" OR "outdoor*" OR "light" OR "green space*") AND ftany(yes) AND peer(yes) AND stype.exact("Scholarly Journals") AND la.exact("English")) AND (all("Melatonin" OR "serotonin" OR "vitamin D" OR "activities of daily living" OR "ADL" OR "mobility" OR "functional ability" OR "physical activity" OR "sleep") AND ftany(yes) AND peer(yes) AND stype.exact("Scholarly Journals") AND la.exact("English"))) AND (ftany(yes) AND peer(yes) AND yr(1979-2019))

Scopus

(TITLE-ABS-KEY("Aged" OR "elderly" OR "older" OR "older adult" OR "older person" OR "older people" OR "geriatric" OR "caregiver*" OR "carer") AND TITLE-ABS-KEY("Sunlight" OR "daylight" OR "sunshine" OR "sun" OR "natural light" OR "outdoor*" OR "light" OR "green space*") AND TITLE-ABS-KEY("Behaviour*" OR "cognit*" OR "mood" OR "quality of life" OR "satisfaction" OR "stress" OR "service provision" OR "social*" OR "social support*")) AND DOCTYPE(ar OR re) AND PUBYEAR > 1975

Wiley Online Library

"Aged" OR "elderly" OR "older" OR "older adult" OR "older person" OR "older people" OR "geriatric" OR "caregiver*" OR "carer" in Abstract AND "Sunlight" OR "daylight" OR "sunshine" OR "sun" OR "natural light" OR "outdoor*" OR "light" OR "green space*" in Abstract AND "Behaviour*" OR "cognit*" OR "mood" OR "quality of life" OR "satisfaction" OR "stress" OR "service provision" OR "social*" OR "social support*" in Abstract NOT poster OR abstract in All Fields between years 1975 and 2013

Appendix II: Appraisal instruments

MAStARI appraisal instrument

JBI Critical Appraisal Checklist for Randomised Control / Pseudo-randomised Trial

Reviewer Date

Author Year Record Number

	Yes	No	Unclear	Not Applicable
1. Was the assignment to treatment groups truly random?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were participants blinded to treatment allocation?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Was allocation to treatment groups concealed from the allocator?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Were those assessing outcomes blind to the treatment allocation?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Were the control and treatment groups comparable at entry?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were groups treated identically other than for the named interventions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in the same way for all groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal: Include Exclude Seek further info.

Comments (Including reason for exclusion)

JBI Critical Appraisal Checklist for Descriptive / Case Series

Reviewer Date

Author Year Record Number

	Yes	No	Unclear	Not Applicable
1. Was study based on a random or pseudo-random sample?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were the criteria for inclusion in the sample clearly defined?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Were confounding factors identified and strategies to deal with them stated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were outcomes assessed using objective criteria?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. If comparisons are being made, was there sufficient descriptions of the groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Was follow up carried out over a sufficient time period?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal: Include Exclude Seek further info

Comments (Including reason for exclusion)

JBI Critical Appraisal Checklist for Comparable Cohort/ Case Control

Reviewer Date

Author Year Record Number

	Yes	No	Unclear	Not Applicable
1. Is sample representative of patients in the population as a whole?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Are the patients at a similar point in the course of their condition/illness?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Has bias been minimised in relation to selection of cases and of controls?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Are confounding factors identified and strategies to deal with them stated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Are outcomes assessed using objective criteria?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Was follow up carried out over a sufficient time period?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were the outcomes of people who withdrew described and included in the analysis?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall appraisal: Include Exclude Seek further info.

Comments (Including reason for exclusion)

Appendix III: Data extraction instruments

MAStARI data extraction instrument

JBI Data Extraction Form for Experimental / Observational Studies

Reviewer Date

Author Year

Journal Record Number

Study Method

RCT Quasi-RCT Longitudinal
 Retrospective Observational Other

Participants

Setting _____

Population _____

Sample size

Group A _____ Group B _____

Interventions

Intervention A _____

Intervention B _____

Authors Conclusions:

Reviewers Conclusions:

Study results

Dichotomous data

Outcome	Intervention () number / total number	Intervention () number / total number

Continuous data

Outcome	Intervention () number / total number	Intervention () number / total number

Appendix IV: Excluded studies

Sugiyama T, Thompson CW. Environmental Support for Outdoor Activities and Older People's Quality of Life. *Journal of Housing For the Elderly* 2005;19:167-185.

Reason for exclusion: Did not meet the quality criteria

Appendix V: List of study findings/conclusions

MAStARI

Study	Methods	Participants	Intervention A	Intervention B	Study findings/conclusions
Alessi et al., 2005	Randomized controlled trial	118 residents 62 in intervention arm Mean age: 86.9y, Gender: 77% female	Non-pharmacological, multicomponent intervention 1. >30minutes daylight exposure 2. Increased physical activity 3. Structured bed-time 4. Decreased night-time noise	Usual care	Intervention participants had increased participation in social activities (F=22.42, p<0.001) and conversation (F=5.04, p=0.03). A multidimensional intervention including exposure to daylight resulted in increased social activities and conversation, which could be related to lowered daytime sleeping.
Calkins et al., 2008	Observational - repeated measures	17 residents living with dementia in 3 nursing homes Mean age: not reported, Gender: 88% female Mean Mini Mental State Examination (MMSE) score: 10.5	Direct observation every 20m for 4h/day measured agitation and time spent outdoors under four conditions: 1. winter/no activity 2. winter/ inside activity 3. summer/no activity 4. summer/outside activity		Light exposure measured by Actilume data with light meter Numerous correlations were performed with the CMAI data show highly variable modest correlations between light exposure and Cohen-Mansfield Agitation Inventory Short Form – CMAI (CMAI). Results suggest that increasing time spent outdoors has a mixed or immeasurable impact on agitation.
Connell et al., 2008	Randomized controlled trial	20 residents living with dementia in a single nursing home	A daily structured 1hour activity program was offered outdoors or indoors.	Usual care	Light exposure measured by Actilume data with light meter. There was a significant improvement in verbal agitation in the outdoor activity group only (p=0.1). There was no

Study	Methods	Participants	Intervention A	Intervention B	Study findings/conclusions
		<p>10 in intervention arm</p> <p>Mean age: 79.7, Gender 95% male</p> <p>Mean MMSE score = 15.3</p>			<p>significant effect for other aspects of behavioral disturbance; however there was a declining trend.</p> <p>Structured activity programs that capitalized on the availability of planned outdoor space to provide bright light exposure were a promising means to improve behavior in residents with dementia.</p>
Matsuoka et al., 2005	Randomized controlled trial	<p>55 sedentary older women</p> <p>Mean age 64.8, Gender: 100% female</p>	<p>12 week outdoor recreational exercise program for three treatment groups: <u>Group 1</u> -3x45minute exercise sessions/week <u>Group 2</u> -2x45minute exercise sessions/week <u>Group 3</u> -1x45minute exercise sessions/week</p>	No physical activity program	<p>After the 12-week training program there was a significant increase in self-reported mood for those who exercised twice a week or more.</p> <p>Overall, outdoor exercise was associated with improved mood in elderly women.</p>
Shin, 1999	Controlled-trial (pre-test, post-test design)	<p>35 sedentary older women, community dwelling. 20 in intervention arm.</p> <p>Mean age not reported, Gender 100% female</p>	8 week outdoor walking exercising program		<p>Mood assessed by Profile of Mood States (POMS).</p> <p>After the 8-week training program there was a significant difference between the exercise and non-exercise group for total emotional state (F= 19.49, p=0.0002), which was especially related to anxiety and vigor, which influenced overall mood.</p>

Study	Methods	Participants	Intervention A	Intervention B	Study findings/conclusions
Aydin et al., 2010	Observational – cross sectional	125 internal medicine outpatients Mean age: 72y, Gender 58% female			Summer sun exposure was an independent predictor of a Clock drawing test (CDT) score >0 (OR = 1.73, 95%CI = 1.16–2.57). A CDT can be used to identify an association between cognition and sun exposure; however further investigation is required.
deCraen et al., 2005	Observational – repeated measures	599, 85y old Dutch elderly (1914 birth cohort) Gender: 63% female MMSE score >19			Within each of the four years of observation (85, 86, 87 and 88 years) and all years combined, there was also no significant association between the one-month accumulation of duration of sunlight, daylight, or rain and the score on the GDS (all p-values >0.05). Estimates of prevalence of seasonality reported in the literature could be overestimated or a remarkable difference between young and old subjects existed.
Grandner, Kripke and Langer, 2006	Observational – prospective cohort	459 post-menopausal women Mean age: 67.7, Gender: 100% female			Actillum wrist monitor with light sensor measured illumination levels. Significant partial correlations (controlling for age, education and ethnicity) were found between the daily mean light exposure and Quality of Life and mood. The relationship between quality of life could account for mood associations. Increased light exposure was related to improved quality of life and social and emotional functioning.

Study	Methods	Participants	Intervention A	Intervention B	Study findings/conclusions
Kerr et al., 2012	Observational – cross sectional	117 older adults living in retirement communities Mean age: 83.3, Gender: 69% female			Significant differences were found for those who spent >30 min in PA or outdoors for depressive symptoms. QoL and cognitive functioning scores were not significantly different according to time spent outdoors. Being outdoors and being active were both related to fewer depressive symptoms. However, there was no statistically significant benefit of being outdoors and being active on the selected health indicators. This warrants further in-depth investigation.
Kono et al., 2004	Observational – prospective cohort	112 frail older adults living at home Mean age: 82.9, Gender: 74.8% female			Frequency of going outdoors was associated with improved GDS scores at baseline, but did not predict changes in mood over time. The frequency of going outdoors among ambulatory frail elders could be a useful and simple indicator of older persons with functional and psychosocial problems and an important predictor of persons at risk for deterioration.
Kripke et al., 2004	Observational – prospective cohort	459 post-menopausal women Mean age: 67.7, Gender: 100% female			Low daily illumination was weakly associated with depressed mood. Environmental illumination accounted for little of the contrasts between ethnic groups mood. Social factors could be involved.
Sheehan and Keene, 2002	Observational – prospective cohort	100 older adults with dementia and their carers			No support was found for the hypothesis that sunlight levels would be inversely related to levels of behavioral and

Study	Methods	Participants	Intervention A	Intervention B	Study findings/conclusions
		Mean age: 77.6, Gender: 51% female Mean MMSE score: 14.9			psychological disturbance in people with dementia. As there was an association between daily sunlight and behavioral disturbances, it could be that the influence of bright light on behaviour in dementia was overestimated.
Suzuki and Murase, 2010	Observational – prospective cohort	53 older adults living at home Mean age: 80.9, Gender: unreported Mean MMSE score: not reported			Participants who displayed cognitive decline had a significantly lower number of outings (8.8 vs. 17.3, $p < 0.01$) compared to those with normal cognitive functioning. There was no cognition decline in those who went outdoors over 20 times per month. Elderly people who had few occasions to go out tend to showed a decrease in cognitive function.