Psychiatry Research 271 (2019) 516–525

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Pet robot intervention for people with dementia: A systematic review and meta-analysis of randomized controlled trials☆

Leng Minmin[a,1], Liu Peng[b,1], Zhang Ping[c], Hu Mingyue[a], Zhou Haiyan[d], Li Guichen[a], Yin Huiru[a], Chen Li[a,e,*]

[a] School of Nursing, Jilin University, Changchun, China
[b] School of Mechanical Science and Engineering, Jilin University, Changchun, China
[c] School of Nursing, Southern Medical University, Guangzhou, China
[d] The First Hospital of Jilin University, Changchun, China
[e] Department of Pharmacology, college of Basic Medical sciences, Jilin University, Changchun, China

ARTICLE INFO

Keywords:
Pet robot intervention
BPSD
Dementia
Meta-analysis

ABSTRACT

This study aims to systematically evaluate the efficacy of Pet robot intervention (PRI) for people with dementia. Two waves of electronic searches of the PubMed, EMBASE, Web of Science, Cochrane library, IEEE Digital Library and PsycINFO databases were conducted. In total, eight articles from six randomized controlled trials (RCTs) met the eligibility criteria and were included in this systematic review. The results of the meta-analysis showed a statistically significant decrease in behavioral and psychological symptoms of dementia (BPSD), especially agitation and depression, in people with dementia who were treated with PRI. Both individual and group format PRI significantly ameliorated BPSD. However, there were no significant improvements in cognitive function or quality of life. The results of the meta-analysis suggest that PRI may be suitable as a treatment option for BPSD in people with dementia and should be considered as a useful tool in clinical practice.

1. Introduction

With 47 million people worldwide living with dementia in 2016 and 131 million people expected to be affected in 2050, dementia has become a major global public health issue and will continue to be a public health burden in the future (Prince et al., 2016). Behavioral and psychological symptoms of dementia (BPSD) are highly prevalent in people with dementia and include affective disturbances, psychotic features, disturbed perception, hyperactivity, sleep disturbances and a variety of socially inappropriate behaviors, of which the most common are agitation and depression (Kales et al., 2015; Rm et al., 2014; Rosenberg et al., 2015; Seitz et al., 2010). Overall, BPSD are associated with a more rapid progression from mild dementia to severe dementia, as they accelerate cognitive decline (Peters et al., 2015; Wetzels et al., 2010), reduce quality of life (Givens et al., 2015; Wetzels et al., 2010), decrease the ability to perform activities of daily living (Wetzels et al., 2010) and lead to a higher caregiver burden (Fauth and Gibbons, 2014; Moyle et al., 2018), all of which are major concerns in dementia care.

The strategies available for management of BPSD include pharmacological and nonpharmacological therapies. However, medications have limited effectiveness compared to placebos (Schneider et al., 2006; Seitz et al., 2013), and the repeated use of antipsychotics, such as risperidone and olanzapine, may accelerate cognitive decline (Ma et al., 2014; Sink et al., 2005), increase the risk of falls (Dyer et al., 2017; Tripathi and Vibha, 2010), cause gastrointestinal problems (Tan et al., 2014; Dyer et al., 2017), and result in abnormal liver function (Ma et al., 2014; Tripathi and Vibha, 2010). Thus, nonpharmacological therapies are being increasingly implemented (Morrin et al., 2017) and are recommended as the first-line treatment for BPSD (Guideline Adaptation Committee, 2016). Recent systematic reviews have shown that various types of nonpharmacological interventions, such as exercise training (Fleiner et al., 2016), music therapy (Garcia-Casares et al., 2017), and animal-assisted intervention (Hu et al., 2018), are effective at reducing BPSD. Interacting with pets/animals has long been known to promote emotional benefits. However, while animal-assisted intervention has known positive effects, it is not always appropriate for animals to visit long-term care facilities or day care centers (Moyle et al., 2017; Robinson et al., 2015; Soler et al., 2015).

☆ Present address: School of Nursing, JiLin University, 965 XinJiang Road, Changchun, China.
* Corresponding author at: School of Nursing, JiLin University, 965 XinJiang Road, Changchun 130021, China
E-mail address: chen_care@126.com (L. Chen).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.psychres.2018.12.032
Received 5 March 2018; Received in revised form 5 December 2018; Accepted 6 December 2018
Available online 06 December 2018
0165-1781/

Health care workers fear the risk of the animals injuring residents; possible injuries include bites, scratches, allergic reactions and infections. Additionally, agitated residents could harm or frighten the animals, and animal care may consume resources (time, money and space). Consequently, animal-shaped robots that can serve as alternatives or complements to real animals might be useful in some cases. Compared to live animals, pet robots have fewer requirements in terms of time, space and money, and their sensing devices can respond to changes in posture, touch, sound, and light, simulating interactions with residents (Preuß and Legal, 2017; Soler et al., 2015). Pet robot intervention (PRI) stem from the principle of animal-assisted intervention and is seen as a viable substitute for animal-assisted intervention (Bernabei et al., 2013), which has been shown to provide emotional and physiological benefits for older people in long-term care facilities and to ameliorate agitation and depression in people with dementia (Bernabei et al., 2013; Hu et al., 2018; Huei-Chuan Sung et al., 2015; Robinson et al., 2013). In nursing homes or day care units, PRI are conducted using robotic pets, such as baby harp seals (PARO), dogs (AIBO), cats (NeCoRo) and teddy bears (CuDDler) (Bemelmans et al., 2012; Mordoch et al., 2013; Preuß and Legal, 2017).

In recent years, PRI have drawn the attention of researchers in the field of dementia. However, the effects of PRI on people with dementia are inconsistent. For example, a randomized controlled trial (RCT) (Petersen et al., 2017) showed that the levels of depression and anxiety significantly decreased in the PRI group compared with the control group after the 12-week intervention. Conversely, another study (Liang et al., 2017) indicated that although people with dementia had better social interactions after PRI, there were no significant differences in neuropsychological symptoms between the intervention and control groups. In a previous review (Mordoch et al., 2013), the author included 9 publications in academic journals and 12 conference proceedings and evaluated the effects of PRI on people with dementia; the results indicated that pet robots were potentially useful as a therapeutic intervention. Nonetheless, because the included studies were diverse and the data were insufficient, a meta-analysis could not be conducted, and precise conclusions have not been reached. A recent systematic review and meta-analysis (Pu et al., 2018) investigated the effects of social robots on several health outcomes for older adults; however, the review focused on the effects of social robots for older people, not just the effects of pet robots among people with dementia. Social robots are defined as artificial agents that look and behave like humans or animals (Abdi et al., 2018; Broekens et al., 2009). Pet robots are clearly a type of social robots. However, social robots are tasked with aiding activities of daily living or improving the psychological status and overall well-being of users (Reiser et al., 2013; Abdi et al., 2018). Pet robots, in contrast, are more generally associated with playing the role of a real pet.

In general, the effects of PRI on people with dementia require further exploration. Thus, we performed this systematic review and meta-analysis of RCTs to further clarify the effects of PRI among people with dementia. The primary aim of this study was to examine the effects of PRI on BPSD. The secondary aims were to investigate the effects of PRI on cognitive function and quality of life.

2. Method

We conducted this systematic review and meta-analysis by following the preferred reporting items in the systematic review and meta-analyses (PRISMA) guidelines (Moher et al., 2009).

2.1. Literature search strategy

Two reviewers (LMM and HMY) performed two waves of comprehensive electronic literature searches of the PubMed, EMBASE, Web of Science, Cochrane library, IEEE Digital Library and PsycINFO databases to identify relevant studies that were written in English. An initial search was performed in November 2017, and an updated search was performed in November 2018. Further relevant publications were identified through the reference lists of the included publications and previous related systematic reviews. For each database, the search strategy was personalized. The key search terms were a combination of medical subject heading terms (MeSH) and entry terms (using the PubMed query as an example): "Dementia"[Mesh] OR "Dementias" OR "Amentia" OR "Amentias" OR "Senile Paranoid Dementia" OR "Dementias, Senile Paranoid" OR "Paranoid Dementia, Senile" OR "Paranoid Dementias, Senile" OR "Senile Paranoid Dementias" OR "Familial Dementia" OR "Dementia, Familial" OR "Dementias, Familial" OR "Familial Dementias" OR" Alzheimer Disease" [Mesh] OR "Alzheimer's Disease" OR "Alzheimer Type Dementia" OR "Alzheimer Type Senile Dementia" OR "Alzheimer Sclerosis" OR "Alzheimer Syndrome" OR "Alzheimer Dementia", "Robot-Assisted" OR "robot pet-assisted" OR "companion robot" OR "Pet Robot" OR "Robotic Pets" OR "Robotic" OR "robot", "Randomized Controlled Trial" [Mesh] OR "Clinical Trials, Randomized" OR "Trials, Randomized Clinical" OR "Controlled Clinical Trials, Randomized" OR "Controlled Clinical Trial" OR "Randomized" OR "Randomized Controlled Study" OR "Randomly" OR "Trial". Similar strategies were used to search the other databases.

2.2. Criteria for inclusion

Trials were included in this review if they met the following criteria: (1) Study type: RCTs; (2) Study population: participants were diagnosed with dementia; (3) Intervention method: PRI (including interactions between the participants and the pet robots or interactions among the participants, pet robots, and the activity organizer); and (4) Outcomes: the study reported available detailed data about the effects of the intervention. In addition, the study was required to have assessed at least one of the results investigated in this meta-analysis (BPSD, cognitive function or quality of life).

2.3. Study selection and data extraction

All of the searched records were imported into EndNote X7 to eliminate duplicate studies. The two reviewers (LMM and HMY) worked independently to identify studies that met the inclusion criteria and extracted data independently. To further evaluate the eligibility of potential studies, we obtained the full-text articles and discussed any disagreements with the third reviewer (ZP). From each included study, we extracted data including the author, publication year, country, participants' mean age, intervention details (e.g., type, frequency, duration, and total number of sessions), follow-up times and outcome measurement tools.

2.4. Quality assessment

The quality of the included studies was evaluated using the approach recommended by the Cochrane Handbook for systematic reviews of interventions (Higgins and Green, 2011). The six recommended domains included seven items (random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, selective reporting, and other bias). All included studies were assessed independently, and the risk of bias for each item was categorized as 'low risk', 'unclear' or 'high risk'. Disagreements between the two reviewers were resolved by a third reviewer (ZP).

2.5. Statistical analysis

This meta-analysis was based on the data from the scales used in the respective studies. We used the standardized mean difference (SMD) with 95% CI in most analyses, and the mean difference (MD) with 95% CI was applied when studies used the same outcome scale. The SMD

and MD were interpreted according to Cohen's definitions: 0.2–0.5 represented a small effect size, 0.5–0.8 represented a moderate effect size, and > 0.8 represented a large effect size (Cohen, 1962). The level of heterogeneity was evaluated by the I^2 method, and a value of $I^2 > 50\%$ was regarded as significant heterogeneity (Higgins et al., 2003). We used the fixed-effects model to calculate the pooled effect size if the data were not significantly heterogeneous. Otherwise, the random-effects model was used. RevMan 5.3 provided by Cochrane Collaboration was used for all statistical calculations, and a p value <0.05 was considered statistically significant. Subgroup analysis was performed to explore which PRI format was most beneficial for people with dementia and to assess the effects of PRI on specific types of BPSD.

3. Results

3.1. Overview of the included studies

A total of 980 records were identified from the electronic databases in the final search. After removal of duplicates and obviously irrelevant records, we retrieved 71 full-text publications to further evaluate their eligibility. Sixty-three publications were excluded because they did not meet the inclusion criteria. Ultimately, a total of eight publications (Jøranson et al., 2015, 2016; Liang et al., 2017; Moyle et al., 2013,2017,2018; Petersen et al., 2017; Soler et al., 2015) from six RCTs involving 502 participants with dementia met the eligibility criteria and were included in this systematic review. The detailed screening process is illustrated in Fig. 1. The main characteristics of the included studies are shown in Table 1. Two studies were performed in Australia, and one study each was conducted in Norway, New Zealand, Spain, and the USA. Most participants came from long-term care facilities. All of the included studies reported clear inclusion and exclusion criteria for their participants. In all six RCTs, the robotic pets used for the intervention were baby harp seals (PARO).

3.2. Risk of bias assessment

The risk of bias of each included study is shown in Fig. 2. All included studies reported randomized allocation. Four of the studies specifically reported that the randomization sequence was generated by a random number generator on a computer (Liang et al., 2017; Moyle et al., 2013), a coin toss (Petersen et al., 2017) or a six-sided die (Soler et al., 2015). Two other studies performed random allocation using an external research center (Jøransonet al., 2015; Moyle et al., 2017). Two included studies (Liang et al., 2017; Petersen et al., 2017) did not state their allocation concealment in detail, so the risk of allocation concealment bias was judged as unclear, and the other four studies (Soler et al., 2015; Jøransonet al., 2015; Moyle et al., 2013, 2017) were judged as being low risk for this bias. However, only one study (Moyle et al., 2017) was judged as having a low risk of performance bias because it was difficult to blind personnel and participants in the trials to the PRI. Three studies (Moyle et al., 2013; Moyle et al., 2017; Soler et al., 2015) blinded the outcome assessors; therefore, their risk of detection bias was judged as low. The risk of attrition bias was low in three studies (Jøransonet al., 2015; Moyle et al., 2017; Petersen et al., 2017) because the research data were complete or the amount of missing data and the reasons for missing data were described. There was no evidence of selective reporting bias in any of the included studies. The risk of other bias was categorized as high in one study (Liang et al., 2017) because of the small sample size.

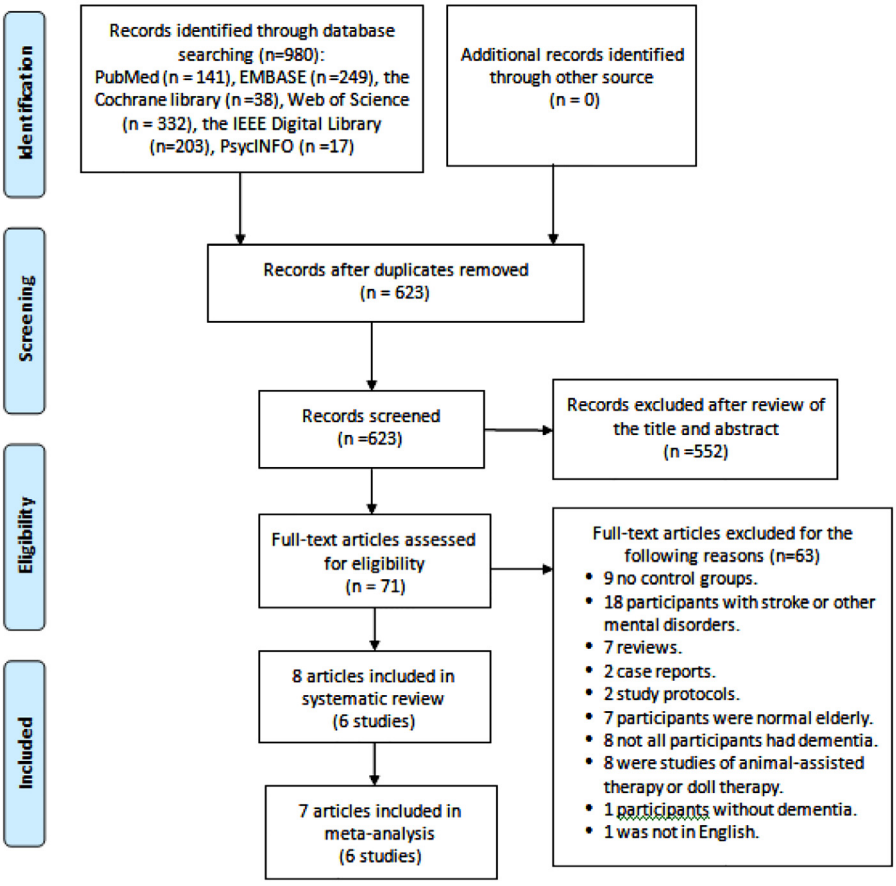

Fig. 1. Flow diagram for search and selection of the included studies.

Table 1
Characteristics of the studies included in this meta-analysis.

Study (year), country	Participants (M/F)	Mean age (IG/CG) (mean ± SD)	Setting	Intervention types	Intervention methods	Frequency, duration of intervention	Intervention format	Follow-ups	Measures/Outcomes
Liang et al., (2017), New Zealand	(NA) IG: n = 13 CG: n = 11	NA	Two dementia day care centers and participants' homes	IG: PARO intervention CG:standard activities	Interactions with PARO, such as stroking PARO's flippers.	At the day care center: 2–3 times/week, 30 min/session, 6 weeks. At home: the length and nature of interactions with PARO were flexible and depended on each dyad's needs and preferences, 6 weeks.	Individual	Baseline, 6 weeks, 12weeks	Addenbrooke's Cognitive Examination/ CMAI-SF/NPI-Q/CSDD
Jøranson et al., (2015), Norway	(18/35) IG: n = 27 CG: n = 26	83.9 ± 7.2/ 84.1 ± 6.7	Nursing home	IG: robot-assisted intervention CG: treatment as usual	Accordance with protocol: interact with PARO.	Twice per week, 30 min/session, 12 weeks	Group	Baseline, 12 weeks, 6months	BARS/CSDD/ QUALID
Soler et al., (2015), Spain	(NA) IG: n = 33 CG: n = 38	Total mean age84.68years old	Nursing home	IG: animal-shaped robot therapy CG: conventional therapy	Interactions with the animal-shaped robots (PARO) to perform several therapeutic activities, including identifying numbers, words, and colors using flash cards.	2 days per week, 30–40 min/day, 3months	Group	Baseline, 3months	MMSE/APADEM-NH/ NPI/QUALID
Petersen et al., (2017), USA	(14/47) IG: n = 35 CG: n = 26	83.5 ± 5.8/ 83.3 ± 6.0	Urban secure dementia units	IG: robotic pet therapy CG: standard care, which includes physical activity, music, and mental stimulation.	Interactions with the robotic pet (PARO).	Three times/week, 20 min/session, three months	Group	Baseline, 3months	RAID/GDS[1]/CSDD
Moyle et al., (2013), Australia	(NA) IG: n = 18 CG: n = 18	Total mean age 85.3 + 8.4	Residential care facility	IG: companion robot intervention CG: reading	Involved activities around the concepts of discovery, engaging an emotional response, social interaction in the group through discussion about PARO, and touching PARO.	Three times/week, 45 min/session, 5 weeks.	Group	Baseline, 5 weeks, 13weeks	QOL-AD/AWS/AES/ GDS[2]/RAID
Moyle et al., (2017), Australia	(75/200) IG: n = 138 CG: n = 137 TG: n = 140	84.0 ± 8.4/ 85.0 ± 7.1	Long-term care facilities	IG: pet-type robot intervention CG: usual care TG: plush toy intervention	Participants interacted with PARO as they liked.	Three times/week, 15 min/session, 10 weeks	Individual	Baseline, 1 weeks, 5weeks, 10 weeks, 15weeks	CMAI-SF/ motor activity / sleep patterns

F, female; M, male; IG, intervention group; CG, control group; TG: toy group; SD, standard deviation; NA, not available; CMAI-SF, Cohen-Mansfield Agitation Inventory-Short Form; NPI-Q, Neuropsychiatric Inventory Brief Questionnaire Form; CSDD, Cornell Scale for Depression in Dementia; QUALID, Quality of Life in Late-Stage Dementia scale; BARS, Brief Agitation Rating Scale; MMSE, Mini Mental State Examination; APADEM-NH, Apathy Scale for Institutionalized Patients with Dementia Nursing Home version; NPI, Neuropsychiatric Inventory; RAID, Rating Anxiety in Dementia Scale; GDS[1],Global Deterioration Scale; QOL-AD, Quality of Life in Alzheimer's Disease scale; AWS, Revised Algase Wandering Scale; AES, Apathy Evaluation Scale; GDS[2], Geriatric Depression Scale.

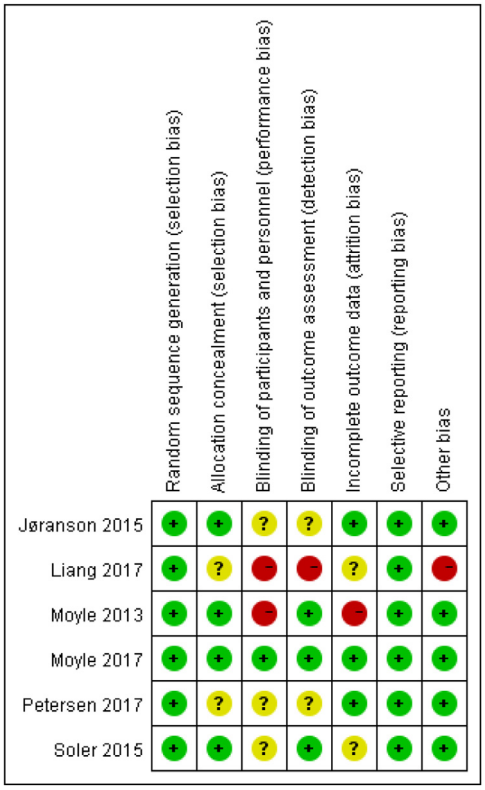

Fig. 2. Risk of bias summary: review of the authors' judgments about each risk of bias item for each included study.

3.3. Meta-analysis results of PRI among people with dementia

3.3.1. Primary outcomes

3.3.1.1. BPSD. All six studies (Jøranson et al., 2015; Liang et al., 2017; Moyle et al., 2013, 2017; Petersen et al., 2017; Soler et al., 2015) provided detailed data on BPSD.(Liang et al., 2017) examined the effects of PRI on agitation, depression, and neuropsychiatric symptoms in older adults with dementia. They found that PARO significantly improved depressive symptoms compared with those of the controls. However, there were no significant differences in agitation or neuropsychiatric symptoms between the intervention and control groups. Jøranson et al. (2015) evaluated the effects of robot-assisted activity for 12 weeks with a follow-up after 12 weeks in people with dementia. There were no significant differences in the changes in agitation or depression between the groups from baseline to the end of the intervention. The important findings in this study were that statistically significant differences in the changes in agitation and depression were found between the groups from baseline to 12 weeks after the end of the intervention. It is uncertain what causes contributed to the significant results measured at follow-up; they may have been caused by changes in the psychosocial milieu or hormone levels. Soler et al. (2015) assessed the effects of 3 months of PRI on apathy and neuropsychiatric symptoms in people with dementia. Participants in the PARO group showed an improvement in apathy. However, there were no significant differences in neuropsychiatric symptoms between groups. Petersen et al. (2017) evaluated the effects of PRI on depression and anxiety in people with dementia. Treatment with the PARO robot for 12 weeks significantly decreased depression and anxiety in the treatment group. Moyle et al. (2013) assessed the effects of PRI on emotions in people with dementia. Small to moderate effects on Rating Anxiety in Dementia Scale (RAID) scores were observed in the treatment group compared to the reading group. However, there were no significant differences between the groups regarding effects on depression or apathy. In another study performed by. Moyle et al. (2017), the PARO robot was compared to a look-alike plush toy and usual care in people with dementia. When agitation was measured by video observation, PARO demonstrated effectiveness in reducing agitated behavior compared with usual care. When agitation was measured using the Cohen-Mansfield Agitation Inventory-Short Form scale (CMAI-SF), there were no significant differences among the 3 groups after the 10-week intervention. The result of the first meta-analysis showed that compared with the control participants, the participants in the intervention group experienced significant amelioration of global BPSD ($n = 384$, SMD = −0.38, 95% CI [−0.59, −0.18], $p = 0.0002$, $I^2 = 16\%$, the fixed-effects model; Fig. 3).

3.3.1.2. BPSD subgroups. The results from three studies (Jøranson et al., 2015; Liang et al., 2017; Moyle et al., 2017) showed that the PRI had a significant beneficial effect on agitation ($n = 216$, SMD = −0.37, 95%CI [−0.64, −0.09], $p = 0.008$, $I^2 = 28\%$). Four included studies (Jøranson et al., 2015; Liang et al., 2017; Petersen et al., 2017; Moyle et al., 2013) showed a beneficial effect on depression ($n = 174$, SMD = −0.35, 95%CI [−0.65, −0.04], $p = 0.03$, $I^2 = 66\%$). In addition, three studies (Petersen et al., 2017; Soler et al., 2015; Moyle et al., 2013) were included in an analysis of the effects of PRI on other subtypes of BPSD (anxiety or apathy). The results showed significant improvement in these subtypes compared to the control group ($n = 168$, SMD = −0.42, 95%CI [−0.72, −0.11], $p = 0.008$, $I^2 = 0\%$, the fixed-effects model; Fig. 4).

Two studies (Liang et al., 2017; Moyle et al., 2017) reported detailed data on individual format PRI, while four studies (Jøranson et al., 2015; Petersen et al., 2017; Soler et al., 2015; Moyle et al., 2013) reported detailed data on group format PRI. In the individual format subgroup, the results showed that the participants in the PRI group had a significant reduction in SMD scores for BPSD compared with the participants in the control groups ($n = 163$, SMD = −0.37, 95% CI [−0.69, −0.06], $p = 0.02$, $I^2 = 66\%$). In the group format subgroup, a significant reduction in SMD scores for BPSD was also observed ($n = 221$, SMD = −0.39, 95% CI [−0.66, −0.12], $p = 0.004$, $I^2 = 0\%$, the fixed-effects model; Fig. 5).

3.3.2. Secondary outcomes

3.3.2.1. Cognitive function. Three studies assessed the effects of PRI on

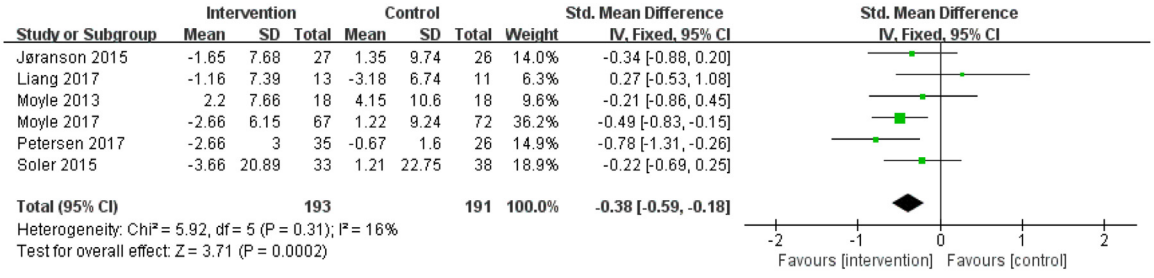

Fig. 3. The effect of PRI on BPSD.

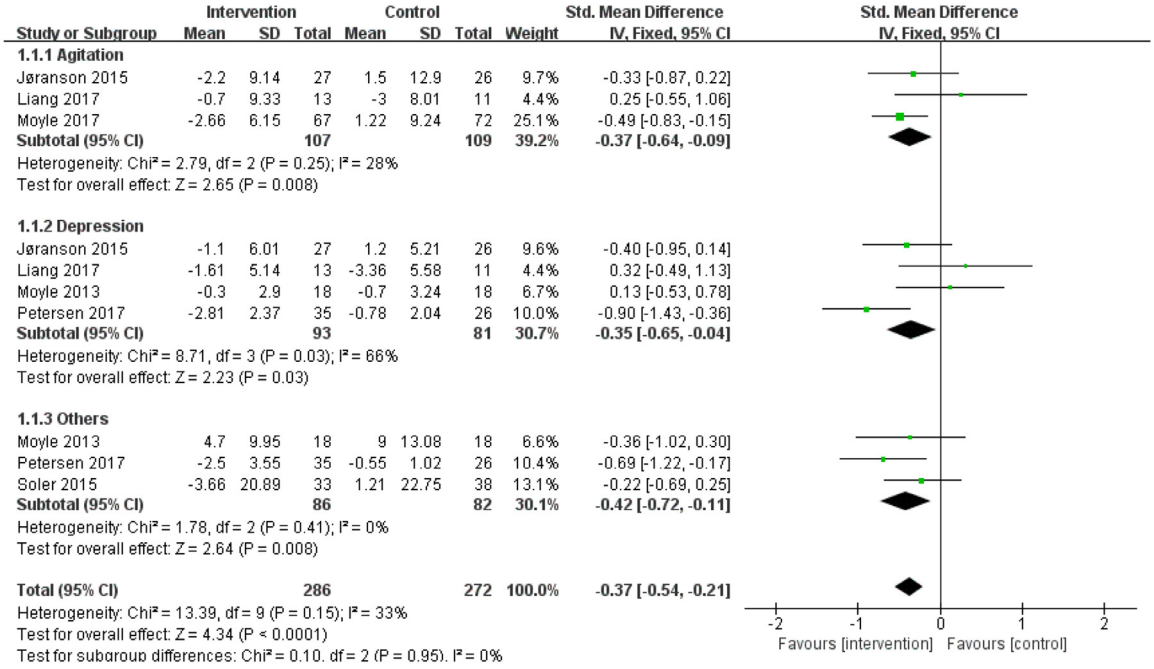

Fig. 4. The effects of PRI on agitation, depression and other types of BPSD.

cognitive function using Addenbrooke's Cognitive Examination (Liang et al., 2017), the Mini-Mental State Examination (MMSE) (Soler et al., 2015) and the Global Deterioration Scale (GDS) (Petersen et al., 2017). The meta-analysis showed no significant difference between the PRI group and the control group (n = 156, SMD = 0.02, 95% CI [−0.29, 0.34], p = 0.88, I^2 = 0%, the fixed-effect model; Fig. 6).

3.3.2.2. Quality of life. Three studies (Jøranson et al., 2016; Soler et al., 2015; Moyle et al., 2013) provided detailed data on quality of life. Moyle et al. (2013) reported Quality of Life in Alzheimer's Disease scale (QOL-AD) scores while the other two studies (Jøranson et al., 2016; Soler et al., 2015) reported Quality of Life in Late-Stage Dementia scale (QUALID) scores. The meta-analysis results showed that PRI had no significant effect on quality of life (n = 160, SMD = 0.19, 95% CI [−0.64, 1.01], p = 0.66, I^2 = 85%, the random-effects model; Fig. 7).

3.4. Description of outcomes not suitable for meta-analysis

BPSD can present as agitation and sleep disturbances. One core aspect of agitation is excessive motor activity (Cummings et al., 2015). A recent study (Moyle et al., 2018) assessed the effects of PARO on motor activity and sleep patterns in people with dementia, as measured by a wearable triaxial accelerometer. This article (Moyle et al., 2018) was not included in the meta-analysis because it measured different parameters and we could not combine the data to obtain information on the total motor activity and the total sleep quality. Instead, the effectiveness of PARO for these outcomes is described and summarized in the following narrative review. In this research, the PARO group was compared to the plush toy group and the usual care group. After the intervention, the PARO group showed a greater reduction in daytime step count than the plush toy group and a greater reduction in nighttime step count compared with both the plush toy group and the usual care group. The PARO group also had a greater reduction in nighttime physical activity than the usual care group. However, no significant differences were found among the 3 groups in the amount of time spent

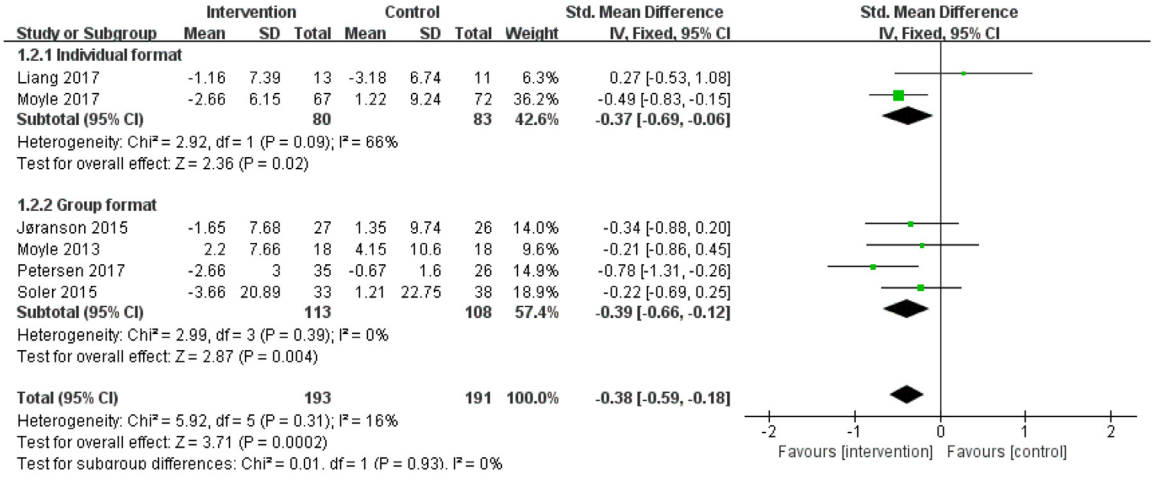

Fig. 5. Effects of the individual and group format PRI on BPSD.

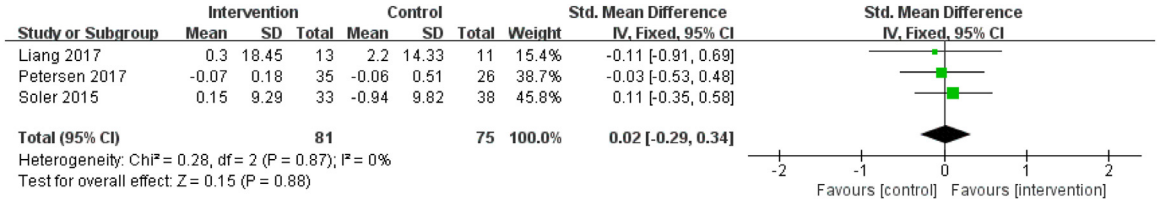

Fig. 6. The effect of PRI on cognitive function.

awake, lying down, and asleep during daytime and nighttime periods.

4. Discussion

4.1. Summary and interpretation of findings

Eight articles from six studies of PRI in people with dementia were included in our systematic review, and seven articles were included in our meta-analysis. The results of this meta-analysis showed a statistically significant decrease in BPSD, especially agitation and depression, in people with dementia who were treated with PRI. Both the individual and group format PRI significantly ameliorated BPSD. However, there were no significant improvements in cognitive function or quality of life. Quality of life includes psychological and physiological aspects. PRI can improve the mental state of people with dementia, but as time progresses, their physiological status may continue to worsen; thus, PRI may not have an overall positive impact on quality of life.

In 2013, the International Association of Human-Animal Interaction Organizations (IAHAIO) established animal-assisted intervention as a structured and goal-oriented intervention that aims to incorporate animals into human services, health, and education for the therapeutic benefit to humans. In recent years, several studies (Friedmann et al., 2014; Majić et al., 2013; Menna et al., 2016; Moretti et al., 2011) have confirmed the beneficial effects of animal-assisted intervention on BPSD. The underlying mechanism may be explained by changes in hormone levels (Handlin et al., 2012), self-efficacy (Bandura, 1977), biophilia (Beetz, 2017), anthropomorphism (Beetz, 2017; Urquiza-Haas and Kotrschal, 2015), social support (Barker et al., 2003; Heinrichs et al., 2003) or attachment (Miesen, 1993) that occur when people with dementia are in contact with animals. Although animal-assisted interventions have several positive effects on people with dementia, some potential safety risks to patients, staff or visitors may arise during implementation (Soler et al., 2015; Velde et al., 2015). In addition, in some countries, such as Japan, animals are not allowed in nursing homes or hospitals (Kimura et al., 2010). Moreover, caring for animals requires a great deal of human, material and financial resources (Soler et al., 2015). Pet robots aim to mimic the benefits of caring for animals while circumventing potential safety risks and minimizing costs (Preuß and Legal, 2017). Therefore, pet robots have been suggested as a potential viable alternative to real animals (Shibata, 2012; Wada et al., 2008). Similar to animal-assisted intervention, PRI may exert positive effects on people with dementia through similar mechanisms.

There are several explanations for the positive effects of PRI on BPSD in people with dementia. First, pet robots are thought to exert a calming influence by affecting the stress response (Bemelmans et al., 2012; Mordoch et al., 2013). Some researchers believe that in a positive social context, an increase in the hormone oxytocin will lower blood pressure and reduce cortisol levels, resulting in a reduced stress response, which is seen as a response to the positive social interaction occurring in the PRI setting (Jøranson et al., 2015; Uvnäsmoberg, 1998). A previous PRI study (Wada and Shibata, 2007a) reported that oxytocin levels were increased after the intervention. Another study (Robinson et al., 2015) showed that after stroking and interacting with a PARO, participants' systolic and diastolic blood pressure values decreased compared to their baseline values. In most of the included studies, hormone levels and physiological parameters were not measured; however, a similar response might provide a plausible explanation for the declining trend in BPSD observed during the intervention. Second, physical interaction with pet robots included stroking, hugging and petting (Chang and Huber, 2013; Takayanagi et al., 2014). Petting the soft fur of pet robots could stimulate the participants' palms, mimicking the effects of hand massages. A previous study found that hand massages release stress-relieving hormones that alter stress responses and reduce neuropsychiatric symptoms such as depression and agitation in older adults (Remington, 2002). People with dementia usually show higher levels of stress (Kikhia et al., 2016), and they are likely to have similar beneficial health responses when interacting with pet robots. If interacting with pet robots can create emotions similar to those experienced when caring for real pets, this effect may help explain the increased levels of oxytocin measured in a previous pet robot study (Wada and Shibata, 2007a). In short, some of the main reasons for the decreased BPSD in the intervention group include reduced stress responses and calming effects caused by social and physical interactions with pet robots.

In our study, subgroup analysis showed that both individual and group format PRI had beneficial effects on BPSD. Previous studies (Marti et al., 2006; Wada et al., 2004) have shown that interacting with pet robots in a group format can enhance cooperation and communication with other participants, therapists and staff. However, interacting with pet robots in an individual format can better meet the needs of the participants and reflect the purpose of personalized care. In a recent study (Liang et al., 2017), most participants preferred one-on-one engagement with pet robots compared to shared group interactions, suggesting that one-on-one interactions with pet robots are important and meaningful in dementia care. To date, no empirical studies have investigated which intervention format has the strongest therapeutic effect in clinical practice. Future research may focus on exploring which intervention formats are most effective for people with dementia.

Some PRI studies found that the mood of participants was ameliorated based on video observations of the activity period; people with dementia were described as exhibiting more smiles, laughter, pleasure, and positive emotional expressions during the interaction (Moyle et al.,

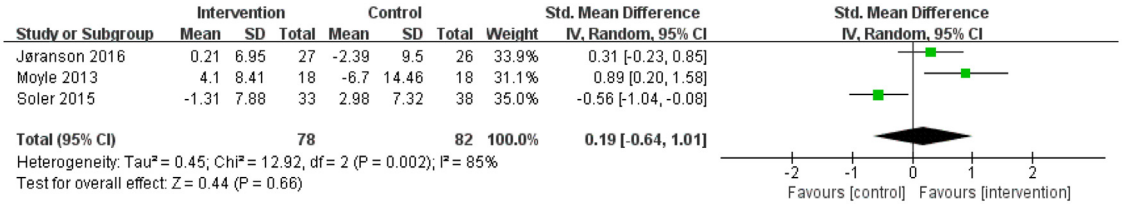

Fig. 7. The effect of PRI on quality of life.

2017; Takayanagi et al., 2014; Wada and Shibata, 2007b; Wada et al., 2004). In Moyle's study (Moyle et al., 2017), video observation for 15 min before the intervention and 15 min during the intervention revealed that compared with the participants in the control group, the participants who interacted with the PARO exhibited greater pleasure. In Takayanagi's study (Takayanagi et al., 2014), a time sampling method was used to analyze the participants' responses during the initial 6 min of interaction with the PARO. The video data suggested that the participants laughed more frequently with the PARO than with a toy and exhibited more positive changes in emotional expression with the PARO than with a toy. Data recorded by video are more objective and accurate and are suitable for research involving people with dementia. Therefore, future research could utilize this assessment method.

However, we found no statistically significant effects of PRI on cognitive function or quality of life. Our findings regarding cognitive function are expected, because dementia is a degenerative and progressive brain disease, and it is impractical to expect PRI to restore cognitive function to a normal state. Our results are also consistent with the findings reported in another literature review (Bernabei et al., 2013 showing that animal-assisted intervention for people with dementia have positive effects on coping ability and communication but not cognitive state. Regarding the effect of PRI on quality of life, the results of the three studies (Jøranson et al., 2016; Soler et al., 2015; Moyle et al., 2013) that we included are controversial. Soler et al. (2015) and Moyle et al., (2013) reported a significant effect of PRI on quality of life in people with dementia compared to participants in the control group. Jøranson et al. (2016) found no significant effects on quality of life in people with dementia who received PRI compared with those who received usual care. Another RCT was not included in our meta-analysis because not all participants had dementia (only 48% of participants showed signs of cognitive impairment); the results of that study also showed no significant differences in the change in quality of life between the groups from baseline to the end of the intervention. Thus, the effect of PRI on quality of life in people with dementia remains unclear. The inconsistencies in the reported results may be due to the use of different assessment tools, the subjective nature of the assessments, the use of different sample sizes, or the inclusion of people with different severities of dementia. Nevertheless, due to the insufficient evidence in these categories in our included studies, further research should be performed to explore other parameters in addition to BPSD.

4.2. Issues that require attention and directions for future research

Our findings suggest that PRI may be suitable as a treatment option for BPSD in people with dementia and should be considered as a useful tool in clinical practice. Several issues require attention to advance research on the effects of PRI in people with dementia. First, it is important to introduce pet robots in an appropriate manner, taking into account cultural differences in the acceptance of pet robots. In Asian countries, animal-assisted intervention is not universally accepted, and people tend to accept pet robots as companions rather than therapeutic tools. In contrast, Europeans tend to pay attention to the effects of an interaction with pet robots and accept them as therapeutic tools because animal-assisted intervention has been widely used. Americans tend to accept pet robots as therapeutic tools as well as companions. Second, applicability might vary from person to person, as not everyone likes pet robots or is interested in PRI. Therefore, we suggest that planners who formulate PRI protocols should take into consideration the participant's previous life background when choosing the most suitable type of pet robot. Third, for future studies, the assessments of outcome measures should be as comprehensive as possible and should use a combination of self-reported measures, objective records (such as video records) and subjective assessments. This approach could more accurately reveal the effects of PRI. Fourth, the cost of pet robots should be considered when deciding to introduce pet robots into care facilities or research. In addition, pet robots need to be serviced in the event of malfunction, and the cost of repairs and the time required for service may limit their availability. Finally, it would be best for an organization that is planning to initiate PRI programming to develop formal guidelines for the PRI schedule, including the frequency and duration of each session as well as the duration of the entire intervention process. In most of the studies that we included in this analysis, the frequency of the sessions, the time per session, and the duration of the entire intervention ranged from twice per week to three times per week (mostly three times per week), 15–40 min (mostly 30 min), and six weeks to three months (three months was common), respectively. Consequently, because the intervention durations in prior studies have been short, future studies should extend the duration of the intervention to explore the optimal duration.

4.3. Strengths and limitations

A strength of this meta-analysis is that only RCTs were included, which implies that the included studies had a rigorous study design. This study also has some limitations. First, only eight articles reported from six trials were included in the study. Although each trial provided detailed data on BPSD, data were less sufficient regarding secondary outcomes; only three trials provided detailed data on cognitive function, and three trials provided detailed data on quality of life. The limited number of trials limits the strength of the evidence and resulted in a poor interpretation of the findings of some of these studies. However, we believe that with the development of intelligent robots, an increasing number of researchers will explore the effectiveness of PRI in people with dementia. Second, the included studies used varying approaches, e.g., facilitated and non-facilitated interventions, group and individual interventions, cluster and parallel methods, and varying durations of the intervention. Thus, the optimal intervention design for eliciting beneficial effects remains unclear. Third, although there are many types of pet robots, the pet robots used in the interventions in our included studies were all PARO robots, so a subgroup analysis based on the type of pet robot could not be performed. Future research could focus on exploring which type of pet robot is most effective. Fourth, the characteristics of people with dementia (e.g., the severity and subtype of dementia) who may benefit the most from PRI remain to be established. Finally, we searched only a few English language databases. Therefore, some studies may have been missed.

5. Conclusions

A total of eight articles from six studies of PRI in people with dementia were included in our systematic review. The results of the meta-analysis showed that PRI have positive effects on BPSD in people with dementia. However, the potential beneficial effects on cognition and quality of life remain unclear. Considering that most of the included studies were of low to moderate quality and that only one study conducted by Moyle et al. (2017) met the seven criteria for RCTs, there is a potential risk of bias. The limited number of included studies and the potential risk of bias limit the strength of the evidence, so developers who make positive comments on the effectiveness of PRI should be cautious about these results. Larger-scale studies using more rigorously designed and standardized protocols are needed to draw specific and accurate conclusions.

Funding sources

This research did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

The authors would like to thank Dr. Changgui Kou from the School of Public Health at Jilin University for his guidance and review of the data analysis.

References

Abdi, J., Al-Hindawi, A., Ng, T., Vizcaychipi, M.P., 2018. Scoping review on the use of socially assistive robot technology in elderly care. BMJ Open 8, e018815.
Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychol. Rev. 1, 139–161.
Barker, S.B., Pandurangi, A.K., Best, A.M., 2003. Effects of animal-assisted therapy on-patients' anxiety, fear, and depression before ECT. J. ECT. 19, 38–44.
Beetz, A.M., 2017. Theories and possible processes of action in animal assisted interventions. Appl. Dev. Sci. 21, 139–149.
Bemelmans, R., Gelderblom, G.J., Jonker, P, Witte, L.D., 2012. Socially assistive robots in elderly care: asystematic review into effects and effectiveness. J. Am. Med. Dir. Assoc. 13, 114–120.
Bernabei, V., De Ronchi, D., La Ferla, T., Moretti, F., Tonelli, L., Ferrari, B., et al., 2013. Animal-assisted interventions for elderly patients affected by dementia or psychiatricdisorders: a review. J. Psychiatr. Res. 47, 762–773.
Broekens, J., Heerink, M., Rosendal, H., 2009. Assistive social robots in elderly care: a review. Gerontechnology 8, 94–103.
Chang, W.L., Huber, L., 2013. Situated analysis of interactions between cognitively impaired older adults and the therapeutic robot PARO. Int. Con. Soc. Robo. 8239, 371–380.
Cohen, J, 1962. The statistical power of abnormal-social psychological research: a review. J Abnorm. Soc. Psychol. 65, 145–153.
Cummings, J., Mintzer, J., Brodaty, H., Sano, M., Banerjee, S., Devanand, D.P., et al., 2015. Agitation in cognitive disorders: International Psychogeriatric Association provisional consensus clinical and research definition. Int. Psychogeriatr. 27, 7–17.
Dyer, S.M., Harrison, S.L., Laver, K., Whitehead, C., Crotty, M., 2017. An overview of systematic reviews of pharmacological and non-pharmacological interventions for the treatment of behavioral and psychological symptoms of dementia. Int. Psychogeriatr. 30, 295–309.
Fauth, E.B., Gibbons, A., 2014. Which behavioral and psychological symptoms of dementia are the most problematic? Variability by prevalence, intensity, distress ratings, and associations with caregiver depressive symptoms. Int. J. Geriatr. Psychiatry. 29, 263–271.
Fleiner, T., Leucht, S., Foerstl, H., Zijlstra, W., Haussermann, P., 2016. Effects of short-term exercise interventions on behavioral and psychological symptoms in patients with dementia: a systematic review. J. Alzheimers. Dis. 55, 1583–1594.
Friedmann, E., Galik, E., Thomas, S.A., Hall, P.S., Chung, S.Y., Mccune, S., 2014. Evaluation of a Pet-Assisted Living Intervention for improving functional status in assisted living residents with mild to moderate cognitive impairment: apilot study. Am. J. Alzheimers. Dis. Other. Demen. 30, 276–289.
Garcia-Casares, N., Moreno-Leiva, R.M., Garcia-Arnes, J.A., 2017. Music therapy as a non-pharmacological treatment in Alzheimer's disease: A systematic review. Rev Neurol 65, 529–538.
Givens, J.L., Jones, R.N., Mazor, K.M., Prigerson, H.G., Mitchell, S.L., 2015. Development and psychometric properties of the family distress in advanced dementia scale. J. Am. Med. Dir. Assoc. 16, 775–780.
Guideline Adaptation Committee, 2016. Clinical practice guidelines and principles of care for people with dementia. Sydney: NHMRC Cognitive Decline Partnership Centre. Available at: http://www.clinicalguidelines.gov.au/portal/2503/clinical-practice-guidelines-and-principles-care-people-dementia.
Handlin, L., Nilsson, A., Ejdebäck, M., Hydbringsandberg, E., Uvnäsmoberg, K., 2012. Associations between the psychological characteristics of the human–dog relationship and oxytocin and cortisol levels. Anthrozoös 25, 215–228.
Heinrichs, M., Baumgartner, T., Kirschbaum, C., Ehlert, U., 2003. Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. Biol. Psychiatry 54, 1389–1398.
Higgins, J.P., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in meta-analyses. BMJ 327, 557–560.
Higgins, J.P.T., Green, S., 2011. Cochrane Handbook For Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration.
Hu, M., Zhang, P., Leng, M., Li, C., Chen, L., 2018. Animal-assisted intervention for individuals with cognitive impairment: a meta-analysis of randomized controlled trials and quasi-randomized controlled trials. Psychiatry. Res. 260, 418–427.
Huei-Chuan Sung, R.N., Msn, S.M.C.R., Msn, M.Y.C.R., Lee, W.L., 2015. Robot-assisted therapy for improving social interactions and activity participation among institutionalized older adults: a pilot study. Asia. Pac. Psychiatry. 7, 1–6.
Jøranson, N., Pedersen, I., Rokstad, A.M., Ihlebæk, C., 2015. Effects on symptoms of agitation and depression in persons with dementia participating in Robot-Assisted Activity: acluster-randomized controlled trial. J. Am. Med. Dir. Assoc. 16, 867–873.
Jøranson, N., Pedersen, I., Rokstad, A.M., Ihlebæk, C., 2016. Change in quality of life in older people with dementia participating in Paro-activity: a cluster-randomized controlled trial. J. Adv. Nurs. 72, 3020–3033.
Kales, H.C., Gitlin, L.N., Lyketsos, C.G., 2015. Assessment and management of behavioral and psychological symptoms of dementia. BMJ 350, h369.
Kikhia, B., Stavropoulos, T.G., Andreadis, S., 2016. Utilizing a wristband sensor to measure the stress level for people with dementia. Sensors 16, 1989–2005.
Kimura, R., Miura, K., Murata, H., Yokoyama, A., Naganuma, M., 2010. Consideration of physiological effect of robot assisted activity on dementia elderly by electro-encephalogram (EEG): estimation of positive effect of RAA by neuroactivity diagram. Proc. IEEE 102, 1418–1422.
Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U.M., et al., 2017. A pilot randomized trial of a companion robot for people with dementia living in the community. J. Am. Med. Dir. Assoc. 18, 871–878.
Ma, H., Huang, Y., Cong, Z., Wang, Y., Jiang, W., Gao, S., et al., 2014. The efficacy and safety of atypical antipsychotics for the treatment of dementia: a meta-analysis of randomized placebo-controlled trials. J Alzheimers Dis. 42, 915–937.
Majić, T., Gutzmann, H., Heinz, A., Lang, U.E., Rapp, M.A., 2013. Animal-Assisted Therapy and agitation and depression in nursing home residentswith dementia: amatched case–control trial. Am. J. Geriatr. Psychiatry. 21, 1052–1059.
Marti, P., Bacigalupo, M., Giusti, L., Mennecozzi, C., 2006. Socially assistive robotics in the treatment of behavioural and psychological symptoms of dementia. In: Proc. IEEE. RAS. EMBS. Int. Conf. Biomed. Robot. Biomechatron. 14. pp. 483–488.
Menna, L.F., Santaniello, A., Gerardi, F., Maggio, A.D., Milan, G., 2016. Evaluation of the efficacy of animal-assisted therapy based on the reality orientation therapy protocol in Alzheimer's disease patients: a pilot study. Psychogeriatrics 16, 240–246.
Miesen, B.M.L., 1993. Alzheimer's disease, the phenomenon of parent fixation and bowlby's attachment theory. Int. J. Geriatr. Psychiatry. 8, 147–153.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Group, P., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. PLoS. Med. 6, e1000097.
Mordoch, E., Osterreicher, A., Guse, L., Roger, K., Thompson, G., 2013. Use of social commitment robots in the care of elderly people with dementia: a literature review. Maturitas 74, 14–20.
Moretti, F., De Ronchi, D., Bernabei, V., 2011. Pet therapy in elderly patients with mental illness. Psychogeriatrics. 11, 125–129.
Morrin, H., Fang, T., Servant, D., Aarsland, D., Rajkumar, A.P., 2017. Systematic review of the efficacy of non-pharmacological interventions in people with Lewy body dementia. Int. Psychogeriatr. 30, 395–407.
Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., et al., 2013. Exploring the effect of companion robots on emotional expression in older adults with dementia: a pilot randomized controlled trial. J. Gerontol. Nurs. 39, 46–53.
Moyle, W., Jones, C., Murfield, J., Thalib, L., Beattie, E., Shum, D., et al., 2018. Effect of a robotic seal on the motor activity and sleep patterns of older people with dementia, as measured by wearable technology: a cluster-randomised controlled trial. Maturitas 110, 10–17.
Moyle, W., Jones, C.J., Murfield, J.E., Thalib, L., Beattie, E.R.A., Shum, D.K.H., et al., 2017. Use of a robotic seal as a therapeutic tool to improve dementia symptoms: acluster-randomized controlled trial. J. Am. Med. Dir. Assoc. 18, 766–773.
Peters, M.E., Schwartz, S., Han, D., 2015. Neuropsychiatric symptoms as predictors of progression to severe Alzheimer's dementia and death: the cache county dementia progression study. Am. J. Geriatr. Psychiatry 172, 460–465.
Petersen, S., Houston, S., Qin, H., Tague, C., Studley, J., 2017. The utilization of robotic pets in dementia care. J. Alzheimers. Dis. 55, 569–574.
Preuß, D., Legal, F., 2017. Living with the animals: animal or robotic companions for the elderly in smart homes? J. Med. Ethics. 43, 407–410.
Prince, M., Comas-Herrera, A., Knapp, M., Guerchet, M., Karagiannidou, M., 2016. WorldAlzheimer Report 2016: improving healthcare for people living with dementia: coverage, quality and costs now and in the future. Alzheimer's DiseaseInternational, London.
Pu, L., Moyle, W., Jones, C., Todorovic, M., 2018. The effectiveness of social robots for older adults: a systematic review and meta-analysis of randomized controlled studies. 46.
Reiser, U., Jacobs, T., Arbeiter, G., Parlitz, C., Dautenhahn, K., 2013. Care-O-bot ® 3: vision of a robot butler. Lect. Note Comput. Sci. 7407, 97–116.
Remington, R., 2002. Calming music and hand massage with agitated elderly. Nurs. Res. 51, 317–323.
Rm, V.D.L., Dening, T., Matthews, F.E., Brayne, C., 2014. Grouping of behavioural and psychological symptoms of dementia. Int. J. Geriatr. Psychiatry. 29, 562–568.
Robinson, H., Macdonald, B., Broadbent, E., 2015. Physiological effects of a companion robot on blood pressure of older people in residential care facility: a pilot study. Australas. J. Ageing. 34, 27–32.
Robinson, H., Macdonald, B., Kerse, N., Broadbent, E., 2013. The psychosocial effects of a companion robot: arandomized controlled trial. J. Am. Med. Dir. Assoc. 14, 661–667.
Rosenberg, P.B., Nowrangi, M.A., Lyketsos, C.G., 2015. Neuropsychiatric symptoms in Alzheimer's disease: what might be associated brain circuits? Mol. Aspects Med. 43, 25–37.
Schneider, L.S., Tariot, P.N., Dagerman, K.S., Davis, S.M., Hsiao, J.K., Ismail, M.S., et al., 2006. Effectiveness of atypical antipsychotic drugs in patients with Alzheimer's disease. N. Engl. J. Med. 355, 1525–1538.
Seitz, D., Purandare, N., Conn, D., 2010. Prevalence of psychiatric disorders among older adults in long-term care homes: a systematic review. Int. Psychogeriatr. 22, 1025–1039.
Seitz, D.P., Gill, S.S., Herrmann, N., 2013. Pharmacological treatments for neuropsychiatric symptoms of dementia in long-term care: a systematic review. Int. Psychogeriatr. 25, 185–203.
Shibata, T., 2012. Therapeutic seal robot as biofeedback medical device: qualitative and quantitative evaluations of robot therapy in dementia care. Proc. IEEE. 100, 2527–2538.
Sink, K.M., Holden, K.F., Yaffe, K., 2005. Pharmacological treatment of neuropsychiatric symptoms of dementia: a review of the evidence. JAMA 293, 596–608.
Soler, M.V., Agüera-Ortiz, L., Olazarán, R.J., Mendoza, R.C., Pérez, M.A., Rodríguez, P.I., et al., 2015. Social robots in advanced dementia. Front. Aging. Neurosci. 7, 133–144.

Takayanagi, K., Kirita, T., Shibata, T., 2014. Comparison of verbal and emotional responses of elderly people with mild/moderate dementia and those with severe dementia in responses to seal robot, PARO. Front. Aging. Neurosci. 6, 257–261.
Tan, C.C., Yu, J.T., Wang, H.F., Tan, M.S., Meng, X.F., Wang, C., et al., 2014. Efficacy and safety of donepezil, galantamine, rivastigmine, and memantine for the treatment of Alzheimer's disease: a systematic review and meta-analysis. J. Alzheimers Dis 41, 615–631.
Tripathi, M., Vibha, D., 2010. An approach to and the rationale for the pharmacological management of behavioral and psychological symptoms of dementia. Ann. Indian Acad. Neurol. 13, 94–98.
Urquiza-Haas, E.G., Kotrschal, K., 2015. The mind behind anthropomorphic thinking: attribution of mental states to other species. Anim. Behav. 109, 167–176.
Uvnäsmoberg, K., 1998. Oxytocin may mediate the benefits of positive social interaction and emotions. Psychoneuroendocrinology. 23, 819–835.
Velde, B.P., Cipriani, J., Fisher, G., 2015. Resident and therapist views of animal-assisted therapy: implications for occupational therapy practice. Aust. Occup. Ther. J. 52, 43–50.
Wada, K., Shibata, T., 2007a. Living with seal robots—its sociopsychological and physiological influences on the elderly at a care house. IEEE. Trans. Robot. 23, 972–980.
Wada, K., Shibata, T., 2007b. Social effects of robot therapy in a care house - change of social network of the residents for two months. IEEE. Int. Conf. Robot. Autom. 107, 1250–1255.
Wada, K., Shibata, T., Musha, T., Kimura, S., 2008. Robot therapy for elders affected by dementia. IEEE Eng. Med. Biol. Mag. 27, 53–60.
Wada, K., Shibata, T., Saito, T., Tanie, K., 2004. Effects of robot-assisted activity for elderly people and nurses at a day service center. Proc. IEEE. 92, 1780–1788.
Wetzels, R.B., Zuidema, S.U., de Jonghe, J.F., Verhey, F.R., Koopmans, R.T., 2010. Determinants of quality of life in nursing home residents with dementia. Dement. Geriatr. Cogn. Disord. 29, 189–197.