Effects of horticultural therapy on health in the elderly: A review and meta-analysis

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Abstract

Given the current aging population, the demand on medical facilities, facilities for elderly care, and even their high prevalence, it is crucial to investigate the advantages of older people. The amount of scholarly literature examining natural factor-related activities to enhance older people's health status has steadily risen over the last few decades. But the scope of the present review is limited. We compiled the results of 33 peer-reviewed publications and conducted a meta-analysis using a total of 27 relevant variables to assess the advantages of horticultural therapy (HT) for, among other things, the physical and psychological functioning of the elderly. Results show that horticultural therapy may be helpful in helping seniors lose weight -0.195 (95% CI -0.507,0.117), reduce their waist circumference -0.327 (95% CI -0.637, -0.017), improve their physical flexibility (chair sit-and-reach) 0.302 (95% CI 0.036, 0.569), lower their stress -0.339 (95% CI -0.610, -0.069) and cortisol -0.902 (95% CI -0.728, -0.002) levels, improve social interaction 0.370, (95% CI 0.115, 0.624), increase daily vegetables and fruit consumption 0.688 (95% CI: 0.287, 1.089). HT may be a useful tool for enhancing the physical, mental and social aspects of older adults.

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Abstract : Given the current aging population, the demand on medical facilities, facilities for elderly care, and even their high prevalence, it is crucial to investigate the advantages of older people. The amount of scholarly literature examining natural factor-related activities to enhance older people's health status has steadily risen over the last few decades. But the scope of the present review is limited. We compiled the results of 33 peer-reviewed publications and conducted a meta-analysis using a total of 27 relevant variables to assess the advantages of horticultural therapy (HT) for, among other things, the physical and psychological functioning of the elderly. Results show that horticultural therapy may be helpful in helping seniors lose weight -0.195 (95% CI -0.507,0.117), reduce their waist circumference -0.327 (95% CI -0.637, -0.017), improve their physical flexibility (chair sit-and-reach) 0.302 (95% CI 0.036, 0.569), lower their stress -0.339 (95% CI -0.610, -0.069) and cortisol -0.902 (95% CI -0.728, -0.002) levels, improve social interaction 0.370, (95% CI 0.115, 0.624), increase daily vegetables and fruit consumption 0.688 (95% CI: 0.287, 1.089). HT may be a useful tool for enhancing the physical, mental and social aspects of older adults. However, there is substantial heterogeneity and wide variation in the quality of the included studies. Further high-quality

studies, rigorous controls and adjustments for significant confounding variables, and larger populations are needed in the future to further our understanding of the link between HT and elder health.

Keywords: Horticultural Therapy; Elderly; Health; Meta-analysis

1. Introduction

With increasing life expectancy, there is a significant increase in the proportion of elderly and very elderly population and the problems caused by age-related diseases. Social support for the elderly is also becoming increasingly prominent. Sustained attention toward these problems is of highly important for medical expenditure and policy planning, labor trend forecast, and economic orientation of a country.

Older individuals are more vulnerable to physical decline, cognitive decline, and social inequality because of a variety of factors. There are three major enablers for these declines and issues. The first enabler is body composition changes and changes in physical function and metabolic risk factors associated with aging (Wilson and Kannel, 2002). Brain diseases (cerebral arteriosclerosis, cerebral hemorrhage, and senile dementia) (Parkar, 2015; Lyonset al., 2017), cardiovascular diseases (heart failure and coronary heart disease), digestive system diseases (chronic gastritis, constipation, and cirrhosis), respiratory system diseases, bone and muscle mass loss, and other common diseases of the elderly pose a great threat to their health and life (Bauer, Hödl and Eglseer, 2020). The second enabler is psychological diseases, with common diseases including depression, anxiety, and suspicious (Abdoli et al., 2021). In addition, previous studies have shown that social concerns, including ageism and prejudice (Li et al., 2021), reduced social interaction in the family or community (Gyasi et al., 2020), and lifestyle-related issues (such as sedentary behavior, dietary risks, decreased fruit and vegetable consumption), are also important factors affecting the health of the elderly. These risks greatly affect the survival of the elderly. Especially since the COVID-19 outbreak, quarantine measures and social panic in some areas have led to reduced physical activity and sleep disturbances, as well as increased psychological symptoms among elderly (McKinlay et al., 2021; Lebrasseur et al., 2021; Gorenko et al., 2020).

WHO has proposed that the main indicators of health evaluation in elderly should not only focus on death and illness but should also pay attention to the quality of life and activities of daily living among elderly (Siegrist, 2000). When they are in poor health, happiness will reduce, and the quality of life will decline (Nina, 1992). Access to medical and/or pharmacological intervention alone is not sufficient to control these conditions (Afrooz et al., 2015). We have found strong recent evidence indicating that horticultural therapy programs (HT) can reduce morbidity, are cost effective, and achieve better outcomes in the elderly who are already in poor health conditions (Söderback et al., 2004). In the past, we believed that gardening, which is the work of growing, caring for plants, and maintaining the attraction of gardens, as an art or science other than botany (Smith, 1998). Gardening is now often understood as a form of leisure, or as a means that is the easiest to achieve easy accessibility to a green space, or as a special therapeutic program (Joseph et al., 2017). The benefits of gardening may not only be limited to improved diet of individuals and increased ornamental value of a space but also include improved physical function, improved quality of life, and/or development of a social skill (e.g., via shared open spaces, skill building, and social bonding) (Rebecca et al., 2019). For some people, HT may help promote the mind-body-spirit connection (Chan et al., 2017). However, the definition of HT is complicated, and therapeutic gardening is thought to have the same meaning. Therefore, the definition of HT by the American society of horticultural therapy (AHTA) was adopted. HT is an effective complementary therapy for the social, educational, psychological, and physical adjustment of people in need of physical and mental assistance in the use of plant cultivation and gardening activities, assisted by trained therapists (Walters, 1980; Smith, 1998). Although HT was introduced by the British scholar Linato Mecca in 1699, it has considerably evolved in the recent decades (Blake and Mitchell, 2016). HT has been shown to improve or ease memory problems in patients (Shimada et al., 2019), especially those with Alzheimer's disease, helping them focus and gain confidence (Pedrinolla et al., 2019). It is also another effective nonpharmacological method for delaying the negative effects of aging. HT has been proven to enhance telomerase activity that can ameliorate DNA damage and stimulate DNA Damage Repair (DDR) (Lu et al., 2001), preventing not only replicating senescence but also senescence induced

by oxidative stress and, thus, senescence-related age-related macular degeneration (AMD) (Christine, 2013). Potted flowers, flower bed making, plant pruning, and other gardening activities can help the elderly improve their living habits, forget worries, and improve their sleep quality (Gorenko et al., 2020). While participating in sowing, transplanting, watering, fertilizing, and harvesting activities (Sin-Ae et al., 2020; Makizako et al., 2015), the elderly sit, stand, and bend, using their eyes, head, fingers, hands, and feet at the same time for a comprehensive movement, leading to effective movement and preventing aging (Mallory et al., 2016). For elderly with limited access to social and material resources, HT has the potential to increase social interaction (Gonzalez et al., 2011). For example, participants share gardening diaries as a topic, which can foster coordination with others, improve social skills, reduce loneliness, and improve self-satisfaction and quality of life. However, there is also evidence showing that HT is less effective with time (Agnes and Custers, 2011).

Although a growing body of literature attempts to quantify the association between HT and health well-being among elderly, systematic evaluations in this field have mainly focused on trial-controlled outcomes (Nicholas et al., 2019) or on a single indicator (Peilin Lin et al., 2022). Previous reviews on this topic have been limited to 10 scopes (Yanping Lin et al., 2022), causing a lack of robustness of evidence. To systematically determine the effects of HT on the physical and mental health of elderly as well as on their quality of life, different types of studies were considered for quality assessment and for a more rigorous analysis of between-group effects. In this review, 33 recent studies were systematically reviewed, and their quality was evaluated.

2. Methods

2.1 Search strategy

The search strategy was adopted according to the Standard Method (PRISMA) of systematic evaluation and meta-analysis, using various terms to identify and eliminate interfering results. The search was performed by retrieving data from five databases: Web of science, ScienceDirect, PubMed, EBSCO, and Google Scholar (Yao et al., 2021). Search terms related to horticultural therapy, indoor gardening, green health, and elderly, elderly patients, etc. The search was limited to articles published in peer-reviewed journals before July 2022. In PubMed and Web of Science, we combined various terms to search. The search strategy for Google Scholar was to combine each simplified word and free word related to horticultural therapy and select the top 100 records with the highest correlation. The complete search strategy is shown in the supplementary material (Table S1). Since the terminology of "horticultural therapy" is usually interchangeable and knowledge in the field is limited, we did not choose other restrictions, focusing on HT and covering literature from clinical, medical and biological sciences, landscape architecture, and other disciplines.

2.2 Inclusion criteria

Therefore, to better and more objectively fit the purpose of our study, a comprehensive perspective was adopted, including original studies on HT and the elderly. Records in each database were independently screened by two reviewers (JY and TM) before full text reading. Duplicates and irrelevant papers were excluded using PICOS principles and the relevant papers were selected:

Participants: Individuals aged [?] 60 years (Singhal et al., 2021).

Intervention: As a means of intervention or complementary treatment, HT activities are not limited to indoor or outdoor locations. Selected articles focus on the use of plants as a material for work and production or performing various tasks under the guidance of a horticultural therapist as the main intervention; accordingly, it is not limited to just one method.

Comparator: A group of elders who participate in traditional activities or therapies, receive regular care or exercise, or attend educational classes, but do not participate in any gardening activities.

Outcome: Changes in physical or mental health or changes in lifestyle.

Interventional and observational studies were both included in our analysis. The sample of elders who participated in the study was selected regardless of their gender, physical or mental health conditions, and

psychiatric conditions. Further, because the terms HT or gardening activities are often interchangeable, we examined the articles carefully, and the study was not confined to indoor or outdoor settings. Studies reporting on growing flowers, crops, or herbs or other horticultural activities were considered, and those reporting on growing only short-term ornamental plants or using plants for aromatherapy were excluded. Interventions should focus on gardening or specific tasks in gardening as the main activity, but there was no limit with regard to the duration of the intervention. More detailed information on the screening criteria is provided in Table 1.

In accordance with PICO declarations and the eligibility criteria, the relevant titles, keywords, and abstracts were manually filtered by two reviewers (JY and TM), and the search process was overseen by the librarian. The records from each database were downloaded and merged into Endnote X9, and duplicates were removed. The coincidence rate was 88.5%. Subsequently, an author (JY) independently evaluated the full texts of all eligible articles (Higgins et al., 2011), extracting data using standardized tables to identify studies that needed to be included in the system evaluation. Another author (JY) verified the accuracy of the selection against the same criteria. In case of a disagreement, the paper was submitted to a third-party reviewer (WF) for adjudication and discussion until consensus was reached.

2.3 Data extraction

The full-text articles were thoroughly assessed for quality based on data filtering and extraction, and the articles that were deemed unsuitable for our search were excluded. The reasons for exclusion included a focus on primary outcomes other than health and well-being of elders (e.g., assessing the number of calories burned in gardening activities), incomplete analysis, or the average age of the participants not meeting the requirements. The remaining articles were included in a standardized extract form, and the following information was extracted: author, publication date, study site, experiment design, information about older participants (e.g., The percentage of female, Mean age), intervention method, measures, study duration, follow-up details, and outcome.

2.4 Quality Assessment

The PEDro scale (de Morton, 2009) was used to assess the methodological quality of all interventional studies (Appendix A). The tool is based on eleven domains: (1) eligibility criteria; (2) random assignment; (3) concealed assignment; (4) baseline similarity; (5) subject blinding; (6) therapist blinding; (7) assessor blinding; (8) [?]85% retention; (9) no missed data, administration (intention to treat analysis); (10) statistical comparison between groups; (11) point measures and variable measures. Appraisals were discussed by two researchers (YJ and WF), until a consensus was reached. A total of eight criteria of the modified Newcastle–Ottawa scale (Kunpeuk et al., 2020) were used to assess observational studies and cross-sectional studies. The data are presented in full in the supplementary materials (Appendix B).

2.5 Synthesis and Meta-analysis

After reviewing and extracting key data from each study, a narrative synthesis was performed. To be considered for meta-analysis, authors needed to provide 1) the mean, standard deviation (SD), and sample size for the horticultural and non-horticultural groups; and 2) report the health status of both groups and the measurement methods used in the study. Only two or more of data using the same measurement method were considered.

All data were directly obtained from articles and published supplementary materials, and STATA SE (version 15) was used for meta-analysis. The sample size and efficacy data for the HT and control group were extracted for studies to be included in the analysis. The combined effect size was evaluated by mean difference (MD), standard mean difference (SMD), and 95% confidence interval (CI) values for each parameter, and all results are shown as forest plots. Heterogeneity between data was quantified using I^2 statistics (Higgins, 2003), and a random effects model was selected. Publication bias of studies included in a meta-analysis can be intuitively assessed by Egger's test (Andreas et al., 1998). Moreover, we explored the causes through sensitivity analysis, and excluded each study to check its impact on the overall combined effect size, thus eliminating the need to

maintain homogeneity. If data from different subgroups were provided, each subgroup was entered separately and combined using state software to determine the causes of heterogeneity.

3 Results

The selection process of each study is described in detail in Figure 1. Overall, 65,915 studies were screened from five databases, of which 7,592 were excluded for duplication and 58,132 for apparent irrelevance of titles and abstracts. The remaining 191 studies were considered relevant for full-text reading and qualification assessment. Of these articles, 158 studies were excluded because of a lack of control group, no quantitative experiment, absence of required data, virtual gardening intervention, or other reasons. A total of 33 studies were finally included for quality assessment.

3.1 Study characteristics

Among the included studies, the number of studies published over the past decade showed a significant increase, indicating that horticultural therapy is gaining traction. The studies were conducted in different countries and regions. Most included studies were conducted in Asia, and the most frequently included countries were Japan (n=7) and China (n=7), followed by Korea (n=5). Six studies were conducted in the United States (Wendy et al., 2018; Karen and Tom, 2003; Jarrott and Gigliotti, 2010; Christina and Shannon, 2006; Park et al., 2009; Chen and Janke, 2012), two in the United Kingdom (Hawkins et al., 2011; Bail et al., 2018), and two in Italy (Pedrinolla et al. 2019; Marta et al., 2018). Further, three studies were conducted in Singapore (Glenn Choon Lim Wong et al., 2021; Kheng et al., 2018; Ng et al., 2021) and one in the Netherlands (van den Berg et al., 2010). A total of 11,779 participants recruited in nursing homes, geriatric community centers, hospitals, geriatric mental health centers, and geriatric welfare centers were included in all studies. The participant size varied from 16 (Suk-Young and Byung-Jin, 2010) to 4576 (Leng and Wang, 2016). Further, nine studies focused on patient conditions (e.g., dementia (Suk-Young and Byung-Jin, 2010; MochizukiKawai et al., 2021; Jarrott and Gigliotti, 2010; Christina and Shannon, 2005), psychological problems (Ah-Reum et al,. 2018; Yuka, 2013; Makizako et al., 2019), and cognitive decline (Tse, 2010; Pedrinolla et al., 2019), or a frail state (Claudia et al., 2018)). Two studies identified specific populations (cancer survivors) (Wendy et al., 2018; Bail et al., 2018). Of the 33 articles included, 25 were identified as intervention studies and 8 as observational studies. Females outnumbered males in all 25 intervention studies except for two that did not report gender, and three of those included only female subjects.

Among the eight observation studies (Table 2), six were cohort studies, one was cross-sectional study, and one was a case-control study. Of the 25 intervention studies, 23 used parallel trials and two used crossover trials. HT intervention studies were conducted with different research settings and treatment options, including nursing homes (n=10) or senior community center (n=2), participants' homes (n=3), mental health center (n=1), welfare center (n=1), indoor therapeutic garden (n=1), university laboratory (n=1), and parks and nature reserve (n=2); four studies did not mention the specific site. There were 10 studies in which horticulturists were advisers. In the remaining studies, follow-ups were conducted and gardening plans were made by researchers and assistants, assisted by medical staff (certified nurse, geriatricians, and neuropsychologists), social workers, and research collaborators. There were no adverse events attributable to any intervention trial. There were 12 studies that did not clearly indicate the attendance rate of participants in HT activities. The details of each intervention experiment are documented in Table 3.

3.2 Methodological Quality

3.2.1Interventional studies

The PEDro scores for interventional studies were highly variable (Table S2), ranging from 5 to 9 (poor to good quality). With regard to therapist blindness, all studies were judged to have low scores because, given the nature of the trial, therapist blindness was not possible. Four studies (Wendy et al., 2018; GCL Wong et al., 2021; Yuka, 2013; Bail et al., 2018) were rated high quality because they used concealed allocation and subject blinding, i.e., the person determining whether a subject was eligible to participate in the trial

or not was unaware of the group that the subject would be assigned to, and participants were randomly allocated to the experimental group. All studies scored 5 and above and described the selection criteria for determining who was eligible to participate in the study. However, the studies that did not involve blinding of participants (subjects, therapists, or assessors) or concealed assignment were considered to be of moderate quality. Eight of these studies had excessive missing data.

3.2.2

Observational studies

The methodological quality of the observation studies is shown in Table S3. All eight studies showed some risk of bias. They adequately reported on the process of sample selection and the measurement tools used to determine exposure validation. The statistical tests of outcome data were clear and appropriate, and relevant measures, including confidence intervals or probability levels (P values) were provided. However, there was no mention of independent blinded assessment of outcomes in any of the included observational studies. Risk factor exposure assessment was mentioned in only one study (Chen and Janke, 2012), and confounding factors were controlled in one study (Leng and Wang, 2016).

3.3 Meta-analysis

In all, 15 studies (112 comparisons) were included in a meta-analysis of the effects of HT on the health of elderly. The results of the 27 indicators and meta-analytic assessments are summarized in Table 4 and complete details are provided in Figures S1–S26.

The results of physical functioning, psychological recovery, and life changes were investigated. Physical functioning parameters included body mass index (BMI), activities of daily living (IPAQ, ADL), weight, waist circumference, physical component score (SF-36v2, PCS), eight indicators of physical fitness test for elders (30-SEC chair stand, arm curl, 2-min step, 8-ft up-and-go, chair sit-and-reach, back scratch, grip force, and pinch force), hand dexterity, cognitive ability, blood pressure, telomerase activity, interleukin-6 levels, and serum BDNF levels. Psychological indicators included loneliness, stress, depression, and mental component score (SF-36v2, MCS). Life changes included social network and vegetable and fruit intake.

3.3.1 Impact of HT on physical functioning outcomes

There were 1^2 indicators of physical functioning that did not show significant differences between the HT and control groups of elders. Elders in the HT group performed better in four indicators of ADL (IPAQ, Barthel Index), weight, and chair sit-and-reach, with p-values less than 0.00001. Further, both waist circumference (p=0.001) and hand dexterity (p=0.012) indicated that HT was effective in improving physical function among elderly. However, health-related quality of life (SF-36v2, PCS) and telomerase activity, which are associated with health in elderly, significantly negatively correlated with HT.

3.3.2 Impact of HT on psychological recovery outcomes

Except for fingernail cortisol (p=0.212), which was not significantly associated with improvement in stress among elderly, other psychological indicators showed a significantly positive effect of HT on loneliness ($p < 0.00001$), stress (SPSS-10, $p < 0.00001$ and salivary cortisol, p=0.021), depressive symptoms ($p < 0.00001$), and mental component score ($p < 0.00001$) in elders. Elders in one study (Wendy et al., 2018) showed a greater impact of HT on psychological component scores, with the study reporting no significant improvement in older cancer survivors after HT, whereas other studies (Hawkins et al., 2011; Bail et al., 2018) reported significantly higher scores in this indicator for the recruited subjects compared with elderly without the disease.

3.3.3 Impact of HT on life changes outcomes

Older adults receiving HT intervention showed significantly improved social interaction (p=0.038) and vegetable and fruit intake ($p < 0.000001$).

The results of the analysis showed low heterogeneity (<30%) in six of the indicators (Figures 2–7), moderate heterogeneity (30%–60%) in four (Figures 8–11), and severe heterogeneity (>60%) in the remaining 17 indicators. This suggests substantial heterogeneity between studies in terms of daily living, weight, waist circumference, SF-36v2, chair sit-and-reach, hand dexterity, cognitive ability, systolic blood pressure, loneliness, PSS-10, salivary cortisol, geriatric depression scale, social network - Lubben Social Network Scale (LSNS), and vegetable and fruit intake (EATS).

3.4 Moderator analysis

We used Galbraith plots and sensitivity analysis metrics ($I^2 > 60$) to explore the impact of individual studies on the overall heterogeneity. Articles that deviate significantly from the linear prediction were excluded, and the combined effect size and the effect of each article on the change in overall heterogeneity were compared by excluding each article. (Table S4 - Table S11). Because of the limited number of studies included in the meta-analysis, sensitivity analyses were not possible for fewer than two articles for each indicator. When three studies (Masuya, 2014; Hyuma et al., 2019; Wendy et al.; 2018) and five comparisons were removed, the results showed a reduction in heterogeneity, suggesting that these studies may be the source of heterogeneity.

Visually, the funnel plot (Figure S28) was relatively stable and roughly symmetrical, no significant publication bias was found, and most studies were distributed in the middle of the funnel plot, indicating that the included studies had moderate sample sizes and moderate study precision. On conducting Egger's test, the results showed that publication bias (p=0.158) had a negligible effect on overall results (Figure S29). We considered six factors (year of publication, country, mode of intervention, duration of intervention, gender, and presence of significant diseases) that could influence the study results, but very few articles showed significant missing data to be effectively addressed when performing meta-regression analyses.

4. Discussions

This review comprehensively searched studies from five databases to investigate the relationship between HT and health outcomes in older individuals, covering a large number of relevant international journals. It extensively analyzed 33 studies from eight different countries, with a total population size of 11,741. The meta-analysis provided evidence that HT is associated with health benefits in the elderly, with results showing that ADL (Minutes of weekly activities: 0.077, 95% CI: -0.146, 0.301, barthel index: 0.644, 95% CI: 0.352, 0.935), physical flexibility (chair sit-and-reach: 0.302, 95% CI: 0.036, 0.569), and manual dexterity (-0.495, 95% CI: -0.923, -0.067) were improved with HT. There were improvements in reduced loneliness (-2.804, 95% CI: -3.223, -2.385), depression (-0.947, 95% CI: -1.206, -0.687), stress (-0.339, 95% CI: -0.610, -0.069), cortisol concentrations (-0.902, 95% CI: -0.728, -0.002), improved social interaction (0.370, 95% CI: 0.115, 0.624) and daily vegetable and fruit consumption (0.688, 95% CI: 0.287, 1.089) with HT.

The I^2 of the Barthel Index and UCLA were 99.1% and 98.2%, respectively, indicating a high risk of statistical heterogeneity. We performed sensitivity analyses, excluding individual studies, and found an improvement in the pooled benefit volume after excluding three studies (Masuya, 2014; Hyuma et al., 2019; Wendy et al.; 2018). Three indicators (waist circumference, SF-36v2 PCS, and SF-36v2 MCS) were significantly reduced to low heterogeneity levels after excluding the study by Wendy, 2017. Probably the main reason for this is that the participants were all cancer survivors, and as time passed, reduced exercise and longer sedentary periods led to an increased risk of physical obesity and mortality (Berentzen et al., 2010; Haydon et al.; 2006), but in this phase of the study, it was also demonstrated that the older adults who received HT showed attenuated increase in waist circumference compared with controls. This may also have contributed to excessive heterogeneity in the other two indicators. Heterogeneity of the combined effect of cognitive ability significantly decreased after removing the article by Hyuma Makizako (2019), according to the original data, the baseline cognitive ability of the control group subjects was higher than that of the experimental group subjects. The cognitive ability of the elderly in the experimental group was significantly better after HT, whereas that of the elderly in the control group decreased, and because of the short duration of HT (6 weeks), this could be the main reason for the heterogeneity difference (Stowell et al., 2018). In the analysis of sensitivity to depression in the experimental and control groups, the heterogeneity of the combined benefit

of "Depression" indicator decreased by 74.4% after removing the study by Hui-Ying Chu (2019). In contrast, the article showed that older adults who participated in gardening activities showed reduced depression and loneliness, and the control group individuals who received usual care showed increased incidence of depression and loneliness. One possible explanation for this is that the usual care received by the control group subjects was not designed to address the specific needs of older adults, resulting in a disproportionate difference in outcomes (Kamioka et al., 2014). However, the results of this study suggest that participation in HT contributes to increased psychological well-being of older adults.

Previous studies have mentioned that telomerase activity decreases after HT (Wendy et al., 2018; Bail et al., 2018). However, current findings are similar to the long-term data reported by Orish et al. (Ornish et al., 2013) on lifestyle interventions in prostate cancer survivors, wherein telomerase activity was found to declining over a 5-year period. While the amount of the telomerase may be predictive of longevity, it may also pose a potential threat to cancer by inhibiting the presence of abnormal cells that can unpredictably respond to prolonged intervention. Thus, these data give pause to the role of telomerase as a biomarker in cancer survivors. Two studies (Wendy et al., 2018; Bail et al., 2018) tested interleukin-6 in older adults after HT, but reported different results. Because the results were presented by only a few studies, we were not able to perform a formal subgroup analysis or determine whether this was the case for other health outcomes.

The results of this review are consistent with those of previous reviews on the effects of gardening on the health of older adults. Nicholas et al. (2019) systematically reviewed 20 studies and noted significant improvements in the quality of life, anxiety level, depression, social relationships, physical outcomes, and cognitive outcomes in patients after HT, and a reduction in body mass index (BMI) (Soga et al., 2017). Yanping Lin et al. (2022) used meta-analysis techniques to assess the positive and negative effects of gardening on the health of older adults, and the random-effects model showed that HT significantly improved upper body flexibility and aerobic endurance in older cancer patients, which is consistent with our findings. However, these reviews cover a limited number of studies and lack the inclusion of observational studies and evaluation of other long-term indicators, such as waist circumference, activity level, and cognitive performance.

This review complements previous systematic evaluations (Kunpeuk et al., 2020; Forbes et al., 2020; Looijaard et al.; 2018) of the health benefits of HT, particularly across multiple indicators. The main strength of this review is its inclusiveness. We did not exclude studies based on study design or horticultural treatment modalities. Accordingly, the 33 included studies identified a wide range of horticultural and older adult health consequences. However, the inclusiveness of this study can also be seen as a limitation because of the high heterogeneity between studies and the difficulty in comparing studies from small-scale intervention studies with large cross-sectional studies. Overall, this review contributes to the growing body of evidence showing the health benefits of HT in older adults.

It was evident from the number of included articles that small interventional studies made up the majority of the included studies, and the studies had a number of confounding factors (type of horticulture, duration of intervention, study site, sample size, gender, moderator, attendance, and adverse events) that may have influenced the results. Some of the included studies reported single- or double-blinded trials to reduce bias and increase article quality, which would help convince policy makers and healthcare professionals to encourage older adults to garden and spend more time gardening, especially individuals who are obese, have poor physical function, or need psychotherapy. Although this research well covers a wide range of aspects, there are still several significant knowledge gaps in this area, with the most common being the underlying mechanisms of the relationship between gardening and health and the long-term effects of HT. Further research is warranted and the results of this review should be considered with caution.

This review also has some limitations. First, the limited number of studies in this review and the high degree of heterogeneity prevented us from performing subgroup analyses and meta-regression analyses to determine the specific sources of heterogeneity. This likewise led to significant limitations in comparing the outcomes, and some studies were accordingly not included in the meta-analysis. Some examples of these include monocyte counts, tumor necrosis factor levels, oxidase levels, brain waves, WBC, lactate levels and serotonin levels, among others (Park et al., 2017; Hassan et al., 2018; Park et al., 2020)..

5. Conclusion and future perspectives

In this systematic review, we included both interventional and observational studies that provide strong evidence on the relationship between HT and older adult health. However, the quality of the included studies varied widely. Results suggest that HT can be effective in helping older adults lose weight and waist circumference and increase physical flexibility. It can further be effective in reducing stress, alleviating depression and loneliness, and increasing interpersonal interactions and vegetable and fruit consumption. HT may be an effective means for improving physical and mental health as well as social health aspects in older adults. In the future, further high-quality research on more horticultural treatment modalities, rigorous control and adjustment of some important confounding variables, and larger populations are needed to improve our understanding of the relationship between HT and the health of older adults.

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