Digital health intervention effect on older adults with chronic diseases living alone: Systematic literature review and meta-analysis

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Abstract

Background: The incidence of chronic diseases is increasing owing to the aging population; in particular, older adults living alone struggle with self-management and medical expenses. Digital health can contribute to medical cost management and health promotion, but its effectiveness for older adults living alone remains unclear. In a rapidly aging society, it is important to demonstrate the effect of digital health on improving the lives of older adults living alone and reducing the burden of chronic diseases.

Objective: This study was a systematic literature review and meta-analysis to confirm the effects of digital health interventions on self-management, quality of life, and medical factors for older adults with chronic diseases living alone.

Methods: PubMed, the Cumulative Index to Nursing and Allied Health Literature, and Cochrane CENTRAL electronic databases were used for literature published abroad and listed in journals until October 2023. The final 11 papers were used for analysis based on selection and exclusion criteria. Meta-analysis was employed to calculate the mean difference and standardized mean difference (SMD) for the selected literature using RevMan 5.4. The effect size and heterogeneity were calculated through 95% confidence interval.

Results: As a result of conducting a meta-analysis of 8 out of 11 documents, there was a significant effect of self-management factors on moderate-to-vigorous physical activity (SMD = 0.08, Z = 2.07, P =.04). However, among self-management factors, LDL-cholesterol (SMD = -0.04, Z = 0.91, P =.36) did not show statistically significant results. Among the medical factors, general quality of life (SMD = 0.11, Z = 0.93, P =.35), depression (SMD = -3.95, Z = 1.59, P =.11), and hospital days (SMD = -1.57, Z = 0.91, P =.36) also did not show statistically significant results. However, it was confirmed that they improved after digital health intervention.

Conclusions: This study demonstrated that digital health interventions are effective in improving physical activity in older adults with chronic diseases living alone. However, owing to the characteristics of older adults living alone, there is a need to further expand digital health to combine care services that can manage diseases at home. Clinical Trial: Published data were used in this study and in the preparation of this paper; hence no ethical approval was required.

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Review

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Conclusions: This study demonstrated that digital health interventions are effective in improving physical activity in older adults with chronic diseases living alone. However, owing to the characteristics of older adults living alone, there is a need to further expand digital health to combine care services that can manage diseases at home.
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Keywords: digital health; chronic diseases; older adults living alone; independent living; systematic review; meta-analysis

Introduction

According to the United Nations, older adults aged 65 years or older are expected to account for 16% of the world's population in 2050, when the risk of interpersonal, cognitive, and physical decline caused by aging will gradually become more prominent [1, 2]. Owing to aging, the number of older adults living alone is continuously increasing, and various social problems require satisfying basic human needs, such as healthcare, and others [3, 4]. Aging, disease, and an increase in chronic diseases are natural phenomena, but the health of older adults living alone must be considered from multifaceted and physical perspectives [5, 6]. Functional status refers to activities of daily living and the ability to adapt to a given environment; older adults living alone can be exposed to more health risk factors and have a lower functional status than older adults living together [7, 8]. Furthermore, because older adults living alone tend to perceive their own subjective health status as lower than that of older adults living together, improving the health of older adults living alone is emerging as an important task [9]. In particular, as the chronic diseases and mental health conditions of older adults living alone, such as feelings of alienation, loneliness, and a sense of isolation, are likely to worsen due to the isolation problem following the coronavirus disease 2019 (COVID-19) pandemic, it is necessary to establish a medical system that can manage the daily lives of older adults living alone [10, 11].

Digital health can improve the quality of life of older adults by allowing them to comfortably manage their health at home and alleviate the physical burden of accessing medical services [12, 13]. Older adults living alone can check their health status in real time to strengthen their self-management abilities by monitoring and managing their personal health data, contributing to preventive healthcare, and helping with the early detection and prevention of chronic diseases [14, 15]. Moreover, the introduction of digital health services can reduce medical costs by improving the efficiency of medical services [16]. Telemedicine and online consultations enable smooth communication with medical experts, reducing medical and travel costs and ultimately alleviating the burden of medical expenses. Accordingly, studies covering various methods and results of preventing, managing, and monitoring chronic diseases through digital health have been actively conducted [17, 18].

For adults with type 2 diabetes mellitus, Aminuddin et al. (2021) reviewed the evidence for self-management interventions through smartphones on self-efficacy, self-management activities, health-related quality of life, glycated hemoglobin, body mass index, and blood pressure levels and then analyzed their effectiveness [19]. Furthermore, Yue Ma et al. (2022) conducted a systematic literature review and meta-analysis of the effectiveness of telemedicine in patients with chronic diseases. They found that the telemedicine intervention improved systolic blood pressure in hypertensive patients and glycated hemoglobin and fasting blood sugar in diabetic patients, and had a positive effect on improving negative sentiments and managing medication compliance in patients with rheumatoid arthritis [20]. Research is being conducted on the effectiveness of digital health; however, there is a lack of research verifying the effectiveness of digital health interventions for older adults with chronic diseases living alone.

Therefore, there is a need to prepare grounds to verify the effectiveness of digital health for the healthy lives of older adults living alone and those with chronic diseases, which will increase in the future, and to increase the use of digital health. This study examined the effects of digital health interventions on older adults with chronic diseases living alone through a systematic literature review and meta-analysis to identify health improvement factors resulting from digital health interventions. This study hoped to contribute to the preparation of digital health utilization plans that can predict and manage the health status of older adults living alone.

Methods

Research Design

This study is a systematic literature review and meta-analysis that integrates research results on the effectiveness of digital health interventions for older adults with chronic diseases living alone. To utilize the search strategy, the study was conducted based on the systematic literature review manual approach of the National Entertainment Collectibles Association and the guidelines and flow charts of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis. Published data were used in this study and in the preparation of this paper; hence no ethical approval was required.

Eligibility Criteria

The specific criteria used to conduct a systematic literature review were as follows: (1) the populations were older adults with chronic diseases living alone, (2) the intervention referred to all digitized health interventions, (3) the comparison focused on older adults living alone who are provided with general and active management, and (4) the outcomes contained self-management, quality of life, and medical factors. This study included randomized controlled trials and excluded cases and protocols.

Data Search and Selection Process

Literature collection was not limited by publication year; studies published up to October 2023 were searched. The literature was collected using a total of three web search engines: PubMed, the Cumulative Index to Nursing and Allied Health Literature, and Cochrane CENTRAL, which are databases that can search for studies in the fields of medicine, nursing, and healthcare systems. The keywords used to search the literature were (Chronic Disease OR Comorbidity OR Chronic Condition) AND (Aged OR Aging) AND (Community OR Independent Living) AND (Digital Health OR Digital Medicine OR Telehealth OR Smart Health). The selection criteria were as follows: (1) studies on the effectiveness of digital health interventions for older adults with chronic diseases living alone, (2) experimental studies on randomized control groups, and (3) academic papers published in academic journals. The exclusion criteria were as follows: (1) studies not written in English, (2) inappropriate experimental research designs, such as case studies or literature reviews, and (3) subjects under 65 years of age.

Quality and Evidence Assessment

After the selection process, Cochrane's Risk of Bias Tool was used to evaluate the quality of the selected studies, which was conducted independently by two researchers [21]. The assessment consisted of seven evaluation areas; each question was evaluated by dividing the risk of bias as low, clear, or high, based on the information described in the literature. Disagreements were resolved through discussions. The risks were assessed to create a random allocation sequence, concealment of the allocation sequence, blinding of participants and researchers, blinding of outcome evaluators, insufficient data, selective reporting of results, and other potentialities that threatened validity.

Data Analysis

After analyzing the properties of the literature included in the systematic literature review, two researchers (Y.P and E.K) organized the data through discussion according to the data extraction form. The data extraction form included general properties of the literature: author, year of publication, country, research design, research subjects, intervention methods, outcome variables (measurement tools), and research results. In cases where a 95% confidence interval (CI) was reported instead of the standard deviation (SD), the CI was calculated using the formula in the Cochrane Handbook of Systematic Reviews [22].

In this study, the Cochrane Library's RevMan 5.4 program was used to conduct the meta-analysis, and heterogeneity tests and effect sizes were calculated and presented. Since the selected literature was judged to have heterogeneity between the diagnosis of subjects, type of digital health intervention, and measurement tools for outcome variables, it was difficult to assume the effect size of a single treatment; thus, they were analyzed using a random-effect model. Furthermore, for the measurement scale of the studies, the mean difference and

standardized mean difference (SMD) were used depending on whether the same or different scales were adopted, in which the 95% CI was utilized. The inverse of variance was used as the weight of each effect size [23].
To evaluate the statistical heterogeneity of the effect size of the selected literature, the Chi^2 Test was performed after calculating the Q value (i.e., the total observed variance); the measurement was conducted using the p value and I^2. I^2 is the index representing the variance ratio between actual studies to total variance, in which if the p-value is less than 0.10 and I^2 is 50% or higher, the heterogeneity of the effect size is considered significant [24].

Results

Identification of Studies

Two researchers independently searched the literature in overseas databases and retrieved 3,423 articles, of which 761 duplicate documents were deleted using the Endnote 20 program or manually. Subsequently, the titles and abstracts of the papers were reviewed to select and exclude primary literature. The full texts of the literature selected in the primary selection process were secured, and the original text was reviewed by applying the previously defined selection and exclusion criteria for the literature to select the secondary literature. The literature included in the final assessment was selected through agreement between the two researchers; in cases where the two researchers could not reach an agreement, they re-evaluated the literature after sufficient discussion and then reached a consensus. Subsequently, 11 papers were selected through a quality assessment of the literature for systematic literature reviews. Among them, eight articles were included in the meta-analysis, after excluding three articles that did not present the statistical values required for meta-analysis (Figure 1).

Characteristics of Included Studies

Regarding the general characteristics of the literature, they are randomized controlled trial studies; nine articles were found that were conducted in a single country (one each in France, Canada, the Netherlands, Italy, China, and Hong Kong, and three in the United States) [25-33], while two were multinational studies (one in the Netherlands, Finland, and France, and one in Spain, the United Kingdom, Slovenia, Estonia, and Sweden) [34, 35]. The mean age of participants was 72. All participants were older adults with chronic diseases living alone. The most frequent chronic diseases were hypertension, diabetes, and cardiovascular disease.
Among the 11 articles, six were on self-management factors [25, 27, 29, 30, 33, 35], two were on quality of life factors [32, 34], and three were on medical factors [26, 28, 31], of which self-management factors were the most important. The types of digital health interventions for self-management factors were divided into remote monitoring, interactive internet intervention, home telehealth, mHealth, and eHealth. The main outcome variables were blood pressure, LDL-cholesterol, 24-hour ambulatory blood pressure monitoring, depression/anxiety symptoms, health status, physical activity, lifestyle habits, and falling accident incidence rate.
In addition, the type of digital health interventions in medical factors was remote monitoring, and the main outcome variables included rehospitalization period and cumulative incidence, health and functional status, patient satisfaction, and healthcare utilization data. The type of digital health interventions in quality of life factors were remote monitoring, in which the main outcome variables were a chronic obstructive pulmonary disease assessment test, depression status (Patient Health Questionnaire-9), and a quality of life (EuroQol-5 Dimension) survey. The results of the data analysis of the 11 papers included in this study are presented in Table 1.

Table 1. Characteristics of the Studies

Author	Country	Study design	Participant characteristics	Disease	Interventions	Main outcome variables (Measurement tools)
Tchalla, Achille, et al. (2023) [26]	France	RCT	- Average age 80.3 years - Intervention group of 237 personnel - Control group of 237 personnel	COPD, Diabetes, Hypertension, Chronic kidney failure, Stroke, Neurodegenera tive disease	Remote monitoring	1. Cumulative incidence of readmission 2. Clinical Outcomes of Readmission
Lau, Darren, et al. (2022) [29]	Canada	RCT	- Average age 79.5 years - Intervention group of 47 personnel - Control group of 45 personnel	Hypertension	Remote monitoring	1. 24 Hours a day, ABPM, HBPM 2. Quality of life: EuroQol-5 Dimension 3. Depression/ Anxiety: PHQ-8, GAD-2
Kwan, Rick YC, et al. (2020) [30]	Hong Kong	RCT	- Average age 71.0 years - Intervention group of 16 personnel - Control group of 17 personnel	Cognitive impairment and dementia progression stages	mHealth	1. Physical activity: montreal cognitive assessment, Fried frailty index, Physical activity Scale for the elderly, Six-minute walk test, Moderate-to-vigorous physical activity
Volders, Esmee, et al. (2020) [25]	Netherlands	RCT	- Average age 74.5 years - Intervention group of 260 personnel - Control group of 325 personnel	Musculoskeleta l and back disorder, COPD, Rheumatism, Osteoporosis, Chronic heart disease	eHealth	1. Self-Management: Short Questionnaire to Assess Health Enhancing Physical Activity 2. Physical Activity: Physical Activity, Leisure-time Physical Activity V, Moderate-to-Vigorous Physical Activity
Richard, Edo, et al. (2019) [35]	Netherlands, Finland, France	RCT	- Average age 69 years - Intervention group of 1389 personnel	Cardiovascular risk factors, Cardiovascular	Interactive internet intervention	1. Health status: systolic blood pressure, LDL cholesterol, BMI, HbA1c,

			- Control group of 1335 personnel	disease, Diabetes		Physical activity (hours per week) 2. Lifestyle habits: Dietary intake, Smoking cessation
Bernocchi, Palmira, et al. (2019) [33]	Italy	RCT	- Average age 79 years - Intervention group of 100 personnel - Control group of 100 personnel	One or more chronic conditions (cardiac, respiratory, neuromuscular, or neurological)	Home-telehealth	1. Fall incidence rate 2. Change in functional status: T1-T0 3. Daily life: Activities of daily living, Bathel index, Instrumental activities of daily living scale
Sun, Chenglin, et al. (2019) [27]	China	RCT	- Average age 68 years - Intervention group of 44 personnel - Control group of 47 personnel	Type 2 diabetes	mHealth	1. Physical activity information: provided by the patient (training on how to send pedometer data to staff via text message) 2. Health information: FBG, PBG, HbA1c, TC, TG, HDL-C, LDL-C, BMI, Blood pressure (Systolic, Diastolic)
Walker, Paul P, et al. (2018) [34]	Spain, England, Slovenia, Estonia, Sweden	RCT	- Average age 71 years - Usual care 158 personnel - Telemonitoring 154 personnel	COPD	Remote monitoring	1. COPD Assessment: COPD Assessment Tool Score 2. Patient Health Questionnaire-9 Score 3. Quality of life: EuroQol-5 Dimension
Gellis, Zvi D, et al. (2014) [31]	USA	RCT	- Average age 79 years - Intervention group of 57 personnel (I-TEAM) - Control group of 58 personnel (UC+P)	Chronic disease (Congestive heart failure, Chronic obstructive pulmonary disease)	Remote monitoring	1. Depression status: Hamilton depression rating scale, Patient health questionnaire-9 2. Health and functional status: 12-item Short-form survey

						3. Problem-solving coping skills: social problem-solving Inventory—revised 4. Patient satisfaction: satisfaction survey 5. Healthcare utilization data: Electronic medical record
Gellis, Zvi D, et al. (2012) [32]	USA	RCT	- Average age 79 years - Intervention group of 51 personnel - Control group of 51 personnel	Heart failure, COPD	Telehealth	1. Depression status: Center for epidemiologic studies Depression, Patient health questionnaire 2. Quality of life: Short form survey of (a) general health, (b) body pain, and (c) social function. 3. Patient satisfaction survey: satisfaction with the telehealth service
Soran, Ozlem Z, et al. (2010) [28]	USA	RCT	- Average age 76.39 years - HFMS group of 160 personnel - Standard Care group of 155 personnel	Heart failure	Remote monitoring	1. Cost of medical services: Medicare claims data information

BMI: Body Mass Index, COPD: Chronic Obstructive Pulmonary Disease, HFMS: Heart Failure Home Care, RCT: Randomized Controlled Trial

Quality Assessment

In this study, we assessed the quality of the literature based on Random Sequence Generation, Allocation Concealment, Blinding of Participants and Personnel, Blinding of Outcome Assessment, Incomplete Outcome Data, Selective Reporting, and Other Bias. For the 11 selected articles, we presented a summary and graphs of the assessment results (Figure 2). Among the selected articles, ten had at least one component with a high risk of bias (90.9%). In particular, due to the properties of the application of the intervention method, the blinding of study participants and personnel was impossible, which may have influenced the behavioral results of the research participants and results; thus, the risk of bias was assessed as high at 81.8%.
Furthermore, because eight articles did not perform allocation concealment or provided insufficient information to determine the risk of bias, the risk of bias for the relevant items was evaluated as high or unclear (72.7%). In other areas, the risk of bias for the literature was low (Random Sequence Generation: 72.7%; Blinding of Outcome Assessment: 63.6%; Incomplete Outcome Data: 81.8%; Selective Reporting: 100%; Other: 90.9%).

Digital Healthcare Intervention Effect

In this study, we conducted a meta-analysis of the effectiveness of digital health interventions for older adults with chronic diseases living alone. Among the 11 articles selected, the effects were assessed on self-management, quality of life, and medical factors for eight articles that presented statistical values necessary for meta-analysis, for which the measurement results were visualized using a Forest Plot. Furthermore, a sub-analysis was conducted by dividing the detailed factors of the measured results.

Self-Management Factor Effects of Digital Healthcare Intervention

The effectiveness of digital health interventions on self-management was assessed in four articles [25, 27, 30, 35]. In this subgroup, systolic blood pressure, LDL-cholesterol level, and moderate-to-vigorous physical activity were divided and then evaluated.
(1) Systolic Blood Pressure
Three articles [27, 29, 35] were measured on systolic blood pressure. Among them, the paper by Lau (2022) [29] was excluded because it measured the target achievement rate of systolic blood pressure for 24-hour ambulatory blood pressure monitoring. Therefore, the remaining two articles were included in the meta-analysis; a total of 2,499 patients participated and provided information on systolic blood pressure. The SMD for this showed an effect size of 0.11 (95% CI: -0.26, 0.49). Additionally, the effects of the intervention and control groups were not statistically significant (Z = 0.59, *P =.56*); the heterogeneity among the articles was considerable (Chi^2 = 3.44, *P =.06*, I^2 = 71%) (Figure 3).
(2) LDL-Cholesterol
Two articles [27, 35] were included in the meta-analysis, in which 2,501 patients participated and provided information on LDL-cholesterol. The SMD for this showed an effect size of -0.04 (95% CI: -0.11, 0.04). Furthermore, the effects of the intervention and control groups were not statistically significant (Z = 0.91, *P =.36*), and heterogeneity among the studies was low (Chi^2 = 0.40, *P =.52*, I^2 = 0%) (Figure 4).
(3) Moderate-to-Vigorous Physical Activity
Three articles [25, 30, 35] were included in the meta-analysis; 2,929 patients participated and provided information on moderate-to-vigorous physical activity. The

SMD showed an effect size of 0.08 (95% CI: 0.00, 0.15). Moreover, the effect of the intervention and control groups was statistically significant (Z = 2.07, *P =.04*), and the heterogeneity among the articles was low (Chi^2 = 1.39, *P =.50*, I^2 = 0%) (Figure 5)

Impact of Digital Healthcare Intervention on Quality of Life Factors

In four articles [31-34], the effectiveness of digital health interventions was evaluated based on quality of life factors. As subgroups, General Quality of Life and Depression were divided and evaluated; since the articles included in General Quality of Life and Depression were assessed using the same scale, they were expressed as the mean difference. For the EuroQol-5 Dimension, which was used as the rating scale for General Quality of Life, being closer to 1 can be interpreted as satisfaction, 0 as a medium level, and -1 as dissatisfaction. In terms of the Patient Health Questionnaire-9, which was used as an evaluation standard for Depression, 0–4 can be interpreted as normal, 5–9 as mild depression, 10–14 as moderate depression, 15–19 as severe depression, and 20 or more as severe depression.

(1) General Quality of Life

Three articles [29, 33, 34] were measured using the EuroQol-5 Dimension rating scale. One article [29] was excluded because it presented the outcome values for differences at the baseline. Therefore, the remaining two articles were included in the meta-analysis; a total of 548 patients participated and provided information on their general quality of life. The mean difference showed an effect size of 0.11 (95% CI: -0.12, 0.35). Additionally, the effects of the intervention and control groups were not statistically significant (Z = 0.93, *P =.35*), while the heterogeneity among the articles was considerable (chi^2 = 9.97, *P =.002*, I^2 = 90%) (Figure 6).

(2) Depression

Three articles [31, 32, 34] were included in the meta-analysis, in which 514 patients participated and provided information on depression. For the rating scale, all three articles were evaluated using the Patient Health Questionnaire-9, in which the mean difference showed an effect size of -3.95 (95% CI: -8.81, 0.91). Furthermore, the effects of the intervention and control groups were not statistically significant (Z = 1.59, *P =.11*), while the heterogeneity among the articles was considerable (Chi^2 = 41.51, *P <.001*, I^2 = 95%) (Figure 7).

Impact of Digital Healthcare Intervention on Medical Factors

In two articles [31, 34], the effect of Digital Healthcare Interventions on medical factors was assessed, and the number of hospital days was evaluated as a subgroup.

(1) Hospital Days

A total of 406 patients participated and provided information on the number of hospital days, and the SMD for this showed an effect size of -1.57 (95% CI: -3.57, 0.44). Additionally, the effects of the intervention and control groups were not statistically significant (Z = 0.91, *P =.36*), and the heterogeneity among the articles was considerable (Chi^2 = 61.73, *P <0.001*, I^2 = 98%) (Figure 8).

Narrative Synthesis

The three articles included in this study were not included in the meta-analysis because they did not present meaningful results. Regarding self-management factors, Lau (2022) implemented home blood pressure monitoring in older patients with hypertension for 12 months. The intervention group had a higher rate of systolic blood pressure < 110 mmHg, a conservative indicator of hypotension, than that of the control group, suggesting the potential effectiveness of home blood pressure monitoring [29]. Regarding medical factors, Soran (2010) conducted a heart failure monitoring system in older patients with cardiac insufficiency for six months. The mean six-month Medicare Cost for the intervention subjects was estimated at $17,837 and that of the control group at $13,886; thus, the cost for the patients assigned to the intervention group was higher, suggesting no cost benefit. This may have been due to differences in the baseline demographics of the population [28]. Regarding medical factors, Tchalla (2023) implemented a remote monitoring program for 12 months for older patients with chronic diseases. The rehospitalization rate of the intervention group was 40.4% (108 people), and that of the control group was 48.7% (130 people), which showed a significant difference, suggesting the effectiveness of remote monitoring [26].

Discussion

In this study, we aimed to confirm the properties of the intervention effect through systematic literature reviews on the effect of digital health interventions for older adults with chronic diseases living alone, and to identify the effect size of intervention factors through meta-analysis. Existing studies have mainly confirmed the effects of digital health interventions targeting adults over 18 years of age or middle-aged people aged 50–60 years [36, 37]. Clear evidence on the effectiveness of digital health interventions for those aged 65 years or older has not yet been established. Accordingly, in this study, we systematically analyzed the effects of digital health interventions for older adults with chronic diseases living alone published until October 2023 without limiting the publication year. Eleven articles were selected based on self-management, quality of life, and medical factors, and a meta-analysis was conducted on eight articles. Digital health interventions were found to be effective in self-management factors for older adults with chronic diseases living alone. This suggests that digital health focuses on disease prevention and management through an increase in physical activities and the improvement of health management; thus, if effective disease management can be achieved through self-management in older adults living alone, it can be utilized as an alternative measure for nursing and caregiving for older adults living alone.

Interpretation of Meta-Analysis Results on Self-Management Factor Effects

Among self-management factors, moderate-to-vigorous physical activity represented statistically significant results. This indicates that digital health interventions are effective in maintaining or improving the physical activity levels of older adults living alone. Considering that digital health is effective in improving moderate-to-vigorous physical activity in older adults living alone, the usefulness of digital health in promoting physical activity can be emphasized. These results can serve as an important basis to support the contention raised in previous studies that mHealth apps can increase the physical activities of older adults; in particular, increased physical activity among older adults with chronic diseases living alone is expected to improve their health and help prevent chronic diseases [38].

However, the results showed that the effectiveness of digital health interventions on systolic blood pressure and LDL-cholesterol levels was not significant. Comprehensive differences existed in the number of populations and intervention periods between the two studies. Furthermore, the measurement time, environmental conditions, and variations due to the psychological effects of the patient affected the results [39-41]. Richard (2019) [35] suggested that among the population who participated in the study, those with a higher desire for health were more likely to take statins and antihypertensive drugs more frequently or to participate in other cardiovascular risk reduction programs. Sun (2019) [27] did not consider personal and family medical history and emphasized uncertainty in the data on diet and caloric intake.

In summary, a customized digital health system and integrated caring healthcare policy are needed to maximize the preventative effect on systolic blood pressure and LDL cholesterol. Personalized guidance is provided through the digital health system, taking into account an individual's health status and habits. We can expect to prevent chronic diseases by improving personal eating habits, lifestyle habits, and blood pressure and cholesterol management. To improve the access of older adults living alone to digital health, digital health must be combined with existing medical service delivery methods, and active participation must be encouraged by reinforcing education and support for the use of digital health. Community care based in local communities is currently expanding to manage chronic diseases among older adults living alone. It is necessary to improve their self-management skills by combining community care with digital health. In particular, the government must prepare policies for linking community care and digital health, and digital health education programs for older adults living alone. By supplementing the healthcare workforce that can provide this, the government will be able to ensure health promotion and care continuity for older adults living alone.

Interpretation of Meta-Analysis Results on Impact of Quality of Life Factors

In studies on general quality of life and depression, digital health interventions were found to have no significant effect on older adults living alone. In terms of general quality of life, the combined results of the two articles did not show a significant effect of digital health. The monitoring method, characteristics of chronic diseases, and other factors may have influenced the results. In other words, the monitoring methods used in different studies and the differences depending on chronic diseases must be comprehensively considered. Additionally, in terms of depression, digital health interventions did not show a significant effect on improving depression in older adults with chronic diseases living alone. This suggests that the methods or properties of digital health applied in each study may not have had a sufficient effect on depression among older adults living alone.

In a study by Bernocchi (2019) [33], a digital health system was applied that could immediately relay information to a nurse through remote monitoring, even after discharge in the event of an emergency. This had a positive effect on improving the quality of life of older adults with chronic diseases. However, in a study conducted by Walker (2018) [34] on patients with chronic obstructive pulmonary disease, it was found that when a medical alert occurred during the digital health monitoring process, it took a considerable amount of time to establish contact [34]. Such contact delays in urgent medical situations negatively impact patient health and safety, suggesting the need for improvements in the emergency response to digital health. Moreover, for patients with COPD, depression-related factors may occur due to worsened respiratory function, difficulties in daily life, and limitations in social participation, rather than the problems of the disease itself. In this regard, the study results suggest that for older adults living alone who already have chronic diseases, there are limits to improving their quality of life according to the type of chronic disease, psychological condition, and so on.

In summary, the systematic segmentation of disease-specific monitoring systems is required to improve the quality of life factor. The main measurement factors for each disease included heart rate in patients with heart disease, respiratory rate in patients with respiratory disease, and blood sugar and food intake in patients with diabetes. Based on these key measurement factors, by implementing monitoring for each chronic disease group and then providing a variety of treatment methods, such as self-management, medication, physical therapy, and breathing exercises, appropriate for the individual, patients can improve their physical and mental quality of life. Furthermore, the integrated management of chronic diseases and mental health must be implemented. Older adults with chronic diseases living alone could become patients with multiple chronic diseases. It seems that the increase in chronic diseases could be combined with social isolation and is thus expected to worsen mental health. To this end, the integrated management of mental health for each disease is necessary, and regular management using digital health seems to improve the mental health of patients, including anxiety and depression.

Interpretation of Meta-Analysis Results on the Impact of Medical Factors

Hospital days, a subgroup of medical factors, were found to have a smaller population in the digital health intervention group than in that of the control group, which did not show statistical significance. We believe that this was because the differences in the total population and intervention period in each of the two integrated articles had a significant impact on the results. Additionally, this can be attributed to differences in the outcome measurement periods. In the study by Gellis (2014) [31], integrated telehealth education and activation of mood was evaluated to improve the chronic disease of cardiac insufficiency and chronic obstructive pulmonary disease and the accompanying depression in a home healthcare environment; the intervention period was three months, but the measurement of hospital days was performed 12 months after the baseline. On the other hand, the study by Walker (2018) [34] assessed the effectiveness of home monitoring in older patients with chronic obstructive pulmonary disease and comorbidities, in which the intervention period was nine months. Additionally, measurements of hospital days were performed immediately after the intervention period. Therefore, the difference in the time at which the number of hospital days was assessed between the two studies appeared to have influenced the effect size. In particular, in the case of older adults living alone, hospitalization may not occur due to a lack of guardians or difficulty moving around, and the intervention effect is judged to be insignificant. Thus, it is necessary to continuously verify the effectiveness of providing community care and caring services based on digital health for older adults living alone who have difficulty traveling to hospitals. Furthermore, if post-discharge care can be performed through the analysis of patients' medical records and personalized health indicators, it can reduce medical costs by preventing the hospitalization of older adults living alone.

Limitations and Strengths

The limitations of this study were as follows. First, in assessing the quality of articles, Blinding of Outcome Assessment was performed well in most studies; however, Blinding of Research Participants and Personnel was not implemented. Since the major outcome was measured using a subjective assessment tool, awareness of the intervention may have affected blinding. Second, only a few studies were included in this meta-analysis. A total of eight articles were included in the overall meta-analysis, but as a result of dividing the studies into subgroups, only two to three articles were included and analyzed per group. There were limitations to the analysis owing to the relatively small number of articles. Third, heterogeneity was observed among the included studies. The intervention period varied between the studies, ranging from 3 to 18 months, and the timing of the outcome measurements differed slightly for each study. In particular, the number of participants in each study was very diverse, ranging from a minimum of 33 to a maximum of 2,451. Therefore, the number of articles included per study group was relatively small, which may have resulted in a high degree of heterogeneity. Additionally, due to the small number of articles, the test for heterogeneity was not presented separately.

Despite these limitations, this study confirmed the clinical effects of digital health on older adults living alone through a standardized systematic literature review. To respond to current social problems, digital health has shown positive effects in promoting physical activities and managing chronic diseases in the self-management of older adults living alone, which will contribute to improving their health and quality of life. From this perspective, digital health can play an important role in replacing nursing and caring for older adults living alone. In the future, considering the difficulty that older adults living alone have in maintaining voluntary long-term activities, it will be necessary to continuously monitor older adults living alone through community care by applying digital health measures. Furthermore, follow-up studies are needed to explore various intervention methods to activate digital health in the healthcare field, which will contribute to patient-centered medical care services and a reduction in national medical costs. Ultimately, digital health interventions will move in a positive direction to manage the health of older adults living alone more effectively and improve their quality of life.

Conclusion

This study confirmed the effectiveness of digital health interventions for older adults with chronic diseases living alone. A significant effect was found for moderate-to-vigorous physical activity among the self-management factors, but other factors did not display statistically significant results, which showed that they improved after the digital health intervention. In other words, digital health-based healthcare can help maintain a healthy lifestyle for older adults living alone and prevent chronic diseases. Additionally, to expand the acceptance of digital health among older adults living alone, it is necessary to strengthen their digital literacy. The number of healthcare personnel needs to be expanded for this purpose. Therefore, a combination of digital health and local community-based care services is essential to improve the quality of life of older adults living alone and reduce their medical costs. As such, the use of digital health can serve as an inclusive technology that can supplement insufficient healthcare personnel and reduce social costs at the same time.

Author Contributions

Conceptualization, Y.P.; Data curation, Y.P.; Formal analysis, E.K.; Methodology, Y.P, E.K.; Supervision, S.P, M.L.; Writing—original draft, Y.P, E.K.; Writing—review & editing, M.L. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare that they have no competing interests.

Data Availability

Requests to access the datasets should be directed to ML; emunjae@ajou.ac.kr

Abbreviations

SMD: standardized mean difference
RCT: randomized controlled trial
ABPM: ambulatory blood pressure monitoring
HBPM: home blood pressure monitoring
BMI: body mass index
HFMS: heart failure home care
COPD: chronic obstructive pulmonary disease
MVPA: moderate to vigorous physical activity

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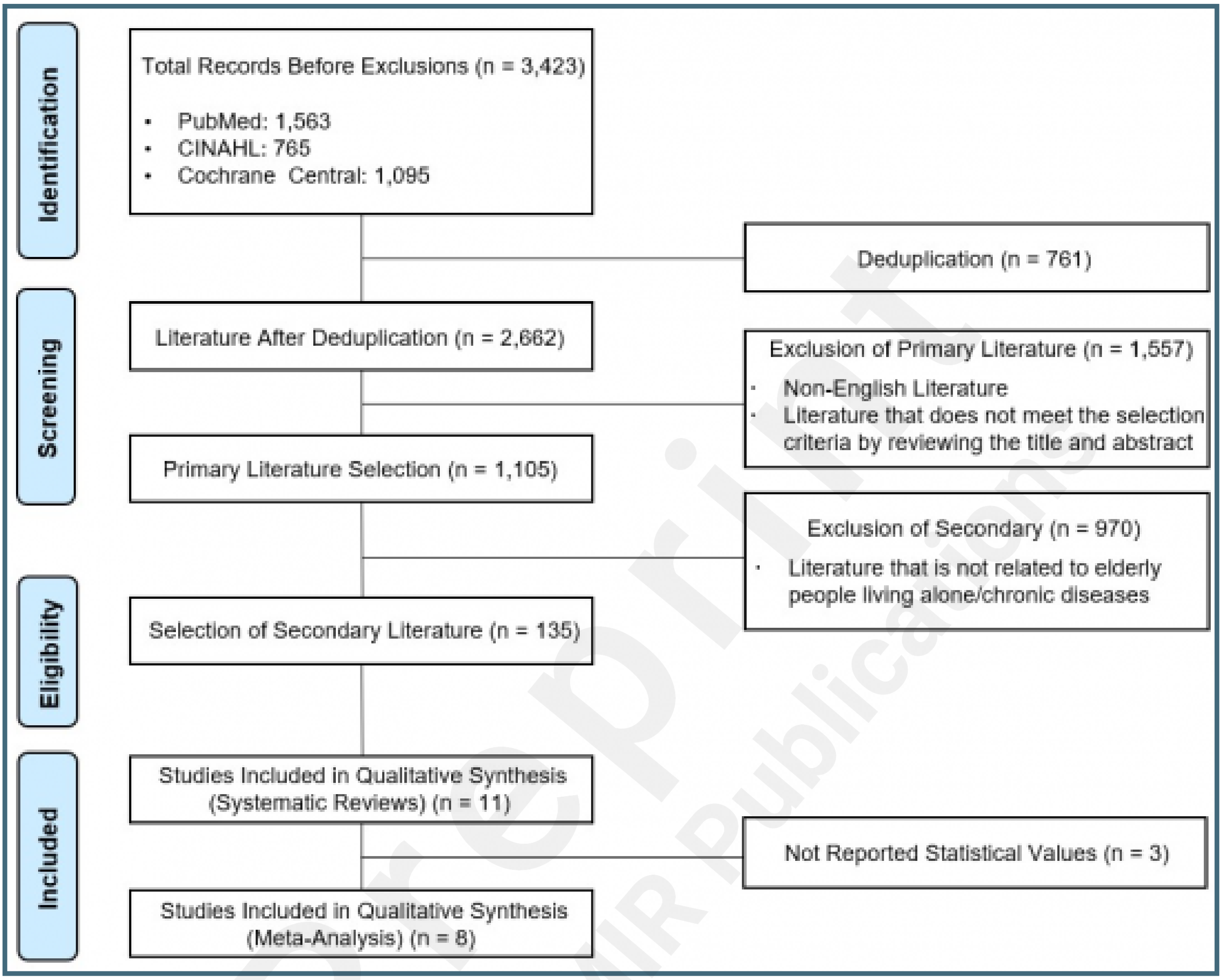
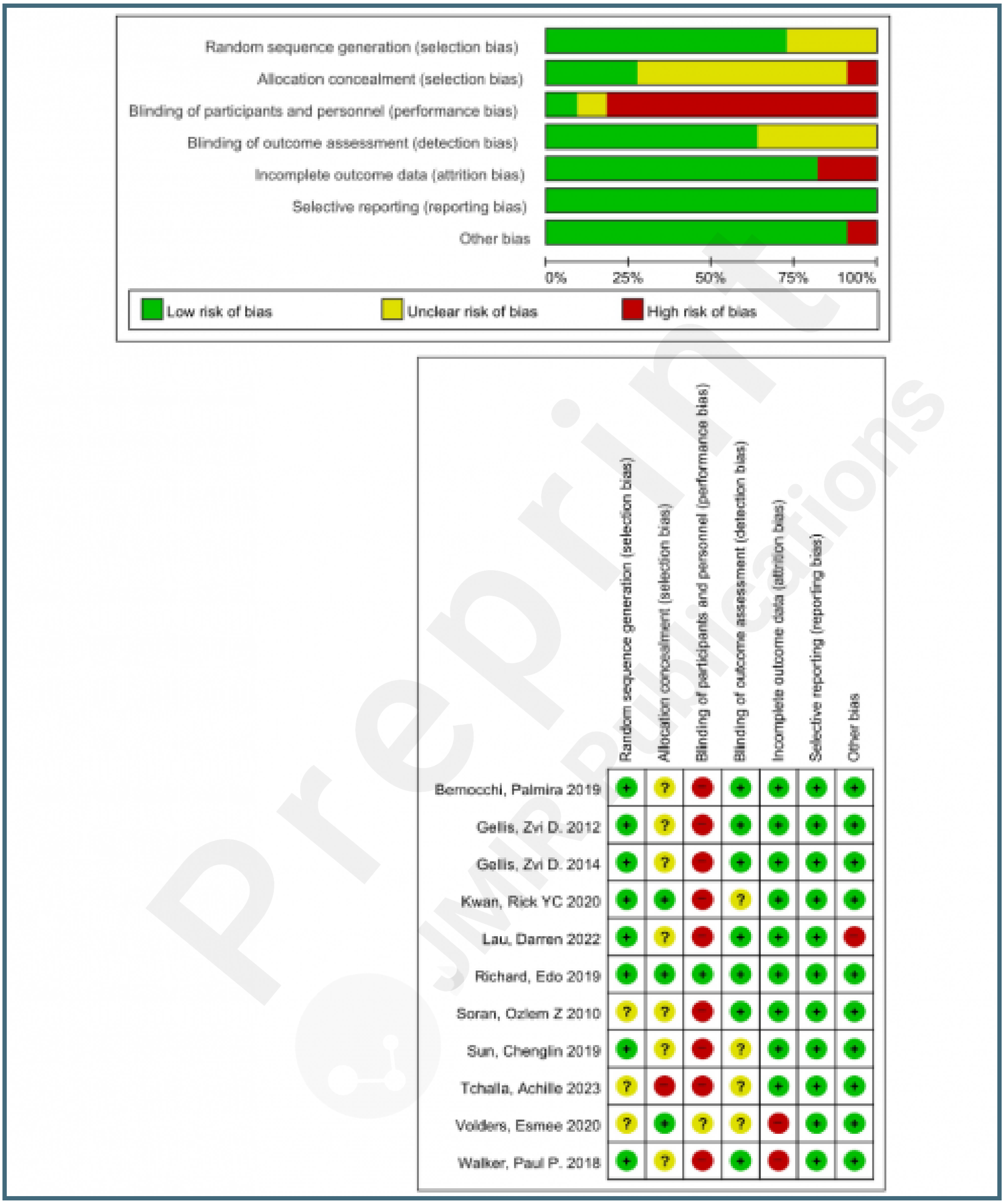
Supplementary Files

Figures

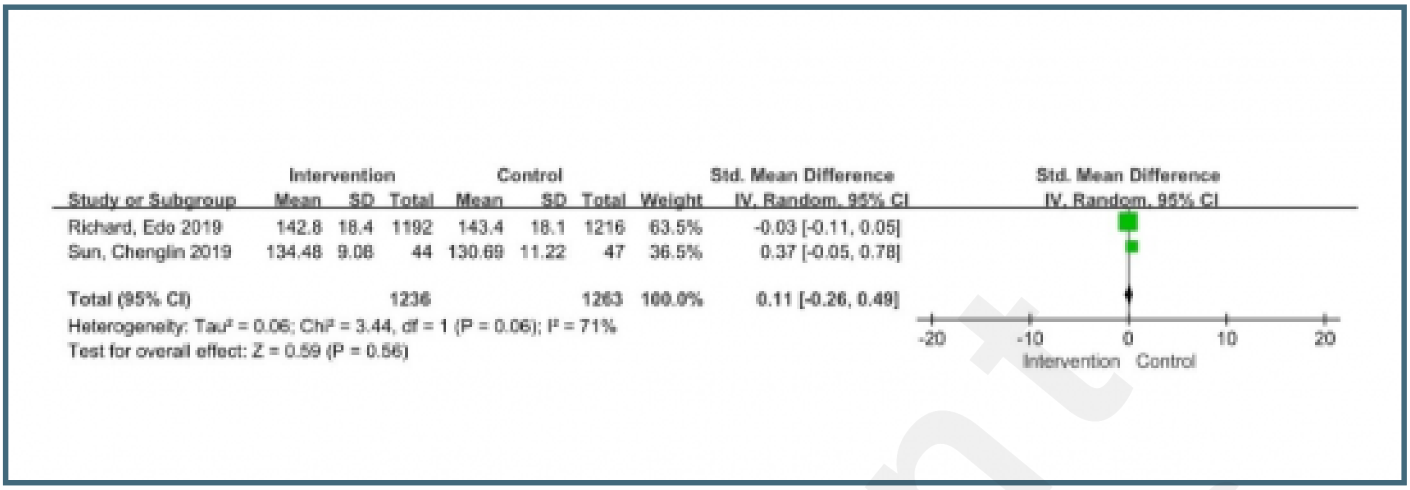
PRISMA Flow Diagram of Study Selection and Screening Process.



Risk of bias summary and graph.



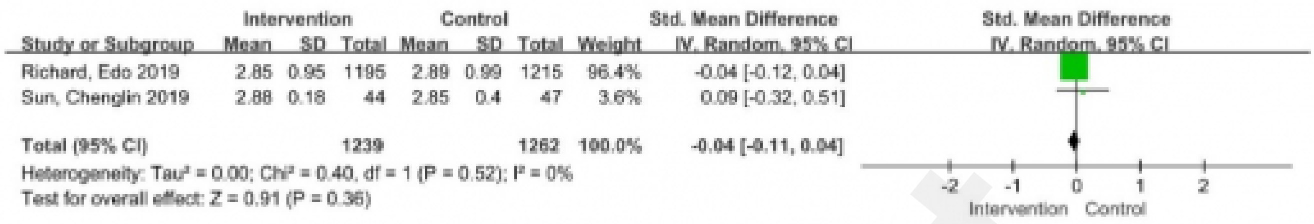
Effect Size of SBP.



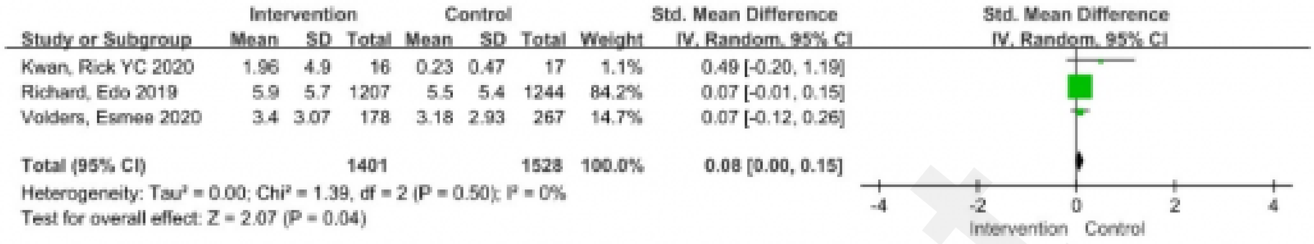
Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Richard, Edo 2019	142.8	18.4	1192	143.4	18.1	1216	63.5%	-0.03 [-0.11, 0.05]
Sun, Chenglin 2019	134.48	9.08	44	130.69	11.22	47	36.5%	0.37 [-0.05, 0.78]
Total (95% CI)			**1236**			**1263**	**100.0%**	**0.11 [-0.26, 0.49]**

Heterogeneity: $Tau^2 = 0.06$; $Chi^2 = 3.44$, df = 1 (P = 0.06); $I^2 = 71\%$
Test for overall effect: Z = 0.59 (P = 0.56)

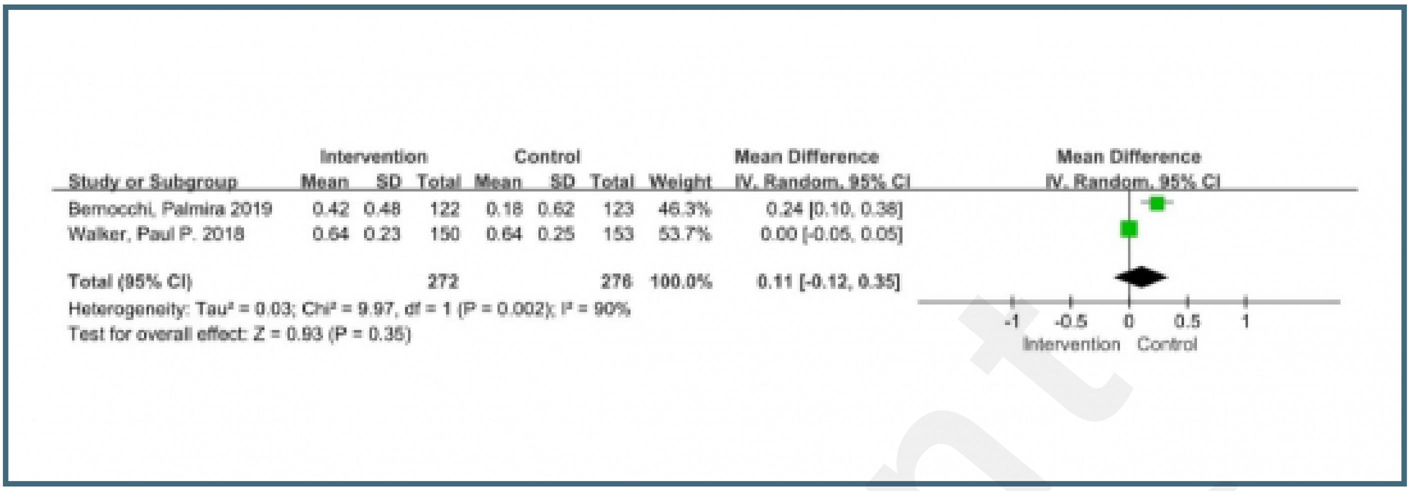
Effect Size of LDL-Cholesterol.



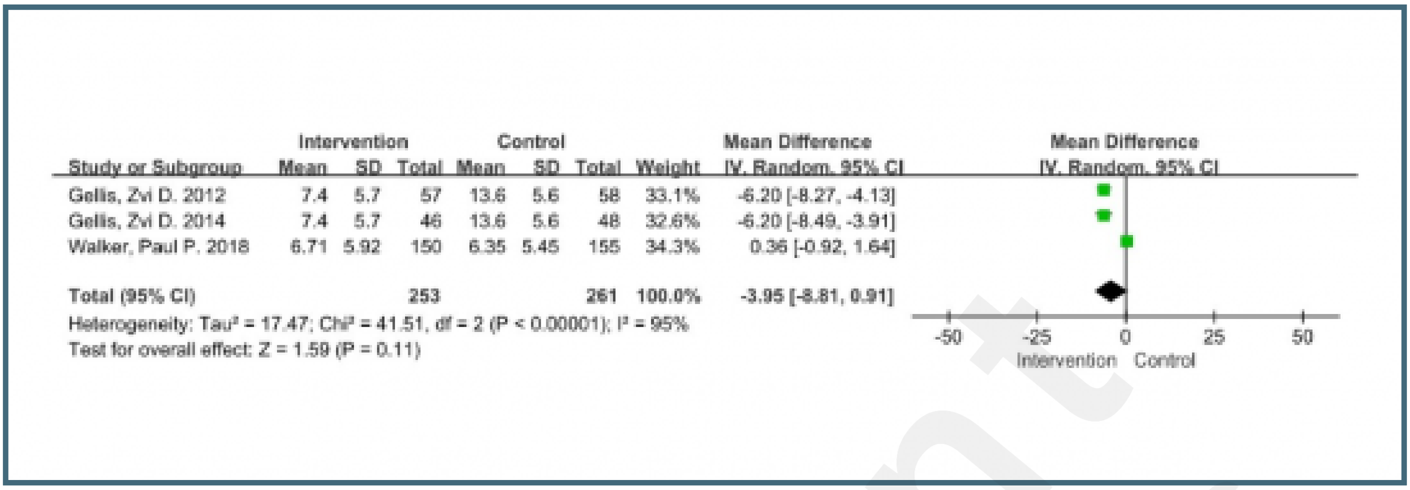
Effect Size of MVPA.



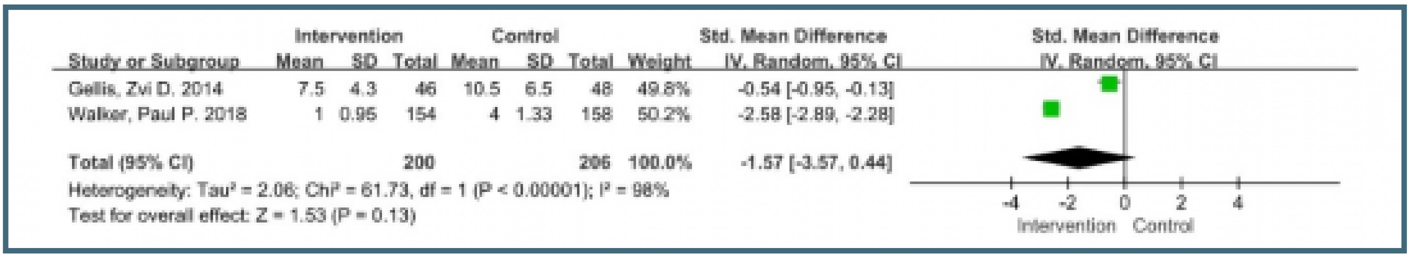
Effect Size of General Quality of Life.



Effect Size of Depression.



Effect Size of Hospital Days.



	Intervention			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Gellis, Zvi D. 2014	7.5	4.3	46	10.5	6.5	48	49.8%	-0.54 [-0.95, -0.13]
Walker, Paul P. 2018	1	0.95	154	4	1.33	158	50.2%	-2.58 [-2.89, -2.28]
Total (95% CI)			**200**			**206**	**100.0%**	**-1.57 [-3.57, 0.44]**

Heterogeneity: $Tau^2 = 2.06$; $Chi^2 = 61.73$, df = 1 ($P < 0.00001$); $I^2 = 98\%$
Test for overall effect: Z = 1.53 (P = 0.13)

CONSORT (or other) checklists

PRISMA checklist.
URL: http://asset.jmir.pub/assets/c2bf13f11f12d96df814e9a6787650de.pdf