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Effectiveness of Comprehensive Physical Activity Health Promotion Program on the Essential Physical Functions of Older Patients With Multiple Diseases and Dementia in Rural Area

Lain-Li Lin, PhD[1] and Chih-Chi Liu, MEd[2,3]

Abstract

Against the backdrop of aging populations worldwide, physical activity programs aimed at promoting the health of older adults have begun to flourish. However, few studies have focused on elderly residents in rural areas who may have multiple comorbidities. Therefore, the current study aimed to investigate the effects of a 12-week physical activity program on health promotion among rural elderly with multiple diseases. The study included 18 elderly participants, with a mean age of 82.39 years, who had dementia and one or more additional diseases. Among the participants, 89% were female. The results showed that the 12-week physical activity program intervention significantly improved participants' walking speed and range of motion of the arm joints. Based on these findings, it is hoped that this study will provide a reference for future researchers and practitioners targeting rural or elderly populations who may have multiple diseases to develop more comprehensive physical activity programs.

Keywords

physical activity program, older adults, rural area, multiple diseases, dementia

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Introduction

Lack of physical activity (PA) or a sedentary lifestyle is one of the causes of global mortality and disability (Boyle et al., 2007; Sanchez-Sanchez et al., 2020), and this includes dementia (Blondell et al., 2014; Nuzum et al., 2020). In addition, there are also multifunctional disabilities such as stroke (C. D. Lee et al., 2003), heart diseases, high blood pressure (LaCroix et al., 2019) and depression (de Oliveira et al., 2019). The symptoms of dementia encompass a wide range of cognitive and behavioral changes, including memory impairment (Mitchell et al., 2014), cognitive decline (Eshkoor et al., 2015), emotional changes (Moyle et al., 2013; Winchester et al., 2013) and language deficiency (Dijkstra et al., 2006) disturbances in perceptual abilities, and, in severe cases, loss of the ability to perform self-care and live independently (Mitseva et al., 2009; Patel et al., 2020).

Although an increasing body of research suggests that a well-designed physical activity program is associated with a reduced risk of dementia symptoms (e.g., de Almeida et al., 2020; Forbes et al., 2008; Kemoun et al., 2010; H. S. Lee et al., 2016), public awareness regarding the benefits of physical activity may still be inadequate and requires further dissemination (Godbey et al., 2010; Marcus et al., 1998), particularly among older adults (Franco et al., 2015) or rural populations (Veluswamy et al., 2014). Considering that dementia primarily affects the elderly population and with the rapid growth of the aging population, the

[1]Ching Kuo Institute of Management and Health, Keelung, Taiwan
[2]National Taiwan Normal University, Taipei, Taiwan
[3]Hsin Sheng College of Medical Care and Management, Taoyuan, Taiwan

Corresponding Author:
Chih-Chi Liu, Department of Adult and Continuing Education, National Taiwan Normal University, No. 162, Sec. 1, He-Ping E. Rd., Taipei 10610, Taiwan.
Email: 81002001e@ntnu.edu.tw

increase in the number of these cases is expected to be significant. As a result, elderly patients with dementia may bring enormous pressure and cost to their families or social resources (Connolly et al., 2014; Wimo et al., 2013). Therefore, solutions to these issues are actively being developed and researched.

In particular, a physical activity program may be a significant contributing factor for individuals who were already diagnosed with dementia. For instance, Bossers et al. (2015) compared the cognitive function changes in dementia patients after a 9-week physical activity intervention versus a social visit intervention in a randomized controlled trial conducted in nursing homes. They found that a combined intervention of aerobic and strength training was more effective in improving cognitive function compared to the social visit intervention for dementia patients. Arcoverde et al. (2014) observed significant improvement in cognitive function in dementia patients through a treadmill-based exercise intervention. Additionally, in a randomized controlled trial by Holthoff et al. (2015), it was found that physical activity intervention was more effective in improving daily physical activity condition of dementia patients compared to standard care. In summary, the current study primarily focuses on the potential contribution of physical activity to improving physical activity levels in older adults with dementia.

Previous research has shown that it is common for elderly individuals with dementia to experience multiple comorbidities, including hypertension, diabetes, hyperthyroidism, heart disease, and degenerative joint disease (Richards & Brayne, 2010; Savva & Stephan, 2010; Skoog, 2000). However, previous research on dementia patients has paid less attention to whether their subjects also suffer from multiple comorbidities (Bunn et al., 2012). In other words, the current study has yet to explore the associations between the various diseases of dementia patients and their overall health, well-being, and quality of care they received (Valderas et al., 2009). In addition, a meta-analysis study has indicated that a comprehensive PA program is more effective than a single type of PA program in promoting the physical health of dementia patients (H. S. Lee et al., 2016). Furthermore, according to H. S. Lee et al. (2016), a comprehensive physical activity (PA) program should go beyond a single type of exercise and encompass both aerobic exercise and muscle training components. Therefore, the current study proposes a comprehensive PA program for elderly dementia patients with multiple comorbidities to examine whether implementing a comprehensive PA program can effectively promote their health.

Furthermore, considering the disparity of resources between urban and rural areas and the higher prevalence of an aging population in rural areas (e.g., Chen et al., 2016; Jensen et al., 2020; Jung et al., 2016; Qu et al., 2012), there is a necessity to allocate greater long-term care opportunities and resources specifically to rural areas.

In particular, the lack of convenient transportation in rural areas may result in older adults being unable to seek medical care or needing to spend longer time for it (Mattson, 2011; Smith et al., 2017). Additionally, the inadequate infrastructure in rural areas may exacerbate the negative consequences of aging, making it more difficult for older adults with multiple comorbidities, declined or impaired basic physical functions to live and receive treatment. In addition, as stated by Moholt et al. (2020), care delivery is more prevalent in urban areas than in rural areas. The above evidence supports the need for researchers and practitioners to pay more attention to the issue of long-term care in rural areas. Therefore, the present study aims to propose a comprehensive PA program targeting the promotion of basic physical functions of older adults with dementia and to implement it in rural areas. This is expected to provide practical contributions to relevant policy-making agencies and elderly care institutions.

Methods

Participant

The participants in this study were recruited from a long-term care institution located in a rural area of Taiwan through convenience sampling. Recruitment criteria include: (1) voluntary and the caregiver (after family or agency assessment) agrees to participate in a 12-week course; (2) having multiple comorbidities and being diagnosed with dementia; (3) non-bedridden. A total of 22 individuals were initially recruited, but four participants did not complete all the measurements, resulting in a final sample of 18 participants. All participants were elderly patients with multiple diseases and were diagnosed with dementia. Additionally, the participants also had other medical conditions, including hypertension, diabetes, hyperthyroidism, cardiovascular disease, prostate hyperplasia, depression, gout, osteoarthritis, osteoporosis, intellectual disability, hyperlipidemia, stroke, and left lower limb artery occlusion, as presented in Table 1 with de-identified basic information. Finally, all voluntary participants in this study are individuals who utilize the day-care service provided by long-term care institutions.

To ensure anonymity, each participant was assigned a code instead of using their real name, and their participation in the study and data collection was authorized by both the institution and their family. Due to the presence of multiple diseases, each participant required permission from the institution and their family to participate in this study. The current study was approved by the Research Ethics Committee, National Taiwan University (Case number: 202109EM005).

The final sample of 18 participants had a mean age of 82.39 years. The age distribution was as follows: one participant was below 74 years old (69 years old), five participants were aged 75 to 79 years, five participants were aged 80 to 84 years, five participants were aged 85

Table 1. Basic Information of Participants.

Number	Gender	Age	List of diseases the participant suffered from (remark)
1	Female	86	Dementia, Hypertension, Diabetes, Hyperthyroidism (During walking, the participant is able to walk without the use of assistive devices, but occasionally exhibits unsteady gait. Assistance is required when transitioning from a seated to standing position.)
2	Female	79	Dementia, Hypertension
3	Female	89	Dementia, Hypertension (using assistive devices during walking)
4	Female	77	Dementia, Hypertension, Heart Disease
5	Female	87	Dementia, Hypertension, Neurodegeneration
6	Male	95	Dementia, Hypertension, Heart Disease, Enlarged Prostate, Depression (using a one-handed crutch)
7	Female	84	Dementia, Hypertension, Gout
8	Female	89	Dementia, Hypertension, Diabetes (using assistive devices during walking)
9	Female	69	Dementia, Hypertension, Diabetes, Osteoarthritis, Osteoporosis, Intellectual Disability (using assistive devices during walking)
10	Female	91	Dementia, Hypertension, Diabetes, Hyperlipidemia (using a one-handed crutch)
11	Female	81	Dementia, Hypertension
12	Female	80	Dementia, Hypertension, Depression (using assistive devices during walking)
13	Female	74	Dementia, Heart Disease, Diabetes (using assistive devices during walking)
14	Female	76	Dementia, Hypertension, Stroke (using a one-handed crutch)
15	Female	78	Peripheral artery occlusion (treated), Dementia (using a one-handed crutch)
16	Female	79	Dementia, Hypertension
17	Male	87	Dementia, Hypertension (using a one-handed crutch)
18	Female	82	Dementia, Hypertension

to 89 years, and two participants were aged 90 years or above. Therefore, individuals aged between 80 and 89 years old comprised 55% of the sample. In addition, 16 participants were female, accounting for 89% of the sample. Finally, all participants included in the study data had moderate or severe dementia.

Design and Procedure

After obtaining consent from all participants (and obtaining institutional and family consent), the researchers held an information session for those who agreed to participate in the study. A 12-week (2 days per week, 1 hr per day) comprehensive exercise training program was implemented starting 2 days after the information session. The content and goals of the program for each week are detailed in Table 2. The comprehensive exercise program was led by a lecturer who holds a master's degree in sports science and a Ph.D. in adult education, ensuring that the program's implementation was not only professionally based on sports science but also more suitable for adult learning contexts.

Measures

When evaluating physical activity in older adults, clinical practitioners and researchers widely use tests such as gait speed, grip strength, jump test, and walking test (Patrizio et al., 2021). This study aims to improve the basic physical activity function needed for participants' daily lives, such as moving, carrying objects, and performing simple household chores. Therefore, to better meet the participants' daily life context, we examined their changes in "6m walk," "grip strength," and "range of motion across arm joints" before and after participation in the study. Among them, the 6 m walk was measured in seconds, grip strength was measured separately for the left and right hands in kilograms, and finally, the range of motion of the arm joints was measured in degrees.

Furthermore, the study by Lyons et al. (2015) confirmed the validity of the 6 m walk test in samples of older adults. Additionally, they suggested that excessively long test distances may not be feasible in limited environments, hence opting for shorter courses as they are also effective. Therefore, the current study adopted the 6 m walk as the measurement standard. Furthermore, grip strength in older adults is considered to be strongly associated with cognitive function (Carson, 2018), and arm joint mobility greatly influences the range of motion in older adults (Bains & Askari, 2022). Therefore, these indicators were adopted as measurement variables in the current study.

Data Analysis

The current study involves descriptive statistical analysis and paired-sample t-test analysis. The descriptive statistical analysis will present the mean and standard deviation of participants' pre-test and post-test scores before participating in the comprehensive PA program. In addition, a paired-sample t-test will be used to examine whether there is a statistically significant difference between participants' pre-test and post-test scores.

Table 2. Weekly Schedule of PA Program for Current Research Design.

Week	Topic	Objectives	Supplementary
1	Upper body Stretching exercises	Shoulder joint muscle group for upper limb stretching	• Take 20 min to do the pre- (post-) test at the first (12th) week. • It takes about 10 min to complete the subject content of a set of courses, and each course takes about 20 min for step-by-step teaching, about 20 min for the lecturer to lead the practice, and about 10 min for breaks between classes. • In the weeks of "Review lessons from previous weeks," the instructor will lead all participants to complete at least one set of lessons in the previous weeks. • The course content of the current PA program has been recorded as a video and publicly broadcast on the YouTube platform. The reference video materials for each course are listed below: 1. Upper body stretching exercises (https://youtu.be/t0r9BqBVH3A) 2. Lower body stretching exercises (https://youtu.be/9PV0JrqSf0I) 3. Lower extremity strength training (https://youtu.be/vpHWktwQb70) 4. 1 min run (https://youtu.be/IhQkZ3Qvr5c) 5. Water bottle dumbbell (https://youtu.be/QvC47YmyJ7I) 6. Fine motor training for hands (https://youtu.be/Ow8nkiPOGAA) 7. Sports bungee cord (https://www.youtube.com/watch?v=KZ3-nmhS5TQ#t=1m36s)
2	Lower body stretching exercises	Relaxing the muscles of the lower limbs	
3	Lower extremity strength training	Enhance lower extremity muscular strength	
4	1 min run	Enhance reaction ability and speed ability	
5	Review lessons from previous weeks		
6	Water bottle dumbbell	Enhance upper extremity muscular strength	
7	Fine motor training for hands	Train the precision of hand movements	
8, 9	Review lessons from previous weeks		
10, 11	Sports bungee cord	Training muscle strength and muscle endurance	
12	Review lessons from previous weeks		

Results

The descriptive statistics and paired-sample t-test results of this study are presented in Table 3. Among them, in the 6 m walking test, the participants' walking time in the post-test ($M=29.29$, $SD=29.79$) was significantly shorter than that in the pre-test ($M=32.82$, $SD=27.16$; $t=-3.53$, $p=.011$), indicating an increase in walking speed after participating in the comprehensive PA program. In addition, for the range of motion of the arm joint, the post-test angle was significantly greater than the pre-test angle for both the left hand ($t=21.00$, $p=.002$) and the right hand ($t=13.68$, $p=.032$), indicating an increase in the range of motion of the participants' arm joints. Finally, there were no statistically significant changes in grip strength for either the left hand ($t=1.36$, $p=.085$) or the right hand ($t=0.67$, $p=.371$) as measured by the grip strength test.

Discussion

Effectiveness of Comprehensive PA Health Promotion Program on Older Patients With Multiple Diseases

The results indicate that the PA program intervention had a significant effect on improving participants' walking speed and arm joint range of motion, which may be helpful for their daily activities. Firstly, our finding regarding the improvement in walking speed among older adults through the PA program is consistent with previous research (e.g., Falls et al., 2018; Kanwar et al., 2021; Kemoun et al., 2010; Pau et al., 2014). However, previous studies mostly focused on either healthy older adults or older adults with specific diseases, such as Kanwar et al. (2021)'s study, which showed significant effects of the PA program on improving walking speed among healthy older adults, and Kemoun et al. (2010)'s study, which found significant improvement in walking speed among older adults with dementia after participating in a PA program. While few studies have considered whether participants have multiple diseases. However, in the current study, no significant improvement in grip strength was found among participants. Although the mean grip strength score in the post-test was numerically higher than that in the pre-test, it did not pass statistical tests and therefore needs to be interpreted with caution. Finally, due to some limitations, the current study could not discuss each disease separately but still indicates that the PA program may be an effective way to promote the health of this population. Therefore, the current study also provides a program schedule and concise content for future researchers and practitioners to further explore, pointing out a clear direction for future research.

Promoting PA Health Promotion Programs in Long-Term Care Institutions in Rural Areas

Furthermore, the current study participants are all from long-term care facilities in rural areas. Based on past research findings, it can be inferred that there may be some issues with long-term care in rural areas, such as shortages in human resources, inadequate infrastructure, policy issues, and inconvenient transportation (Chuakhamfoo et al., 2020; Radcliff et al., 2022; Zhu & Österle, 2017). In addition, the issues of outflow of the young population and aging population in rural areas may urgently require support for aging-related facilities (Fang et al., 2020). Although the current study cannot provide any analysis of the differences between elderly

Table 3. Results of Paired-Sample *t*-test.

	Pre-test		Post-test			
N = 18	*M*	*SD*	*M*	*SD*	*t*	*p*-value
6 m Walking Time (s)	32.82	27.16	29.29	29.79	−3.53	.011
Grip strength (left hand) (kg)	10.32	6.44	11.68	5.95	1.36	.085
Grip strength (right hand) (kg)	10.05	5.34	10.71	5.20	0.67	.371
Range of motion across arm joints (left)	48.00	17.05	69.00	15.27	21.00	.002
Range of motion across arm joints (right)	54.74	15.04	68.42	14.53	13.68	.032

individuals in urban and rural long-term care facilities Our findings suggest that PA programs may also be effective in rural long-term care. Therefore, the current study suggests that researchers and practitioners focus more resources on promoting the overall health and quality of care of elderly individuals in rural areas. For example, Hsu et al. (2022) designed a portable package for promoting older adults' health, which allows service providers who are willing to serve rural areas to more easily enter various regions and communities.

Limitations and Conclusion

First, the current study includes some limitations that require careful interpretation of the findings. Firstly, due to the lack of manpower and resources, the current study was not based on a randomized controlled trial (RCT), thus, there was no control group for comparison to determine whether the current PA program is suitable for other study populations, such as the general elderly population. Hence, it is suggested that future research should include a control group in the implementation (such as comparing urban and rural areas or comparing healthy and older adults with multiple comorbidities) to establish that the improvement in participants' physical health is based on the experimental intervention and not influenced by other potential factors. These potential factors include the person-centered care approach proposed by the authoritative scholar Tom Kitwood, which is currently supported by empirical evidence and emphasizes the use of interactive methods and humanistic ethics, rather than medical interventions in providing care for dementia patients (Kitwood, 1998). In conclusion, it is important to interpret the current research findings cautiously to avoid making erroneous attributions.

Second, the current study only physiological measures were collected, limiting the interpretation of participants' psychological changes. To obtain more comprehensive empirical results, it is recommended to include psychological variables such as subjective well-being, emotion, or cognition in the measurements.

Last but not least, the current study is limited by the uniqueness of the target population and the challenges encountered in participant recruitment, resulting in a final sample size of only 18 participants. This limitation is crucial to consider in interpreting the statistical analysis results of the current study. Therefore, it is recommended that future research endeavors make every effort to recruit a larger number of participants to enhance statistical power and improve the generalizability of findings.

Declaration of Conflicting Interests

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Research Ethics and Patient Consent

This study was approved by Research Ethics Committee, National Taiwan University with IRB protocol/human subjects approval number 202109EM005.

ORCID iD

Chih-Chi Liu https://orcid.org/0000-0003-1039-3533

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The data are not publicly available due to restrictions their containing information that could compromise the privacy of research participants.

References

Arcoverde, C., Deslandes, A., Moraes, H., Almeida, C., Araujo, N. B., Vasques, P. E., Silveira, H., & Laks, J. (2014). Treadmill training as an augmentation treatment for Alzheimer's disease: A pilot randomized controlled study. *Arquivos de neuro-psiquiatria*, *72*, 190–196. https://doi.org/10.1590/0004-282X20130231

Bains, B. S., & Askari, S. S. (2022). The role of physiotherapy in the rehabilitation of chronic neck pain and shoulder pain: Single subject case study. *International Journal of Aging Health and Movement*, *4*(1), 24–28. https://doi.org/10.7575/ijahm.v4i1.101

Blondell, S. J., Hammersley-Mather, R., & Veerman, J. L. (2014). Does physical activity prevent cognitive decline and dementia?: A systematic review and meta-analysis of longitudinal studies. *BMC Public Health*, *14*(1), 510. https://doi.org/10.1186/1471-2458-14-510

Bossers, W. J., van der Woude, L. H., Boersma, F., Hortobágyi, T., Scherder, E. J., & van Heuvelen, M. J. (2015). A 9-week aerobic and strength training program improves cognitive and motor function in patients with dementia: A randomized, controlled trial. *The American Journal of Geriatric Psychiatry*, *23*(11), 1106–1116. https://doi.org/10.1016/j.jagp.2014.12.191

Boyle, P. A., Buchman, A. S., Wilson, R. S., Bienias, J. L., & Bennett, D. A. (2007). Physical activity is associated with incident disability in community-based older persons. *Journal of the American Geriatrics Society*, *55*(2), 195–201. https://doi.org/10.1111/j.1532-5415.2007.01038.x

Bunn, F., Goodman, C., Sworn, K., Rait, G., Brayne, C., Robinson, L., McNeilly, E., & Iliffe, S. (2012). Psychosocial factors that shape patient and carer experiences of dementia diagnosis and treatment: A systematic review of qualitative studies. *PLoS Medicine*, *9*(10), e1001331. https://doi.org/10.1371/journal.pmed.1001331

Carson, R. G. (2018). Get a grip: Individual variations in grip strength are a marker of brain health. *Neurobiology of Aging*, *71*, 189–222. https://doi.org/10.1016/j.neurobiolaging.2018.07.023

Chen, J., Wang, Y., Wen, J., Fang, F., & Song, M. (2016). The influences of aging population and economic growth on Chinese rural poverty. *Journal of Rural Studies*, *47*, 665–676. https://doi.org/10.1016/j.jrurstud.2015.11.002

Chuakhamfoo, N. N., Phanthunane, P., Chansirikarn, S., & Pannarunothai, S. (2020). Health and long-term care of the elderly with dementia in rural Thailand: A cross-sectional survey through their caregivers. *BMJ Open*, *10*(3), e032637. https://doi.org/10.1136/bmjopen-2019-032637

Connolly, S., Gillespie, P., O'Shea, E., Cahill, S., & Pierce, M. (2014). Estimating the economic and social costs of dementia in Ireland. *Dementia*, *13*(1), 5–22. https://doi.org/10.1177/1471301212442453

de Almeida, S. I. L., Gomes da Silva, M., & Marques, A. S. P. D. (2020). Home-based physical activity programs for people with dementia: Systematic review and meta-analysis. *The Gerontologist*, *60*(8), e600–e608. https://doi.org/10.1093/geront/gnz176

de Oliveira, L. D. S. S. C. B., Souza, E. C., Rodrigues, R. A. S., Fett, C. A., & Piva, A. B. (2019). The effects of physical activity on anxiety, depression, and quality of life in elderly people living in the community. *Trends in Psychiatry and Psychotherapy*, *41*, 36–42.

Dijkstra, K., Bourgeois, M., Youmans, G., & Hancock, A. (2006). Implications of an advice-giving and teacher role on language production in adults with dementia. *The Gerontologist*, *46*(3), 357–366. https://doi.org/10.1093/geront/46.3.357

Eshkoor, S. A., Hamid, T. A., Mun, C. Y., & Ng, C. K. (2015). Mild cognitive impairment and its management in older people. *Clinical Interventions in Aging*, *10*, 687–693. https://doi.org/10.2147/CIA.S73922

Falls, D., Shake, M., Norris, E., Arnett, S., Taylor, J., & Crandall, K. J. (2018). Bingocize®: Utilizing a mobile application to improve gait in community-dwelling older adults. *American Journal of Recreation Therapy*, *17*(2), 9–19. https://doi.org/10.5055/ajrt.2018.0156

Fang, E. F., Xie, C., Schenkel, J. A., Wu, C., Long, Q., Cui, H., Aman, Y., Frank, J., Liao, J., Zou, H., Wang, N. Y., Wu, J., Liu, X., Li, T., Fang, Y., Niu, Z., Yang, G., Hong, J., Wang, Q., & Woo, J. (2020). A research agenda for ageing in China in the 21st century (2nd edition): Focusing on basic and translational research, long-term care, policy and social networks. *Ageing Research Reviews*, *64*, 101174. https://doi.org/10.1016/j.arr.2020.101174

Forbes, D., Forbes, S., Morgan, D. G., Markle-Reid, M., Wood, J., & Culum, I. (2008). Physical activity programs for persons with dementia. *Cochrane Database of Systematic Reviews*, *3*, CD006489. https://doi.org/10.1002/14651858.CD006489.pub2

Franco, M. R., Tong, A., Howard, K., Sherrington, C., Ferreira, P. H., Pinto, R. Z., & Ferreira, M. L. (2015). Older people's perspectives on participation in physical activity: A systematic review and thematic synthesis of qualitative literature. *British Journal of Sports Medicine*, *49*(19), 1268–1276. https://doi.org/10.1136/bjsports-2014-094015

Godbey, G., Mowen, A., & Ashburn, V. (2010). *The benefits of physical activity provided by park and recreation services: The scientific evidence*. National Recreation and Park Association.

Holthoff, V. A., Marschner, K., Scharf, M., Steding, J., Meyer, S., Koch, R., & Donix, M. (2015). Effects of physical activity training in patients with Alzheimer's dementia: Results of a pilot RCT study. *PloS one*, *10*(4), e0121478. https://doi.org/10.1371/journal.pone.0121478

Hsu, H.-I., Liu, C.-C., Yang, S. F., & Chen, H.-C. (2022). A health promotion program for older adults (KABAN!): Effects on health literacy, quality of life, and emotions. *Educational Gerontology*. Advance online publication. https://doi.org/10.1080/03601277.2022.2147331.

Jensen, L., Monnat, S. M., Green, J. J., Hunter, L. M., & Sliwinski, M. J. (2020). Rural population health and aging: Toward a multilevel and multidimensional research agenda for the 2020s. *American Journal of Public Health*, *110*(9), 1328–1331. https://doi.org/10.2105/AJPH.2020.305782

Jung, H.-W., Jang, I.-Y., Lee, Y. S., Lee, C. K., Cho, E.-I., Kang, W. Y., Chae, J. H., Lee, E. J., & Kim, D. H. (2016). Prevalence of frailty and aging-related health conditions in older koreans in rural communities: A cross-sectional analysis of the aging study of pyeongchang rural area. *Journal of Korean Medical Science*, *31*(3), 345–352. https://doi.org/10.3346/jkms.2016.31.3.345

Kanwar, K. D., Moore, J. L., Hawkes, R., & Salem, G. J. (2021). Golf as a physical activity to improve walking speed and cognition in older adults: A non-randomized, pre-post, pilot study. *Mental Health and Physical Activity*, *21*, 100410. https://doi.org/10.1016/j.mhpa.2021.100410

Kemoun, G., Thibaud, M., Roumagne, N., Carette, P., Albinet, C., Toussaint, L., Paccalin, M., & Dugué, B. (2010). Effects of a physical training programme on cognitive function and walking efficiency in elderly persons with dementia. *Dementia and Geriatric Cognitive Disorders*, *29*(2), 109–114. https://doi.org/10.1159/000272435

Kitwood, T. (1998). Toward a theory of dementia care: Ethics and interaction. *The Journal of Clinical Ethics*, *9*(1), 23–34. https://doi.org/10.1086/jce199809103

LaCroix, A. Z., Bellettiere, J., Rillamas-Sun, E., Di, C., Evenson, K. R., Lewis, C. E., Buchner, D. M., Stefanick, M. L., Lee, I.-M., Rosenberg, D. E., & LaMonte, M. J.; Women's Health Initiative (WHI). (2019). Association of light physical activity measured by accelerometry and incidence of coronary heart disease and cardiovascular disease in older women. *JAMA Network Open*, *2*(3),

e190419–e190419. https://doi.org/10.1001/jamanetworkopen.2019.0419

Lee, C. D., Folsom, A. R., & Blair, S. N. (2003). Physical activity and stroke risk: A meta-analysis. *Stroke*, *34*(10), 2475–2481. https://doi.org/10.1161/01.STR.0000091843.02517.9D

Lee, H. S., Park, S. W., & Park, Y. J. (2016). Effects of physical activity programs on the improvement of dementia symptom: A meta-analysis. *BioMed Research International*, *2016*, 1–7. https://doi.org/10.1155/2016/2920146

Lyons, J. G., Heeren, T., Stuver, S. O., & Fredman, L. (2015). Assessing the agreement between 3-meter and 6-meter walk tests in 136 community-dwelling older adults. *Journal of Aging and Health*, *27*(4), 594–605. https://doi.org/10.1177/0898264314556987

Marcus, B. H., Owen, N., Forsyth, L. H., Cavill, N. A., & Fridinger, F. (1998). Physical activity interventions using mass media, print media, and information technology. *American journal of preventive medicine*, *15*(4), 362–378. https://doi.org/10.1016/s0749-3797(98)00079-8

Mattson, J. (2011). Transportation, distance, and health care utilization for older adults in rural and small urban areas. *Transportation Research Record*, *2265*(1), 192–199.

Mitchell, A. J., Beaumont, H., Ferguson, D., Yadegarfar, M., & Stubbs, B. (2014). Risk of dementia and mild cognitive impairment in older people with subjective memory complaints: Meta-analysis. *Acta Psychiatrica Scandinavica*, *130*(6), 439–451. https://doi.org/10.1111/acps.12336

Mitseva, A., Kyriazakos, S., Litke, A., Papadakis, N., & Prasad, N. (2009). ISISEMD: Intelligent system for independent living and self-care of seniors with mild cognitive impairment or mild dementia. *The Journal on Information Technology in Healthcare*, *7*(6), 383–399.

Moholt, J. M., Friborg, O., Blix, B. H., & Henriksen, N. (2020). Factors affecting the use of home-based services and out-of-home respite care services: A survey of family caregivers for older persons with dementia in Northern Norway. *Dementia*, *19*(5), 1712–1731. https://doi.org/10.1177/1471301218804981

Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., & Gray, C. (2013). Exploring the effect of companion robots on emotional expression in older adults with dementia: A pilot randomized controlled trial. *Journal of Gerontological Nursing*, *39*(5), 46–53. https://doi.org/10.3928/00989134-20130313-03

Nuzum, H., Stickel, A., Corona, M., Zeller, M., Melrose, R. J., & Wilkins, S. S. (2020). Potential benefits of physical activity in MCI and dementia. *Behavioural Neurology*, *2020*, 1–10. https://doi.org/10.1155/2020/7807856

Patel, N., Stagg, B. C., Swenor, B. K., Zhou, Y., Talwar, N., & Ehrlich, J. R. (2020). Association of co-occurring dementia and self-reported visual impairment with activity limitations in older adults. *JAMA Ophthalmology*, *138*(7), 756–763. https://doi.org/10.1001/jamaophthalmol.2020.1562

Patrizio, E., Calvani, R., Marzetti, E., & Cesari, M. (2021). Physical functional assessment in older adults. *The Journal of Frailty & Aging*, *10*(2), 141–149. https://doi.org/10.14283/jfa.2020.61

Pau, M., Leban, B., Collu, G., & Migliaccio, G. M. (2014). Effect of light and vigorous physical activity on balance and gait of older adults. *Archives of Gerontology and Geriatrics*, *59*(3), 568–573. https://doi.org/10.1016/j.archger.2014.07.008

Qu, B., Li, X., Liu, J., & Mao, J. (2012). Analysis of the current situation regarding the aging rural population in China and proposed countermeasures. *Population Health Management*, *15*(3), 181–185. https://doi.org/10.1089/pop.2011.0033

Radcliff, T. A., Horney, J. A., Dobalian, A., Macareno, B. O., Kabir, U. Y., Price, C., & Strickland, C. J. (2022). Long-term care planning, preparedness, and response among rural long-term care providers. *Disaster Medicine and Public Health Preparedness*, *16*(1), 12–15. https://doi.org/10.1017/dmp.2020.211

Richards, M., & Brayne, C. (2010). What do we mean by Alzheimer's disease? *BMJ*, *341*, c4670. https://doi.org/10.1136/bmj.c4670

Sanchez-Sanchez, J. L., Izquierdo, M., Carnicero-Carreño, J. A., García-García, F. J., & Rodríguez-Mañas, L. (2020). Physical activity trajectories, mortality, hospitalization, and disability in the Toledo Study of Healthy Aging. *Journal of Cachexia Sarcopenia and Muscle*, *11*(4), 1007–1017. https://doi.org/10.1002/jcsm.12566

Savva, G. M., & Stephan, B. C. (2010). Epidemiological studies of the effect of stroke on incident dementia: A systematic review. *Stroke*, *41*(1), e41–e46. https://doi.org/10.1161/STROKEAHA.109.559880

Skoog, I. (2000). K. Jellinger, R. Schmidt, & M. Windisch *Vascular aspects in Alzheimer's disease*. Advances in Dementia Research.

Smith, M. L., Prohaska, T. R., MacLeod, K. E., Ory, M. G., Eisenstein, A. R., Ragland, D. R., Irmiter, C., Towne, S. D., & Satariano, W. A. (2017). Non-emergency medical transportation needs of middle-aged and older adults: A rural-urban comparison in Delaware, USA. *International Journal of Environmental Research and Public Health*, *14*(2), 174.

Valderas, J. M., Starfield, B., Sibbald, B., Salisbury, C., & Roland, M. (2009). Defining comorbidity: Implications for understanding health and health services. *Annals of Family Medicine*, *7*(4), 357–363. https://doi.org/10.1370/afm.983

Veluswamy, S. K., Maiya, A. G., Nair, S., Guddattu, V., Nair, N. S., & Vidyasagar, S. (2014). Awareness of chronic disease related health benefits of physical activity among residents of a rural South Indian region: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 27. https://doi.org/10.1186/1479-5868-11-27

Wimo, A., Jönsson, L., Bond, J., Prince, M., & Winblad, B. (2013). The worldwide economic impact of dementia 2010. *Alzheimer's & Dementia*, *9*(1), 1–11.e3. https://doi.org/10.1016/j.jalz.2012.11.006

Winchester, J., Dick, M. B., Gillen, D., Reed, B., Miller, B., Tinklenberg, J., Mungas, D., Chui, H., Galasko, D., Hewett, L., & Cotman, C. W. (2013). Walking stabilizes cognitive functioning in Alzheimer's disease (AD) across one year. *Archives of Gerontology and Geriatrics*, *56*(1), 96–103. https://doi.org/10.1016/j.archger.2012.06.016

Zhu, Y., & Österle, A. (2017). Rural-urban disparities in unmet long-term care needs in China: The role of the hukou status. *Social Science & Medicine*, *191*, 30–37. https://doi.org/10.1016/j.socscimed.2017.08.025