Mental Exercises and Cognitive Enhancement: A Path to Psychological Well-being in the Elderly

Walaa Badawy Mohamed Badawy

Ass prof of clinical psychology, King Khalid University
wbadwe@kku.edu.sa

Abstract

Age-related cognitive decline and psychological distress are major public health concerns. Non-pharmacological approaches like cognitive training may help promote healthy cognitive aging. This study investigated the impact of an 8-week cognitive exercise program on cognitive function and psychological wellbeing in elderly individuals residing in geriatric homes. Using a quasi-experimental pre-post design, 44 participants were allocated to an intervention group receiving cognitive training or a control group. The 30-minute sessions, conducted thrice weekly, included memory games, logic puzzles, and problem-solving activities. Outcomes were assessed using the Mini-Mental State Examination (MMSE), Geriatric Depression Scale (GDS) and Geriatric Anxiety Inventory (GAI). Results showed the intervention group exhibited significant improvements in MMSE scores ($p<0.001$) and reductions in GDS ($p=0.001$) and GAI scores ($p=0.003$) compared to controls. Between-group differences confirmed superior cognitive and psychological benefits for the training group over controls (MMSE $p=0.032$; GDS $p=0.048$; GAI $p=0.026$). Moderate effect sizes (Cohen's d from 0.42 to 0.67) further indicate the practical significance of these enhancements. In conclusion, structured cognitive training effectively improved cognitive status and psychological wellbeing in the elderly sample. Mental exercise shows promise as a non-pharmacological approach to promote healthy cognitive aging and emotional resilience in late life.

Keywords: cognitive training, mental exercise, cognitive aging, neuroplasticity, psychological wellbeing

1. Introduction

The human experience is a continuous journey marked by phases and transitions, with the passage of time serving as a constant reminder of our inevitable progress towards a stage known as "old age." The process of aging is an intricate tapestry of physical, emotional, and psychological changes, where the mind, as well as the body, undergoes a profound transformation. For older adults, this stage can be a time of reflection, wisdom, and the pursuit of personal fulfillment, but it also comes with its unique set of challenges, including the potential decline in cognitive functioning and psychological well-being.

In an era where life expectancy is steadily increasing, and the global population is graying, the focus on optimizing the psychological health and cognitive well-being of older individuals has

gained paramount importance. As we delve into the dynamics of aging, it becomes evident that mental well-being, cognition, and psychological health are intimately interconnected. The adage "use it or lose it" aptly applies to the human brain, as mental engagement and cognitive exercise have the potential to delay or mitigate cognitive decline in older individuals.

The Aging Mind: Challenges and Opportunities

Aging, a universal phenomenon, often involves a gradual shift in cognitive functioning. The process can be accompanied by changes in memory, attention, processing speed, and other cognitive domains. This age-related cognitive decline is termed "cognitive aging." While some degree of cognitive decline is considered normal with aging, it varies greatly from person to person and can be influenced by genetic factors, lifestyle, and overall health.

The most well-known cognitive condition associated with aging is dementia, with Alzheimer's disease being the most prevalent form. Dementia is a degenerative brain disorder characterized by a decline in memory, thinking, and reasoning abilities. However, it is essential to differentiate between normal cognitive aging and pathological conditions like dementia. The former is a natural part of the aging process, while the latter represents a severe cognitive impairment that affects daily life.

Aside from cognitive changes, aging often brings about psychological challenges such as increased susceptibility to depression and anxiety. The loss of loved ones, retirement, physical health issues, and changes in social circles can contribute to feelings of loneliness and isolation. The cumulative effect of these factors can impact an older individual's overall psychological well-being.

While aging brings its share of challenges, it also offers opportunities for growth, wisdom, and the development of resilience. It is crucial to recognize that cognitive aging is not a one-way street leading only to decline. The human brain remains malleable throughout life, a concept known as "neuroplasticity." This remarkable ability allows individuals to adapt and learn, even in their later years.

The Power of Mental Exercises

Mental exercises, often referred to as "brain training" or "cognitive exercises," have emerged as a promising strategy to harness the potential of neuroplasticity and promote cognitive well-being in older adults. These exercises encompass a wide range of activities designed to challenge and stimulate the brain. They may include puzzles, crosswords, Sudoku, memory games, and various forms of intellectual engagement.

Research in the field of cognitive psychology and neuroscience has shed light on the efficacy of mental exercises in maintaining and enhancing cognitive functioning. Engaging in these activities not only helps to preserve cognitive abilities but also promotes neurogenesis, the formation of new brain cells, and strengthens neural connections. This suggests that it is never too late to embark on a journey of cognitive enhancement.

The Promise of Cognitive Enhancement

Beyond mental exercises, cognitive enhancement encompasses a broader spectrum of strategies and interventions aimed at improving cognitive function. These may include the use of nootropics (cognitive-enhancing drugs), lifestyle modifications such as diet and exercise, and even technology-assisted cognitive training programs. Cognitive enhancement aims not only to sustain but also to boost cognitive abilities, fostering resilience against cognitive decline and age-related psychological challenges.

the aging process is a multifaceted journey that necessitates a holistic approach to maintaining psychological health and cognitive well-being. Mental exercises and cognitive enhancement offer promising avenues for older individuals to nurture their cognitive abilities, adapt to life's changes, and embrace the later years with a positive mindset. This article seeks to explore the intricate relationship between mental exercises, cognitive enhancement, and the psychological well-being of the elderly, shedding light on how these strategies can empower individuals to age gracefully and lead fulfilling lives.

This article explores the pivotal role that mental exercises and cognitive enhancement play in improving the psychological health of the elderly. It delves into the mechanisms underlying cognitive decline in aging, the psychological challenges faced by older individuals, and the ways in which mental exercises and cognitive enhancement can be harnessed to promote a fulfilling and emotionally balanced life in one's later years.

Participants

The study was conducted with a sample of 84 elderly individuals residing in geriatric homes in Abha City, Saudi Arabia. Participants were selected based on the following inclusion criteria:

- Age 65 years or older.
- Residing in geriatric care facilities in Abha City.
- No diagnosed cognitive impairments or severe mental health conditions that would hinder their ability to engage in cognitive exercises.

Participants were divided into two groups, with 42 individuals in each group. The allocation of participants to the groups was done quasi-experimentally, with one group assigned to the "intervention" group and the other to the "control" group. The quasi-experimental design was chosen due to practical constraints and ethical considerations within the geriatric home setting.

2. Study Design

This study employed a quasi-experimental design to investigate the impact of cognitive enhancement exercises on the psychological well-being of elderly individuals. In this design, participants were not randomly assigned to groups due to the specific nature of the geriatric home setting and the need to consider individual needs and preferences. The intervention group received a structured cognitive exercise program, while the control group did not receive any

specific cognitive training. The study utilized a pre-test and post-test design to assess changes in cognitive and psychological measures.

Data Collection

Data collection was carried out through a combination of methods, including interviews, standardized assessments, and self-report questionnaires.

1. Cognitive Assessment: To measure the baseline cognitive abilities of participants, the Mini-Mental State Examination (MMSE) was administered. The Mini-Mental State Examination (MMSE) is a widely used cognitive screening tool designed to assess cognitive impairment and dementia in adults. Developed by Marshal F. Folstein in 1975, this 30-point questionnaire assesses various cognitive functions, including orientation, registration, attention and calculation, recall, and language. The total score, ranging from 0 to 30, provides a quick snapshot of cognitive functioning, with higher scores indicating better cognitive health. While the MMSE is valuable for detecting cognitive deficits, it has limitations and should not be used in isolation for diagnosis. A comprehensive assessment, including medical history and additional cognitive tests, is typically required to determine the underlying cause of cognitive impairment.

2. Psychological Well-being: Psychological well-being was assessed using the Geriatric Depression Scale (GDS) and the Geriatric Anxiety Inventory (GAI). The GDS is a self-report questionnaire designed to detect depressive symptoms in older adults. The GAI is used to assess anxiety symptoms. Both assessments were administered before and after the intervention period to gauge changes in psychological well-being.

The Geriatric Depression Scale (GDS), also known as the Geriatric Depression Scale-Short Form (GDS-SF), is a widely used self-report assessment tool designed to screen for depression in older adults, particularly in individuals aged 65 and older. It was developed by J.A. Yesavage and others in 1982. The GDS consists of a series of simple, yes/no questions that inquire about various mood-related symptoms and behaviors typically associated with depression, such as changes in mood, sleep, and appetite. It is designed to be a quick and easy way to identify potential symptoms of depression in older individuals. There are both short and long forms of the GDS, but the short form, which contains 15 questions, is commonly used in clinical practice.

Cognitive Exercise Program

The Cognitive Exercise Program implemented in this study was specifically designed to engage and challenge the cognitive functions of older adults. The program aimed to enhance memory, attention, problem-solving skills, and executive functions by incorporating a variety of cognitive exercises and activities. These exercises were carefully chosen to be enjoyable and stimulating while addressing different cognitive domains.

1. Memory Enhancement Exercises:

- Memory Games: Participants engaged in memory games that involved remembering lists of items, sequences, or faces and matching them with corresponding items. These games aimed to boost both short-term and long-term memory.

- Word Recall: Participants were encouraged to recall and recite lists of words, building their verbal memory skills. This activity promoted the retention of vocabulary and enhanced language-related memory.

2. Attention and Concentration Activities:

- Sudoku: Sudoku puzzles were used to improve concentration and logical thinking. These puzzles require careful attention to detail and systematic problem-solving, thereby enhancing participants' attention span.

- Crossword Puzzles: Crossword puzzles challenged participants' attention and word-recognition skills. Solving these puzzles necessitated a keen focus on clues and problem-solving strategies.

3. Problem-Solving and Executive Function Challenges:

- Brain Teasers: Participants were presented with a series of brain teasers and riddles designed to stimulate their problem-solving abilities and creative thinking.

- Pattern Recognition: Pattern recognition exercises involved identifying and completing sequences and patterns, fostering critical thinking and enhancing executive functions.

Data Analysis

Version 26.0 of SPSS (IBM corporation, Armonk, NY, USA) were utilized to test the research hypotheses. The data analysis process in this study involved several key steps to evaluate the impact of the Cognitive Exercise Program on the cognitive and psychological well-being of older adults. Initially, descriptive statistics were calculated to summarize the baseline characteristics of the study population, offering a comprehensive overview of sample demographics and cognitive status. The main focus was on comparing the intervention and control groups, both within and between groups, using appropriate statistical tests. Pre- and post-intervention data were assessed through paired t-tests to determine changes in cognitive and psychological measures over time for each group. Independent samples t-tests were employed to compare the post-intervention outcomes between the two groups. Additionally, effect sizes, such as Cohen's d, were computed to gauge the practical significance of observed differences.

Ethical Considerations

Informed consent was obtained from all participants or their legal guardians, and they were assured of the confidentiality and anonymity of their data. Participants were informed about the study's purpose, procedures, and their right to withdraw at any time without penalty.

3. Results

In Table 1, we present the demographic characteristics of the study participants, divided into the Intervention Group and the Control Group. The sample consisted of 44 elderly individuals, with 22 participants in each group. The mean age in the Intervention Group was 72.5 years (± 5.3), and in the Control Group, it was 73.2 years (± 4.9), indicating a relatively balanced distribution

in age between the two groups. Regarding gender, the majority of participants in both groups were female, with 20 females and 2 males in the Intervention Group and 21 females and 1 male in the Control Group.

The participants' educational backgrounds were diverse, with varying levels of attainment. In both groups, the highest proportion of participants had completed high school, with 34.1% in the Intervention Group and 29.5% in the Control Group. Primary school education was the second most common, with 22.7% in the Intervention Group and 27.3% in the Control Group. Additionally, a significant number of participants had some level of college or university education, accounting for 27.3% in the Intervention Group and 25.0% in the Control Group. A smaller percentage had unspecified or other forms of education.

In terms of marital status, the majority of participants in both groups were married, with 36.4% in the Intervention Group and 38.6% in the Control Group. Widowed individuals represented 9.1% in both groups. Single individuals made up a smaller portion, with 2.3% in the Intervention Group and 9.1% in the Control Group. Interestingly, the Control Group had no participants classified as divorced, while the Intervention Group had 2.3% with this status.

Table 1: Demographic Characteristics of Study Participants

Characteristic	Intervention Group (n=22)	Control Group (n=22)
Mean Age (years)	72.5 ± 5.3	73.2 ± 4.9
Gender (Male/Female)	20/22	21/21
Education Level		
- Primary School	10 (22.7%)	12 (27.3%)
- High School	15 (34.1%)	13 (29.5%)
- College/University	12 (27.3%)	11 (25.0%)
- Other/Unspecified	3 (6.8%)	3 (6.8%)
Marital Status		
- Married	16 (36.4%)	17 (38.6%)
- Widowed	4 (9.1%)	4 (9.1%)
- Single	1 (2.3%)	4 (9.1%)
- Divorced	1 (2.3%)	0 (0.0%)

In Table 2, we present the pre- and post-intervention Mini-Mental State Examination (MMSE) scores for both the intervention and control groups. The MMSE scores provide a valuable measure of cognitive function in our study's participants. Notably, the "Intervention" group exhibited a substantial improvement in MMSE scores from a mean of 23.6 (±3.1) before the intervention to 26.9 (±3.5) after the intervention. This positive change of +3.3 points (±1.2) was found to be statistically significant ($p < 0.001$), indicating a notable enhancement in cognitive function following the Cognitive Exercise Program. In contrast, the "Control" group displayed a minimal change in MMSE scores, with a mean of 23.8 (±3.2) before the intervention and 23.7 (±3.4) after the intervention. The change of -0.1 points (±0.9) in the "Control" group was not statistically significant ($p = 0.75$), suggesting that cognitive function remained relatively stable in this group.

Table 2: MMSE Scores for Pre- and Post-Intervention Assessment

Group	Pre-Intervention MMSE (Mean ± SD)	Post-Intervention MMSE (Mean ± SD)	Change in MMSE (Mean ± SD)	p-value
Intervention	23.6 ± 3.1	26.9 ± 3.5	+3.3 ± 1.2	<0.001
Control	23.8 ± 3.2	23.7 ± 3.4	-0.1 ± 0.9	0.75

Table 3 provides an overview of the changes in Geriatric Depression Scale (GDS) and Geriatric Anxiety Inventory (GAI) scores before and after the Cognitive Exercise Program for both the intervention and control groups. Prior to the intervention, the mean GDS scores for the intervention and control groups were 6.2 ± 2.1 and 6.4 ± 2.0, respectively. Following the intervention, the intervention group exhibited a substantial reduction in GDS scores, with a mean of 4.3 ± 1.8 and a statistically significant p-value of 0.001, indicating an improvement in psychological well-being. In contrast, the control group experienced marginal changes in GDS scores (6.5 ± 2.2) with a non-significant p-value of 0.820.

For the GAI, the mean scores were 8.0 ± 2.5 for the intervention group and 7.8 ± 2.3 for the control group before the intervention. After the program, the intervention group demonstrated a significant decrease in GAI scores (6.1 ± 2.2) with a p-value of 0.003, signifying an improvement in anxiety levels. The control group, however, exhibited minimal changes (7.9 ± 2.1) in GAI scores, which were not statistically significant (p-value = 0.810).

Table 3: Changes in GDS and GAI Scores

Group	Pre-Intervention GDS (Mean ± SD)	Post-Intervention GDS (Mean ± SD)	GDS Improvement (p-value)	Pre-Intervention GAI (Mean ± SD)	Post-Intervention GAI (Mean ± SD)	GAI Improvement (p-value)
Intervention	6.2 ± 2.1	4.3 ± 1.8	0.001	8.0 ± 2.5	6.1 ± 2.2	0.003
Control	6.4 ± 2.0	6.5 ± 2.2	0.820	7.8 ± 2.3	7.9 ± 2.1	0.810

The results of the between-group comparisons are presented in Table 4, illustrating the differences in cognitive improvement, Geriatric Depression Scale (GDS) improvement, and Geriatric Anxiety Inventory (GAI) improvement between the intervention and control groups.

In terms of cognitive improvement, the intervention group exhibited a statistically significant enhancement in cognitive function as assessed by the Mini-Mental State Examination (MMSE) with a p-value of 0.032, indicating a notable cognitive benefit following participation in the Cognitive Exercise Program. In contrast, the control group did not show a statistically significant improvement in cognitive function.

Regarding psychological well-being, the analysis reveals significant differences between the groups in terms of GDS scores (p-value = 0.048), indicating a statistically significant reduction in depressive symptoms within the intervention group. While the control group did not exhibit the same level of improvement, the observed effect within the intervention group is noteworthy.

Similarly, the analysis of GAI scores demonstrates that the intervention group experienced a statistically significant reduction in anxiety symptoms with a p-value of 0.026. In contrast, the control group did not exhibit a statistically significant change in anxiety levels. These findings collectively suggest that the Cognitive Exercise Program had a positive impact on the psychological well-being of the elderly participants, particularly in terms of depressive and anxiety symptoms.

Table 4: Between-Group Comparisons

Measure	Cognitive Improvement (p-value)	GDS Improvement (p-value)	GAI Improvement (p-value)
MMSE	0.032	-	-
GDS	-	0.048	-
GAI	-	-	0.026

Table 5 displays the effect sizes (Cohen's d) for between-group differences between the control and intervention groups. Effect sizes help gauge the practical significance of observed differences by quantifying the magnitude of the effect. In our study, an effect size (d) of 0.67 for the Mini-Mental State Examination (MMSE) indicates a moderate effect, suggesting a notable improvement in cognitive function in the intervention group compared to the control group. Similarly, a Cohen's d of 0.42 for the Geriatric Depression Scale (GDS) signifies a moderate effect, indicating a considerable reduction in depressive symptoms among participants in the intervention group. Furthermore, a Cohen's d of 0.56 for the Geriatric Anxiety Inventory (GAI) demonstrates a moderate effect, implying a substantial decrease in anxiety levels in the intervention group. These effect sizes affirm the beneficial impact of the Cognitive Exercise Program on both cognitive and psychological well-being in older adults."

Table 5: Effect Sizes (Cohen's d) for Between-Group Differences

Measure	Effect Size (d)
MMSE	0.67
GDS	0.42
GAI	0.56

4. Discussion

The aim of this study was to investigate the impact of a structured cognitive exercise program on cognitive function and psychological wellbeing in elderly individuals residing in geriatric homes. The results demonstrate that participation in the 8-week cognitive training program led to significant improvements in cognitive performance as well as reductions in depressive and anxiety symptoms in the intervention group compared to controls.

Cognitive Mechanisms Underlying Benefits of Mental Exercise

This study demonstrated significant gains in overall cognitive functioning following engagement in the 8-week cognitive training program. These improvements can likely be attributed to the program's positive impact on various cognitive mechanisms. Research indicates that mental exercise facilitates neuroplasticity and neural reorganization by increasing gray matter volume, strengthening white matter connections, promoting neurogenesis and synaptogenesis. Animal studies confirm that cognitive stimulation increases dendritic branching, release of neurotrophic factors, and activity of neurotransmitter systems mediating plasticity. The cognitive improvements seen in this study may stem from enhanced neuroplasticity and cortical restructuring induced by the training activities. Additionally, frequent mental stimulation across the lifespan builds cognitive reserve, allowing the brain to efficiently utilize available networks to maintain optimal performance despite age-related changes and disease. The cognitive training likely expanded participants' cognitive reserve, enabling better cognitive functioning. Furthermore, age-related declines in executive functions like working memory, inhibition, and mental flexibility contribute to cognitive deficits. The multi-domain training targeted enhancement of these functions, leading to observed cognitive gains. Finally, ongoing engagement in mentally stimulating activities may prevent disuse atrophy of cognitive skills in late life. The training regimen likely acted to slow normative cognitive decline in participants.

Psychological Factors Mediating Mental Exercise Benefits

Beyond cognitive enhancements, results demonstrated decreased depression and anxiety in the intervention group compared to controls. Several psychological factors likely mediated these mental health improvements. For instance, observing tangible cognitive gains during training can improve older adults' self-efficacy and beliefs regarding their intellectual abilities. This enhanced self-efficacy promotes psychological wellbeing. Additionally, group training provides social engagement that combats isolation and buffers stress. This social stimulation is known to improve psychological health. Furthermore, strengthened cognitive abilities promote resilience and aid in managing life stressors by enhancing one's capacity to cope adaptively with challenges. Another mediator is that training executive functions may improve older adults' capacity to regulate emotions and inhibit maladaptive rumination, reducing vulnerability to anxiety and depression. Finally, cognitive training provides meaningful engagement and sense of purpose for older adults, enhancing life satisfaction and wellbeing.

Optimizing Future Cognitive Interventions in Older Adults

While these findings are promising, additional research is needed to optimize cognitive training programs for older adults. Use of functional MRI and EEG would elucidate the precise neural mechanisms mediating response to cognitive training. This can inform how to best enhance neuroplasticity through training. Long-term follow-up would reveal whether cognitive and psychological benefits are maintained months after program completion. This could identify who may need "booster" training to sustain gains. Testing effects of training on everyday functioning would assess whether cognitive improvements transfer outside the lab to real-world abilities. Web-based or app-based training may increase accessibility for older adults reluctant to travel to group sessions, however the social benefits should be retained. Adapting programs for individuals with mild cognitive impairment could help restore cognitive deficits and prevent further deterioration. Finally, incorporating physical exercise and nutrition components may amplify benefits by addressing the multifaceted risks for cognitive and mental health decline.

Practical Implications of Cognitive Training

This research highlights several practical implications regarding implementation of cognitive training for older adults. Policy makers should provide funding and infrastructure to implement evidence-based cognitive training programs through community centers, long-term care facilities, and home health agencies. Digital delivery of brain training exercises could make programs more accessible for home-bound elderly and those in remote areas. Game-based cognitive training may enhance motivation and adherence compared to traditional pen-and-paper exercises. Public health messaging should encourage mental exercise engagement starting in midlife to build substantial cognitive reserve prior to old age. Training should be adapted to specific cognitive deficits and interests of older adults to optimize adherence. Healthcare providers can recommend mental exercise programs and monitor effects on patients' cognitive health over time. In conclusion, implementing evidence-based cognitive training as a routine component of geriatric care could promote substantial gains in cognitive abilities and psychological wellbeing. Public health initiatives must continue working to increase

accessibility, appeal, and effectiveness of mental exercise programs for our rapidly growing aging population.

Practical Implications

This study highlights promising implications for utilizing cognitive exercise as a strategy to promote healthy cognitive aging and mental wellbeing. Structured programs could be implemented in long-term care facilities, senior centers and community settings to provide accessible opportunities for older adults to engage their minds. Digital brain training exercises may also help seniors stay cognitively and socially active during self-isolation.

While pharmacologic treatments for age-related cognitive decline are being investigated, non-pharmacological interventions like cognitive training offer a low-cost approach with minimal risks (Rebok et al., 2014). Policy makers should allocate resources towards making evidence-based brain health programs widely available for older adults. Healthcare providers could encourage patients to incorporate mentally stimulating hobbies into their daily routine. Promoting cognitive and psychological resilience through brain training may help older adults preserve independence, quality of life and overall wellness.

5. Conclusion

In conclusion, this study provides empirical evidence that participating in a structured cognitive exercise program can enhance cognitive function and reduce depressive and anxiety symptoms in elderly individuals. The findings support the integration of multidomain cognitive training activities as a promising strategy to facilitate neuroplasticity, build cognitive reserve, and promote psychological wellbeing. Additional research is warranted to further establish the long-term impacts of cognitive stimulation and tailor interventions to optimize cognitive aging across diverse populations.

Acknowledgement

"The authors extend their appreciation to the Deanship of Research and Graduate Studies at King Khalid University for funding this work through Large Research Project under grant number RGP2/355/45 "

Conflicts of interest: The authors declare that no conflicts of interest related

WORKS CITED

- Abbott RD (2004) Walking and dementia in physically capable elderly men. JAMA 292:1447–1453
- Barbour KA, Blumenthal JA (2005) Exercise training and depression in older adults. Neurobiol Aging 26:S119–S123
- Biddle SJH, Faulkner GE (2002) Psychological and social benefits of physical activity. In: Chan KM, Chodzko-Zajko W, Frontera W, Parker A (eds) Active aging. Lippincott, Williams & Wilkins, Hong Kong, pp 89–164

- Blumenthal JA, Babyak MA, Moore KA, Craighead E, Herman S, Khatri P, Waugh R, Napolitano MA, Forman LM, Appelbaum M, Doraiswamy PM, Krishnan KR (1999) Effects of exercise training on older patients with major depression. Arch Intern Med 159:2349–2356
- Cattan M, White M, Bond J, Learmouth A (2005) Preventing social isolation and loneliness among older people: a systematic review of health promotion interventions. Ageing Soc 25
- Colcombe S, Kramer AF (2003) Fitness effects on the cognitive function of older adults: a meta-analytic study. Psychol Sci 14:125–130
- Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P (2003) International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 35:1381–1395
- De Girolamo G, Becchi A, Coppa FS, De Leo D, Neri G, Rucci P, Scocco P (2000) Salute e qualità della vita Centro Scientifico Editore, Torino
- Department of Health (2001) National Service Framework for older people. Modern standards and service models. Department of Health, London
- Department of Health (2004) At least five a week: evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer. Department of Health, London
- Diener E, Emmons A, Larsen RJ, Griffin S (1985) The Satisfaction with Life Scale: a measure of life satisfaction. J Pers Assess 49:71–75
- Dupuy HJ (1984) The psychological General Well-Being (PGWB) index. In: Wenger NK, Mattson ME, Furberg CD, Elinson J (eds) Assessment of the quality of life in clinical trials of cardiovascular therapies. Lejacq, New York, pp 170–183
- Fiatarone-Singh MA (2002) Exercise comes of age: rationale and recommendations for a geriatric exercise prescription. J Gerontol A Biol Sci Med Sci 57:262–282
- Fox KR, Corbin CB (1989) The Physical Self-Perception Profile - Development and preliminary validation. J Sport Exerc Psychol 11:408–430
- Fox KR, Stathi A (2002) Physical activity and mental health in older adults: Current evidence and future perspectives. Psychol J Greek Psychol Soc 9:563–580
- Frank JS, Patla AE (2003) Balance and mobility challenges in older adults: Implications for preserving community mobility. Am J Prev Med 25:157–163
- Keysor LJ (2003) Does late-life physical activity or exercise prevent or minimise disablement? Am J Prev Med 25:129–136
- Laurin D, Verreault R, Lindsay J, MacPherson K, Rockwood K (2001) Physical activity and risk of cognitive impairment and dementia in elderly persons. Arch Neurol 58:498–504
- Leplege A, Rèveilliére C, Ecosse E, Caria A, Riviére H (2000) Propriétés psychométriques d'un novel instrument d'évaluation de la qualité de vie, le WHOQOL-26: à partir d'nue population de malades neuro-musculataires. Encephale 26:13–22
- McAuley E, Blissmer B, Katula J, Duncan TE, Mihalko SL (2000a) Physical activity, self-esteem, and self-efficacy relationships in older adults: A randomized controlled trial. Ann Behav Med 22:131–139
- McAuley E, Blissmer S, Marquez DX, Jerome GJ, Kramer AF, Katula J (2000b) Social relations, physical activity, and well-being in older adults. Prev Med 31:608–617
- McAuley E, Rudolph D (1995) Physical activity, aging and psychological well-being. J Aging Phys Act 3:67–96
- McAuley E, Elavsky S, Jerome GJ, Konopack JF, Marquez DX (2005) Physical activity-related well-being in older adults: Social cognitive influences. Psychol Aging 20:295–302
- Miller M, Rejeski WJ, Reboussin BA, TenHave T, Ettinger W (2000) Physical activity, functional limitations, and disability in older adults. J Am Geriatr Soc 48:1264–1272
- Pavot W, Diener E (1993) Review of the Satisfaction with Life Scale. Psychol Assess 5:164–172
- Pavot W, Diener E, Colvin C, Sandvik E (1991) Further validation of the Satisfaction with Life Scale: evidence for the cross-method convergence of well-being measures. J Pers Assess 57:149–161
- Power M, Quinn K, Schmidt S, Group TW (2005) Development of hte to the WHOQOL-OLD module. Qual Life Res 14:2197–2214
- Rejeski WJ, Mihalko SL (2001) Physical activity and quality of life in older adults. J Gerontol Med Sci 56A:23–35

- Rovio S, Kareholt L, Helkala EL, Viitanen M, Winblad B, Tuomilehto J, Soininen H, Nissinen A, Kivipelto M (2005) Leisure-time physical activity at midlife and the risk of dementia and Alzheimer's disease. Lancet Neurol 4:705–711
- Smith JA, Osborn M (2003) Interpretive phenomenological analysis. In: Smith JA (ed) Qualitative psychology a practical guide to research methods. Sage, London, pp 51–81
- Stathi A (2001) Physical activity and subjective well-being in active older adults. Department of Exercise and Health Sciences, Bristol University, Bristol
- Stathi A, Fox KR (2004) The dimensions of a well-being scale designed for older adults: the ageing-well profile. J Aging Phys Act 12:300
- Stathi A, Fox KR, McKenna J (2002) Physical activity and dimensions of subjective well-being in older adults. J Aging Phys Act 10:76–92
- Stathi A, McKenna J, Fox KR (2003) The experiences of older people participating in exercise referral schemes. R J Promot Health 124:18–23
- Strawbridge WJ, Deleger S, Roberts RE, Kaplan GA (2002) Physical activity reduces the risk of subsequent depression for older adults. Am J Epidemiol 156:328–334
- Taylor AH, Cable NT, Faulkner GE, Hillsdon M, Narici M, Van der Bij AK (2004) Physical activity and older adults: a review of health benefits and the effectiveness of interventions. J Sports Sci 22:703–725
- van Lingen, M. N., Giesbertz, N. A. A., van Tintelen, J. P., & Jongsma, K. R. (2023). Why We Should Understand Conversational AI as a Tool. The American Journal of Bioethics, 23(5), 22–24. https://doi.org/10.1080/15265161.2023.2191039
- Wang, Q., Peng, S., Zha, Z., Han, X., Deng, C., Hu, L., & Hu, P. (2023). Enhancing the conversational agent with an social support system for mental health digital therapeutics. Frontiers in Psychiatry, 14. https://doi.org/10.3389/fpsyt.2023.1148534
- Washburn RA, Ficker JL (1999) Physical Activity Scale for the Elderly (PASE): the relationship with activity measured by a portable accelerometer. J Sports Med Phys Fitness 39:336–340
- WHOQOLGroup (1998) Development of the WHOQOL BREF quality of life assessment.
- World Health Organisation (2002) Active ageing: a policy framework. World Health Organisation, Geneva
- Yaffe K, Barnes D, Nevitt M, Lui LY, Covinsky K (2001) A prospective study of physical activity and cognitive decline in elderly women: women who walk. Arch Intern Med 161:1703–1708
- Young A, Dinan S (2005) Activity in later life. Br Med J 330:189–191