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EFFECT OF 3-MONTHS HOME-BASED EXERCISE PROGRAM ON CHANGES OF COGNITIVE FUNCTIONING IN OLDER ADULTS LIVING IN OLD PEOPLE'S HOME

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Summary: The aim of the study was to determine the effect of regular participation in home-based exercise programme on cognitive functioning changes in institutionalised older adults. Two groups of participants were recruited for the study: experimental (n = 17) in mean age 76 ± 5.6 years, who participated in home-based exercise program and control (n = 14) in mean age 80 ± 4.2 years. The standardised Stroop Color-Word Test-Victoria version (VST) was used to measure the level of cognitive functions. Group differences were analyzed with Mann–Whitney U-test for independent samples and for differences between pre-measurements and post-measurements on experimental and control group we used non-parametric Wilcoxon Signed – Rank Test. The level of significance was $\alpha < 0.05$. Application of 3-months home-based exercise program significantly improved the cognitive functions only in one (Word condition; $p<0.01$) from three VST conditions in institutionalised older adults. That's why we recommend longer participation in home-based exercise program, at least 6-months, with combination of various types of cognitive interventions, like concepts of cognitive training, cognitive rehabilitation, and cognitive stimulation to improve cognitive functioning in older adults living in old peoples' homes.

Key words: institutionalised seniors, exercise, Stroop Color-Word Test-Victoria, cognitive functions

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Introduction

The growing aging population presents a challenge because most people experience age-related decline in cognitive abilities that are important for maintaining functional independence, and successful aging requires the ability to learn new information to perform complex tasks (Clark et al. 2015). Cognitive functioning refers to attention, episodic and working memory, executive functioning, and processing speed. The ability of the brain to handle information from the environment essential to achieving a particular goal is referred to as attention. The most commonly reported cognitive decline experienced by older adults is in episodic memory, which represents the ability to recognise, consolidate, and use experiential information. Another form of memory, called working memory, temporarily holds auditory, visual, and spatial information that is important for cognitive processes such as recalling instructions and learning a list of words. Process that describe the planning and execution of goal-directed behaviours as regulated by the frontal lobes are known as executive functioning. Finally, processing speed describes mental efficiency or speed of thinking, and it also has an impact on physical action (Gibson & Singleton 2012).

There are 3 types of theories for age-related shifts related to cognitive functions (Salthouse 2011):

1. the dedifferentiation hypothesis which claims that cognitive variables and abilities become less distinct with increased age,
2. the disintegration hypothesis indicates that cognitive variables maybe become more independent of one another during advancing aging because of weaker interrelations among cognitive variables and
3. the equivalent-structural-influences hypothesis which suggests that the advancing aging is associated with cognitive decline without appreciable shifts in the level of which cognitive change happens, as its accepts that there is little or no relation between age and the level at which change operates.

Many studies argue that an appreciable cognitive decline begins between 50 plus and 60 (Salthouse 2009; Schaie 2005; Tsantali et al. 2012) and that little cognitive decline occurs before 60 s. Memory and speed seem to be highly sensitive to age (especially after 60s), though vocabulary and general information do not seem to have a significant decline. The most affected cognitive functions before 55 years old seem to be the reasoning and spatial orientation (Schaie 2005), however, the speed of processing information begins to decline earlier about 45 years (Schneider 2002; Salthouse 2011). According to the neurocognitive disease due to Alzheimer's disease literature refers that the cognitive state of an Alzheimer's disease patient retrograde to the first grades of elementary school and even further, to the levels of kindergarten (Rubial-Alvarez et al. 2007; Shoji et al. 2002; Tsantali et al. 2012).

Aging is associated with declines in certain cognitive domains and lower levels of physical activity (Middleton et al. 2010). Physical inactivity is a recognized modifiable risk factor of cerebrovascular disease and the cognitive decline seen in older adults (Gorelick et al. 1999; Laurin et al. 2001). There is consistent evidence that regular exercise promotes brain health and is associated with a lower risk for age-related cognitive decline and dementia (Eskes et al. 2010), however the underlying mechanisms have not been well defined (Voss et al. 2011). Neuroimaging studies of older adults indicate that higher levels of cardiovascular fitness are associated with larger volumes of specific brain regions including the hippocampus, an important region for learning and memory (Colcombe et al. 2006; Erickson et al. 2011).

Another study reported that a 16 weeks weight training found no significant differences associated to the effects of the practice of strength training on memory and cognition in elderly (Vital, Hernández Salma S., Pedroso, et al. 2012). One study examined the association between movement-based intervention (combination of strengthening, coordination, balance, flexibility, and stamina) and cognitive decline (Yágüez, Shaw, Morris et al. 2011). A short course of 6 weeks of a non-aerobic movement-based intervention improved sustained attention, visual memory and working memory in older adults with Alzheimer disease. Another study reported that group music with movement intervention can be an effective intervention in decreasing agitated behaviours (Sung, Chang, Lee et al. 2006). Some studies examined the association between movement exercise intervention and cognitive function. Thurm and colleagues reported that multimodal physical movement training combined strengthening, coordination, balance, flexibility, and stamina of 10 weeks has positive effects on cognitive function in physically very frail nursing home residents with dementia (Thurm, Scharpf, Liebermann et al. 2011).

Considering the previous research findings, the aim of our research was to investigate the effect of 3-months exercise programme on changes of cognitive functioning in institutionalised older adults and to compare the cognitive abilities performance measured by Stroop Color-Word Test between actively living seniors and group of sedentary elderly. We hypothesize the significant improvement in cognitive function (in all three conditions of

Stroop Color-Word Test) derived from regular exercise in participants who remain physically active as compared to those who revert to a sedentary lifestyle.

Methods

The Stroop Color-Word Test-Victoria version (VST) was used as a main research method. VST developed by Spreen and Strauss (1998) is a brief version of the Stroop task. VST uses three conditions that consist in naming the color of dots, of neutral words, and of color words printed in incongruent colors. Each condition contains 24 items. Due to the brief administration time (cca 5 min.), this version seems particularly appropriate for use with geriatric and brain-damaged populations who are prone to fatigue during neuropsychological examination. The VST demonstrates good psychometric properties, including excellent test–retest reliability (Troyer, Leach & Strauss 2006), sensitivity to frontal lobe versus non-frontal damage (for review, see Strauss, Sherman and Spreen 2006), amnesic mild cognitive impairment and Alzheimer disease (Joubert et al. 2010), and aging (Moroni & Bayard 2009).

Four colors were used: blue, green, yellow, and red. In the **"Dot"** condition, color dots were presented. In the **"Word"** condition, the words "but", "for", "thus", and "when" were written in a random order in one of the four colour inks listed. In the **"Interference"** condition, the words blue, green, yellow and red were written in one of the three other colors (e.g., the word green would be written in yellow ink). Twenty-four stimuli were presented on each card and were arranged in a 4 × 6 matrix. Card conditions were presented in the following order: Dot, Word, and Interference. In each of the three conditions respectively, participants were asked to name as quickly as possible the color of the dots (Dot condition) and the color of the written words (Word condition and Interference condition). In the Word and Interference conditions, participants had to inhibit the written word in order to correctly name the color of the ink. The Word condition may be considered as an intermediate inhibition condition as the classical interference effect between the written word and the color name is not present. For each condition, we measured the completion time and the number of errors.

Two groups of participants were recruited for this study: seniors living in old people's home in city Dunajská Streda who participated in regular home-based exercise program in frequency two times per week (experimental group) for the time period of 3-months (January – March 2013) and elderly participants from the same institution who didn't participate in home-based exercise program at all (control group). Experimental group consisted of 17 seniors (13 women and 4 men, aged between 68 and 93 years old—mean age: 76 [±5.6]). The control subjects lived also in the same institution and did not participate in the regular exercise. Control group consisted of 14 seniors (12 female and 2 male, aged between 71 and 93 years old – mean age: 80 [±4.2]). Home-based exercise program included psychomotor exercises, exercises with fit-balls, balloons, different massage balls, newspapers, scarves etc. Strength exercises were provided on the chair and on the floor, with bars, therabands, over-balls etc. Aerobic activities consisted from spot walking, and different exercise with music accompaniment. Home-based exercise program included also breathing gymnastics.

The statistical analyses were carried out with SPSS version 16.0 for Windows (SPSS, Inc.). The data were examined for normal distribution and homogeneity of variance. Group differences were analysed with Mann–Whitney U-test for independent samples and for differences between pre-measurements and post-measurements on experimental and control group we used non-parametric Wilcoxon Signed – Rank Test. The level of significance was $\alpha < 0.05$.

Results

Differences in performances on the beginning of experiment between control and experimental groups were not significant. Means of the time values in all three conditions of VST were similar in both groups as well as means of errors (Table 1). Performances in post-measurement of times and errors between control and experimental groups neither showed statistically significant differences, but mean values of times showed much better performances in experimental group in all three conditions of VST comparing control group. Also better mean value of errors was on the end of experiment presented by experimental group in all three conditions comparing control group (Table 2).

Table 1

Performances of experimental group and control subject on the VST (pre-measure)

	Controls (N = 14)	**Experimental (N = 17)**	**U-test**	**Sign.**
Dot				
Time	25.57 ± 10.78 [15-49]	21.90 ± 8.29 [14-48]	1.072	ns
Eror	0.21 [0-3]	0.21 [0-2]		
Word				
Time	36.12 ± 13.35 [21-62]	36.88 ± 13.97 [18-68]	0.062	ns
Eror	1.36 [0-7]	0.94 [0-8]		

Interference Time Eror	 45.95 ± 14.97 [29-68] 3.07 [0-8]	 42.85 ± 11.50 [22-63] 2.82 [0-10]	0.298	ns

Mean ± SD [range] are given

Table 2

Performances of experimental group and control subject on the VST (post-measure)

	Controls (N = 14)	**Experimental (N = 17)**	**U-test**	**Sign.**
Dot Time Eror	 25.77 ± 10.01 [14-48] 0.14 [0-2]	 21.37 ± 8.17 [14-50] 0	1.687	Ns
Word Time Eror	 36.09 ± 15.55 [20-66] 1.36 [0-10]	 33.42 ± 13.24 [15-62] 0.53 [0-5]	0.417	Ns
Interference Time Eror	 42.39 ± 13.68 [25-64] 2.57 [0-8]	 41.00 ± 10.36 [25-59] 2.35 [0-8]	0.218	Ns

Mean ± SD [range] are given

Table 3

Changes in performances of experimental group on the VST

	Pre-measure	**Post-measure**	**T-test**	**Sign.**
Dot Time Eror	 21.90 ± 8.29 [14-48] 0.21 [0-2]	 21.37 ± 8.17 [14-50] 0	0.852	ns
Word Time Eror	 36.88 ± 13.97 [18-8] 0.94 [0-8]	 33.42 ± 13.24 [15-62] 0.53 [0-5]	**3.025****	**p ≤ .01**ns
Interference Time Eror	 42.85 ± 11.50 [22-63] 2.82 [0-10]	 41.00 ± 10.36 [25-59] 2.35 [0-8]	0.734	ns

Mean ± SD [range] are given.

Table 4

Changes in performances of control subject on the VST

	Pre-measure	**Post-measure**	**T-test**	**Sign.**
Dot Time Eror	 25.57 ± 10.78 [15-49] 0.21 [0-3]	 25.77 ± 10.01 [14-48] 0.14 [0-2]	0.188	ns
Word Time Eror	 36.12 ± 13.35 [21-62] 1.36 [0-7]	 36.09 ± 15.55 [20-66] 1.36 [0-10]	0.251	ns
Interference Time	 45.95 ± 14.97 [29-68]	 42.39 ± 13.68 [25-64]	**2.385***	**p ≤ .05**

Eror	3.07 [0-8]	2.57 [0-8]		

Comparison the pre-measurements and post-measurements of experimental group of older adults points at 69 % of time improvement involving all three conditions. Significant improvement ($p \leq .01$) presents the Word condition, where 88 % of older adults improved their time score (Table 3). In Dot and Interference condition improved their time only 59 % active older adults. Also in errors we can see improvement in all three conditions, when in pre-measurement made mistake 31 % of older adults and in post-measurement only 22 % of active seniors. Mean value of errors shows also improvement for all three conditions, when at the beginning of experiment it was 1.31 and at the end 0.96. Related to number of seniors who did errors, Dot condition was improved from 12 % to 0 % Word conditions improved from 24 % to 12 % and Interference condition improved from 59 % to 53 %.

Comparison the pre-measurements and post-measurements of control group of older adults also shows time improvement in 57 %. Significant improvement ($p \leq .05$) presents the Interference condition, where 71 % of older adults improved their time score after three months (Table 4). In Dot condition improved their time score only 43 % of older adults and in Word condition improved their time 57 % sedentary seniors. Concerning to number of errors we can see improvement in two conditions (Dot and Interference). In pre-measurement did mistake 36 % of older adults and in post-measurement 26 % of sedentary seniors involving all three conditions. Mean value of errors doesn't show significant improvement for all three conditions, when at the beginning of experiment it was 1.55 and at the end 1.36. Related to number of seniors who did errors, Dot condition wasn't improved, because 7 % of sedentary seniors did mistake at the beginning of experiment and the same number of older adults made errors at the end of experiment. But word conditions improved from 50 % to 29 % and Interference condition improved from 50 % to 43 %.

We didn't confirm our hypothesis, where we hypothesized the significant improvement of cognitive functioning in all three conditions of VST in participants who participated in home-based exercise program comparing sedentary seniors. Although cognitive functions measured by VST were positively changed after 3-months period in all three parts (mean value), but only one part of VST (Word condition) presented statistically significant improvement.

Discussion

Numerous studies have demonstrated a positive relationship between physically active leisure and cognitive health for older adults (Fratiglioni, Paillard-Borg & Winblad 2004). Specifically, frequent engagement in activities such as walking, sport, and exercise is associated with maintained and improved cognitive functioning in older adults. For example, a longitudinal study that followed a group of older American women over a 25-year period found that those who engaged in regular, moderately intense physical activity had higher cognitive functioning than those who engaged in little to no physical activity (Weuve et al. 2004). Also, higher levels of physical activity were associated with less cognitive deterioration over time. Similar results have been found for American men and in other countries such as Canada and the Netherlands (Fratiglioni, Paillard-Borg & Winblad 2004; Laurin, Vereault, Lindsay, MacPherson & Rockwood 2001).

It is believed that a physically active lifestyle can expand brain capacity (brain reserve) and stimulate cognitive reserve directly through a number of vascular and neurological processes and indirectly through a number of health benefits, such as insulin regulation, decreases stress and disease prevention, and increases psychosocial well-being, all of which are associated with positive cognitive functioning (Bielak 2010).

Aerobic exercises in older adults have demonstrated effects on cognitive performance. Especially, treadmill training had a beneficial effect on the global cognitive function (Arcoverde, Deslandes, Moraes et al. 2014) and observed for executive control abilities such as selective attention, search efficiency, processing speed, and cognitive flexibility (Baker, Frank, Foster-Schubert et al., 2010). On the other hand, a 6 weeks walking intervention was not effective in cognitive function (Baker, Frank, Foster-Schubert et al. 2010). Three studies examined the association between multicomponent exercise and cognitive function. Multicomponent exercise includes two or more main types of exercise such as strength training, balance training, flexibility training and aerobic exercise. One studies conducted a home-based exercise program. Vreugdenhil and colleagues suggest that a community based home exercise program specifically developed for people with dementia is effective in improving functional ability across a number of domains, including cognition, physical function and activities daily living (ADL) (Vreugdenhil, Cannell, Davies et al. 2011). Two studies conducted a center-based exercise program. Suzuki and colleagues found that 12 months of multicomponent exercise improved general cognitive function, immediate memory, and language ability in older adults relative to the education control group (Suzuki, Shimada, Makizako et al. 2012). Rolland and colleagues found that a multicomponent exercise program including aerobic, strength, flexibility, and balance, 1 hour twice a week, led to significantly slower decline in ADL score in Alzheimer disease patients living in nursing home than routine medical care. But no effect was observed for behavioural disturbance, depression, or nutritional assessment scores (Rolland, Pillard, Klapouszczak et al. 2007).

In generally we can say, that consisted 3-months home-based exercise program helped to improve the level of cognitive functions in older adults, because mean values of achieved time scores were in all three conditions better performed (Table 3) even only Word condition improved significantly. On the other side, time score of control group in Dot condition was even worse than at the beginning of experiment, in Word condition improved just minimally and in Interference condition improved significantly. Also comparison of number of seniors who improved their time score point to an improvement in experimental group (69 %) comparing control group, when only 57 % seniors improved their performances at the end of experiment. The improvement also point at the errors scores in experimental group, when their performances improved number of errors in all three conditions and sedentary seniors improved their error score only in two conditions (Table 4). Also mean value of all made errors (including all three conditions) between pre-measurement and post-measurement point to better score in active seniors (0.35) comparing those with sedentary life style (0.19).

These findings, including our research, are consistent with the association found between health status and cognitive functioning, particularly given that not only young people (Balga & Chromík 2014; Kraček et al. 2015; Kraček, Pačesová and Oliva 2015) but also older people who are more physically active in their leisure tend to have better physical and mental health and overall quality of their life (Kisvetrová et al. 2013; Nemček 2011; Nemček & Labudová 2011; Nemček, Labudová & Kraček 2012; Nemček et al. 2014; Nemček, Wittmannová & Melicharová 2014).

Conclusion

On the basis of our results we can conclude, that application of 3-months home-based exercise program helped improve the level of cognitive functions in institutionalised older adults (even not significantly in all three conditions), when group of active seniors achieved significant change of improvement only in one from three parts of VST. Paradoxically, also seniors who didn't participate in home-based exercise program have significantly improved their cognitive functioning but only in the most difficult part of VST (Interference condition). Also in errors, active seniors performed better than sedentary, because difference of mean value of all made errors between pre-measurement and post-measurement in active seniors was 0.35 and in sedentary older adults only 0.19.

On the basis of our results we recommend longer participation in home-based exercise program, at least 6-months, and combine mentioned exercise program with various types of cognitive interventions, like concepts of cognitive training, cognitive rehabilitation, and cognitive stimulation (Kim, Cho, Lee & Kohzuki 2015) to improve cognitive functioning in older adults living in old peoples' homes.

References

1. ARCOVERDE, C., A. DESLANDES, H. MORAES, C. ALMEIDA, N.B. ARAUJO, P.E. VASQUES et al., 2014. Treadmill training as an augmentation treatment for Alzheimer's disease: a pilot randomized controlled study. In: *Arquivos de Neuropsiquiatria*, **72**(3), pp. 190-196.
2. BAKER, L.D., L.L. FRANK, K. FOSTER-SCHUBERT, P.S. GREEN, C.W. WILKINSON, A. McTIERNAN et al., 2010. Effects of aerobic exercise on mild cognitive impairment: a controlled trial. In: *Archives of Neurology*, **67**(1), pp. 71-79.
3. BALGA, T. & M. CHROMÍK, 2014. Úroveň kognitívnych schopností detí s telesným postihnutím strednej odbornej školy v Bratislave. In: *Sports, Physical Activity and Health 2014*. Slovak Olympic Committee, Bratislava, pp. 280-287. ISBN 978-80-89075-44-7.
4. BIELAK, A. A., 2010. How can we not "lose it" if we still don't understand how to "use it"? Unanswered questions about the influence of activity participation on cognitive performance in older age--a mini-review. In: *Gerontology*, **56**(5), pp. 507-519.
5. CLARK, R., M. FREEDBERG, E. HAZELTINE & M.W. VOSS., 2015. Are there Age-Related Differences in the Ability to Learn Configural Responses? In: *Plos One Journal,* **10**(8), pp. 1-16.
6. COLCOMBE, S.J., K.I. ERICKSON, P.E. SCALF et al., 2006. Aerobic exercise training increases brain volume in aging humans. In: *J Gerontol A Biol Sci Med Sci*, **61**(11), pp. 1166–1170.
7. ERICKSON, K.I., M.W. VOSS, R.S. PRAKASH et al., 2011. Exercise training increases size of hippocampus and improves memory. In: *Proc Natl Acad Sci U S A*, **108**(7), pp. 3017–3022.
8. ESKES, G.A., S. LONGMAN, A.D. BROWN, C.A. McMORRIS, K.D. LANGDON, D.B. HOGAN & M. POULIN, 2010. Contribution of physical fitness, cerebrovascular

reserve and cognitive stimulation to cognitive function in postmenopausal women. In: *Front Aging Neurosci*, 2, pp. 1-7.

9. FRATIGLIONI, L., S. PILLARD-BORG & B. WINBLAD, 2004. An active and socially integrated life-style in late life might protect against dementia. In: *Lancet Neurology*, **3**(6), pp. 343-353.
10. GIBSON, H.J. & J.F. SINGLETON, 2012. *Leisure and Aging. Theory and Practice*. United States: Human Kinetics. ISBN 978-0-7360-9463-4.
11. GORELICK, P.B., R.L. SACCO, D.B. SMITH et al., 1999. Prevention of a first stroke: a review of guidelines and a multidisciplinary consensus statement from the national stroke association. In: *J Am Med Assoc*, **281**(12), pp. 1112-1120.
12. JOUBERT, S., S.M. BRAMBATI, J. ANSADO, E.J. BARBEAU, O. FELICIAN, M. DIDIC et al., 2010. The cognitive and neural expression of semantic memory impairment in mild cognitive impairment and early Alzheimer's disease. In: *Neuropsychologia*, 48, pp. 978-988.
13. KIM, M., CH. CHO, CH. LEE & M. KOHZUKI, 2015. The Effect of Exercise, Cognitive Intervention and Combine Exercise and Cognitive Interventions in Older Adults with cognitive impairments and Alzheimer's Disease: A literature review. In: *Asian Journal of Human Services*, 8, pp. 131-151.
14. KISVETROVÁ, H., P. KURKOVÁ, B. ŠVEJDÍKOVÁ & R. POPELKOVÁ, 2013. Používání sluchadla jako aspekt kvality života seniorské populace. In: *Medzinárodní konference Kvalita života 2013*. Liberec : Technical Univesity, s. 53-62.
15. KRAČEK, S., P. PAČESOVÁ, P. ŠMELA, M. ŠTEFANOVSKÝ & D. ČIERNA, 2015. Závislosť úrovne vybraných kognitívnych schopností v rankingu v džude u detí od 10 do 15 rokov. In: *Od výskumu k praxi v športe. Zborník vedeckých prác*. STU, Bratislava, s. [7 s.] [CD-ROM], ISBN 978-80-227-4485-0.
16. KRAČEK, S., P. PAČESOVÁ & V. OLIVA, 2015. Porovnanie úrovne vybraných kognitívnych schopností pravidelne športujúcej a nešportujúcej mužskej populácie. In: *Vedecké práce KSS a P 2015. Vedecký zborník*. Univerzita sv. Cyrila a Metoda v Trnave, Trnava, s. 140-146 [CD-ROM]. ISBN 978-80-8105-733-5.
17. LAURIN, D., R. VERREAULT, J. LINDSAY, K. MacPHERSON & K. ROCKWOOD, 2001. Physical activity and risk of cognitive impairment and dementia in elderly persons. In: *Arch Neurol*, **58**(3), pp. 498-504.

18. MIDDLETON, L.E., D.E. BARNES, L. LUI & K. YAFFE, 2010. Physical activity over the life course and its association with cognitive performance and impairment in old age. In: *J Am Geriatr Soc,* **58**(7), pp. 1322-1326.
19. MORONI, C. & S. BAYARD, 2009. Inhibitory process: What evolution after the age of 50? In: *Psychologie & NeuroPsychiatrie du Vieillissement*, 7, pp. 121-129.
20. NEMČEK, D., 2011. Exercise as a part of seniors' life style. In: *Healthy active life style and physical education*. END, Topoľčianky, pp. 49-57. ISBN 978-80-89324-07-1.
21. NEMČEK, D. & J. LABUDOVÁ, 2011. Importance of quality of life factors related to health and exercise in seniors. In: *Exercise and quality of life*. University of Novi Sad, Novi Sad, pp. 87-92. ISBN 978-86-80231-71-6.
22. NEMČEK, D., J. LABUDOVÁ & S. KRAČEK, 2012. Life satisfaction of sedentary and physically active population. In: *Acta Facultatis Educationis physicae Universitatis Comenianae.* Comenius University, Bratislava, pp. 61-71. ISBN 978-80-223-3229-3.
23. NEMČEK, D., J. LABUDOVÁ, T. JAVANAINEN-LEVONEN & J. WITTMANNOVÁ, 2014. Quality of life between active population and population with sedentary behaviour with different health status. In: *EUCAPA European Congress of Adapted Physical Activity.* Universidad politécnica de Madrid, Madrid, pp. 1. ISBN 978-84-941365-5-9.
24. NEMČEK, D., J. WITTMANNOVÁ & M. MELICHAROVÁ, 2014. Quality of life among seniors living in nursing homes in bruntal region: The impact of physical activities. In: *Sports, Physical Activity and Health 2014.* Slovak Olympic Committee, Bratislava, pp. 65-66. ISBN 978-80-89075-43-0.
25. ROLLAND, Y., F. PILLARD, A. KLAPOUSZCZAK, E. REYNISH, D. THOMAS, S. ANDRIEU et al., 2007. Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. In: *Journal of the American Geriatrics Society*, **55**(2), pp. 158-165.
26. RUBIAL-ALVAREZ, S., M.C. MACHADO, E. SINTAS et al., 2007. A preliminary study of the Mini Mental State Examination in a Spanish child population. *J Child Neurol*, 22, pp. 1269-1273.
27. SALTHOUSE, T., 2011. Effects of Age on Time-Dependent Cognitive Change. *Psychol Sci,* **22**(5), pp. 682-688.
28. SALTHOUSE, T. 2009. When does age-related cognitive decline begin? *Neurobiol Aging*, 30, pp. 507-514.
29. SCHAIE, K. W., 2005. *Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study*. New York: Oxford University Press.

30. SCHNEIDER, W., 2002. Memory development in childhood. In: GOSWAMI, U. *Blackwell handbook of childhood cognitive development*. Malden: Blackwell Pub. pp. 236-256.
31. SHOJI, M., K. FUKUSHIMA, M. WAKAYAMA et al., 2002. Intellectual faculties in patients with Alzheimer's disease regress to the level of a 4-5 year old child. In: *Ger Gerontol Int*, 2, pp. 143-147.
32. SPREEN, O. & E. STRAUSS, 1998. *A compendium of neuropsychological tests* (2nd ed.). New York: Oxford University Press.
33. STRAUSS, E., E.M.S. SHERMAN & O. SPREEN, 2006. *A compendium of neuropsychological tests. Administration, norms, and commentary* (5th ed.). New York: Oxford University Press.
34. SUNG, H.C., S.M. CHANG, W.L. LEE & M.S. LEE, 2006. The effects of group music with movement intervention on agitated behaviours of institutionalized elders with dementia in Taiwan. In: *Complementary Therapies in Medicine*, **14**(2), pp. 113-119.
35. SUZUKI, T., H. SHIMADA, H. MAKIZAKO, T. DOI, D. YOSHIDA, K. TSUTSUMIMOTO et al., 2012. Effects of multicomponent exercise on cognitive function in older adults with amnestic mild cognitive impairment: a randomized controlled trial. In: *BMC Neurology*, **12**(128), pp. 1-9.
36. THURM, F., A. SCHARPF, N. LIEBERMANN, S. KOLASSA, T. ELBERT, D. LÜCHTENBERG et al., 2011. Improvement of cognitive function after physical movement training in institutionalized very frail older adults with dementia. In: *The Journal of Gerontopsychology and Geriatric Psychiatry*, **24**(4), pp. 197-208.
37. TROYER, A. K., L. LEACH & E. STRAUSS, 2006. Aging and response inhibition: Normative data for the Victoria Stroop Test. In: *Aging, Neuropsychology and Cognition*, 13, pp. 20-35.
38. TSANTALI, E, D. ECONOMIDIS, S. RIGOPOULOU et al., 2012. Comparison of cognitive performance of Mild Cognitive Impairment and demented patients with that of children and adults. In: *Ger Gerontol Int*, **12**(2), pp. 336-344.
39. VITAL, T.M., S.S. HERNÁNDEZ SALMA, R.V. PEDROSO, C.V.L. TEIXERIA, M. GARUFFI, A.M. STEIN et al., 2012. Effects of weight training on cognitive functions in elderly with alzheimer's disease. In: *Dementia e Neuropsychologia*, **6**(4), pp. 253-259.
40. VOSS, M.W., L.S. NAGAMATSU, T. LIU-AMBROSE & A.F. KRAMER, 2011. Exercise, brain, and cognition across the life span. In: *J Appl Physiol*, **111**(5), pp. 1505-1513.

41. VREUGDENHIL, A., J. CANNELL, A. DAVIES & G. RAZAY, 2011. A community-based exercise programme to improve functional ability in people with Alzheimer's disease: a randomized controlled trial. In: *Scandinavian Journal of Caring Sciences*, **26**(1), pp. 12-19.
42. WEUVE, J., J.H. KANG, J.E. MANSON, M.M.B. BRETELER, J.H. WARE & F. GRODSTEIN, 2004. Physical activity including walking, and cognitive function in older women. In: *Journal of the American Medical Association*, 292, pp. 1454-1461.
43. YÁGÜEZ, L., K.N. SHAW, R. MORRIS & D. MATTHEWS, 2011. The effects on cognitive functions of a movement-based intervention in patients with Alzheimer's type dementia: a pilot study. In: *International Journal of Geriatric Psychiatry*, **26**(2), pp. 173-181.