Clinical Medicine Insights
Received 27 Mar 2021 | Revised 25 Apr 2021 | Accepted 28 May 2021 | Published Online 30 Jun 2021

DOI: https://doi.org/10.52845/CMI/2021-2-2-5
CMI JOURNAL 2 (2), 124−143 (2021)

ISSN (O) 2694-4626

REVIEW ARTICLE

Open Access Journal

Exercise and Non-Communicable Diseases: Part II Cancer, Diabetes Mellitus, Kidney Diseases, Alzheimer's Disease, Arthritis

Shashi K. Agarwal, MD *

[1]2227 US Highway 1, #309 North Brunswick, NJ 08902,USA

Abstract

Non-communicable diseases (NCDs) are the leading global cause of death and disproportionately afflict those living in low-income and lower-middle-income countries. Healthy lifestyle behaviors, including eating a high-quality diet, non-smoking, engaging in moderate to vigorous physical activity, and drinking alcohol in moderation, have been associated with a lower risk of NCDs, a decline in worsening, and a reduction in associated mortality. The first part of this two-part series discussed exercise and its effects on cardiovascular and respiratory diseases, obesity, depression, and liver ailments. This second part discusses the deleterious effects of smoking on five non-communicable diseases, viz., cancer, diabetes mellitus, chronic kidney disease, Alzheimer's disease, and arthritis. This manuscript highlights the benefits of exercise, in reducing the incidence, progression, and premature mortality of NCDs.

Keywords: exercise, non-communicable diseases, cancer, diabetes mellitus, chronic kidney disease, Alzheimer's disease, arthritis

1 | INTRODUCTION

Exercise (or lack of it) is fast becoming a major lifestyle factor in the prevention and treatment of major non-communicable diseases[1]. It is also used to treat back pain[2] sports injuries[3], osteoporosis[4], inflammatory bowel disease[5], neurodegenerative diseases (such as Parkinson's disease)[6], Huntington's disease[7], multiple sclerosis[8], anxiety disorders[9], and many other ailments[10−11]. Exercise helps increase confidence, improve socialization, brings happiness, and helps improve sleep[12,13]. The overall quality of life is also improved[14]. A recent US study suggested that moderate to vigorous physical activity could significantly reduce general premature mortality and increase life expectancy[15].

The World Health Organization recommends that adult men and women should accumulate at least 150 min of moderate-intensity physical exercise per week, while young people aged 5–17 years should accumulate at least 60 min of physical exercise of moderate to vigorous intensity daily[16].

2 | DISCUSSION

Chronic NCDs are common conditions affecting humans[17]. They are gradually replacing infectious diseases as the leading health burden across the world[18]. The Centers for Disease Control and Prevention (CDC) of USA defines chronic diseases as "conditions that last 1 year or more and require ongoing medical attention or limit activities of daily living or both"[19]. They estimate that six in ten adults in the USA have a chronic disease, while four in ten have two or more chronic diseases[19]. In a recent study, Ng et al reported that most individuals develop at least one chronic disease during their lifetime[20]. Rosella et al found that in the Ontario population, two-thirds of individuals had four or more chronic conditions at the time of their death[21]. More and more deaths globally, are now attributable to chronic NCDs[22]. According to the World Health Organization (WHO), chronic NCDs accounted for 71% of the 57 million global deaths in 2016[23].

Chronic non-communicable diseases include cardiovascular diseases (CVDs) (such as hypertension, coronary artery disease, stroke, and heart failure), cancer, chronic respiratory diseases (such as chronic obstructive pulmonary disease, sleep apnea, and asthma), diabetes mellitus, Alzheimer's disease, chronic kidney disease (CKD), arthritis, depression, obesity, and liver diseases (such as nonalcoholic and alcoholic hepatitis, viral hepatitis, cirrhosis of liver)[24]. There is overwhelming evidence that exercise also confers significant benefits in the prevention and management of these diseases[25,26]. As discussed in part I of this two-part manuscript, it has significant benefits for cardiovascular diseases, respiratory diseases, obesity, depression, and liver diseases. This manuscript will discuss its benefits for cancer, diabetes mellitus, kidney diseases, Alzheimer's disease, and arthritis.

Cancer was diagnosed in 18 million individuals in 2018[27]. Cancers of the lung (2.09 million cases), breast (2.09 million cases), and prostate (1.28 million cases) were the most common in this group[27]. Cancer was responsible for 9.6 million deaths globally in 2018[28]. Today, cancer-related mortality exceeds that caused by communicable diseases such as human immunodeficiency virus/acquired immunodeficiency syndrome, tuberculosis, and malaria, combined[29]. Diabetes mellitus (DM) is also a common chronic disease[30]. It is mainly categorized into 2 major subtypes, type I DM (T1D) and type II DM (T2D)[31]. T1D is an autoimmune disorder, with several genetic, epigenetic, and environmental factors playing a role in its genesis[32]. T2D is characterized by insulin resistance and accounts for 90-95% of all diabetes cases[31]. It often leads to the development of several microvascular (retinopathy, nephropathy, and neuropathy) and macrovascular (coronary artery disease, stroke, peripheral artery disease) complications[33]. Deaths from DM continue to increase all over the world[34]. CKD has an estimated prevalence of 10.6%-13.4%[35], and its prevalence is growing rapidly[36]. CKD progresses to end-stage kidney disease requiring a kidney transplant, and these numbers are also on the increase[37]. It is estimated that the number of people requiring renal replacement will double to 5.4 million by 2030[38]. This population has a mortality rate that is over 100-fold compared to that seen in the normal population[39]. DM continues to be the leading cause of CKD[40]. Dementia affects around 50 million people worldwide and this number is projected to increase to 152 million by 2050[41]. Alzheimer's disease (AD) is the most common dementia and is caused by amyloid-beta peptide accumulation in the medial temporal lobe and neocortical structures[42]. Treatment for AD is symptomatic as there is no

Supplementary information The online version of this article (10.52845/CMI/2021-2-2-5) contains supplementary material, which is available to authorized users.

Corresponding Author: *Shashi K. Agarwal, MD*
Shashi K. Agarwal, MD 2227 US Highway 1, #309 North Brunswick, NJ 08902, USA
Email: usacardiologist@gmail.com

cure available at this time[43]. Arthritis is of over 100 types, the most common being rheumatoid arthritis, osteoarthritis, psoriatic arthritis, and inflammatory arthritis[44]. Osteoarthritis (OA) is the most prevalent chronic joint disease and is associated with cartilage loss[45,46]. It usually affects the knees, although it can affect any joint[45,46]. It is a major cause of disability in older adults47. Rheumatoid arthritis (RA) is a chronic, systemic, immune-inflammatory disease, especially affecting the synovial joints resulting in synovitis, joint erosion, and cartilage damage[48]. Its etiology includes several genetic, environmental, and endogenous factors[49].

Lifestyle changes can beneficially modify chronic NCDs[50]. The detrimental but modifiable lifestyle factors include tobacco smoking, inadequate vegetable and fruit consumption, excessive alcohol consumption, physical inactivity, and obesity[51]. Part I reviewed the benefits of exercise for cardiovascular diseases, respiratory diseases, obesity, depression, and liver diseases. This manuscript will discuss its benefits for cancer, diabetes mellitus, kidney diseases, Alzheimer's disease, and arthritis.

2.1 | CANCER

In 1986, Winningham et al suggested that physical activity may play a major role in oncology[52]. The cancer modulating effect of exercise has been confirmed by several subsequent studies[53–55]. Behrens and the group found that low physical activity accounted for 6% of all cancers in Germany[53]. They reported that physical inactivity resulted in an increase in endometrial cancer by 15%, renal cancer by 17%, liver cancer by 24%, and lung cancer by 19%[53]. According to Islami and the group, physical inactivity accounted for 2.9% of all cancer cases in the US54. They estimated that physical inactivity accounted for 26.7% of uterine cancers, 16.3% of colorectal cancers, and 3.9% of female breast cancers[54]. A recent umbrella review, including 19 reviews, 26 meta-analyses, and 541 original studies, evaluating physical activity and cancer risk, concluded that regular physical activity is beneficial in preventing 7 major cancers (colon, breast, endometrium, lung, esophagus, pancreas, and meningioma)[55]. The greatest beneficial impact appears to be on breast and colon cancer[56]. In a meta-analysis of 38 cohort studies in 2016 by Pizot et al, breast cancer risk was reduced by 12-21% in the most physically active women than in those who were least physically active[57]. In another more recent study, exercising 7 hours a week reduced colon cancer risk by 40%[58]. Several studies have also reported significant reductions in physical activity in cancers of the stomach[59], kidney[60], bladder[60], and endometrium[61]. Minimal amounts of exercise may have protective effects[62], although there appears to be a dose-dependent relationship[63–65].

Following a cancer diagnosis, exercise is associated with better clinical outcomes[66–69]. Animal studies have demonstrated a decrease in cancer tumor growth with exercise[67]. Exercise therapy before the initiation of chemotherapy is associated with improvements in tolerance to cancer treatment[68]. Benefits are also noted with exercise pre-surgery[69]. Pre-treatment exercise results in mitigation of the significant functional decline often noted in cancer patients[68,69].

Exercise during treatment also demonstrates clinical benefits[70–83]. These patients notice an improved tolerance to chemotherapy and surgery[69.70]. Their hospital stay is decreased[69]. They have fewer side effects and less fatigue[71,72]. Their aerobic endurance, strength, flexibility, and body composition improves[73]. They become more physically fit and have increased energy levels and vitality[74]. There is an improvement in sleep quality[75] and a reduction in depression[76] and anxiety[77], often experienced by these patients. Exercising cancer patients also improve their self-esteem[71]. Their QOL improves[78]. Exercise helps decrease metastasis and cancer recurrence[79,80]. Benefits of exercise have also been seen in individuals after metastasis has occurred[81]. Survival is increased[82,83]. Regular exercise continues to be recommended by various world health organizations for cancer patients[84–88].

Physical activity induces several cancer-preventive changes in the human body, including reducing adipose tissue, improving insulin resistance, reducing inflammation, enhancing immune function, modulating sex hormones and growth factors, and enhancing resistance to oxidative stress and DNA damage[89]. In patients with established malignant tumors, physical activity/exercise paradigms regulate intra-tumoral vascular maturity and perfusion, hypoxia, and metabolism and augment the antitumor immune response[90].

More than 40% of patients diagnosed with cancer have comorbid NCDs, such as diabetes, obesity, chronic obstructive pulmonary disease, and heart failure[91]. Cancer itself may increase the risk of developing some of these diseases[92,93]. Breast cancer survivors experience an increased risk of cardiovascular disease[92] and cardiovascular mortality[93]. Patients with nonmetastatic breast cancer demonstrate a 23% adjusted reduced risk of cardiovascular events, with exercise[94]. Exercise benefits for cancer, therefore, also extend to coexisting NCDs.

2.2 | DIABETES MELLITUS

Several studies have stressed the value of regular physical activity as part of lifestyle changes to help prevent or delay type 2 diabetes[95,96]. Church et al found that a weight loss of only 5%-7% achieved with physical activity at least 150–175 min/week and dietary energy restriction demonstrate reductions of 40%–70% in the risk of developing type 2 diabetes in people with impaired glucose tolerance[97]. A systemic review of randomized controlled trials found that lifestyle changes, including exercise, had a preventive effect on the development of T2D in people with impaired glucose tolerance. While the control group had a diabetes incidence of 9.3% to 67.7%, in this study, the lifestyle intervention group demonstrated a reduced incidence of 3% to 46%[98]. A recent systematic review of 53 studies done by Balk et al found that, compared with usual care, diet and physical activity promotion programs improved several cardiometabolic risk factors and reduced the incidence of type 2 diabetes[99].

Exercise, especially moderate to vigorous, confers several benefits on patients with both type I and type II diabetes[100]. Aerobic exercise in type I diabetes helps by decreasing insulin resistance and improving lipid levels and endothelial function[101]. In T2D, aerobic exercise reduces blood glucose, A1C, triglycerides, blood pressure, and insulin resistance[102]. Both T1D and T2D patients lose weight and become more cardio-metabolically fit with aerobic exercise. As a result, the cardiovascular risk diminishes[103−105]. The latter is important as diabetics have a higher risk of developing CVDs[106]. CVDs are responsible for most deaths in these patients[107]. Many diabetic patients are obese, and exercise also helps them get more physically fit and function better[108]. Resistance exercises are also helpful in T2D[109,110]. These patients generate more muscle mass, more bone mineral density, and become stronger[109]. There is also improvement in the cardiometabolic profile[109]. Resistance exercises in T1D, if done before aerobic exercises, minimize the risk of exercise-induced hypoglycemia[110]. Flexibility and balance exercises help diabetics improve their joint mobility, which often deteriorates with the combination of hyperglycemia and aging[111]. Stretching exercises increase the range of motion of joints and improve flexibility in these patients[112]. Diabetics may have gait and balance problems, especially if peripheral neuropathy is present[113]. Balance training in these patients can therefore help reduce the risk of falls[114]. Both Yoga and Tai Chi may help improve glycemic control and many QOL parameters[115,116]. Aerobic activity also helps reduce mortality in both types I and type 2 diabetes[117]. Exercise stress testing before starting an exercise program is recommended for previously sedentary diabetics or those with cardiovascular autonomic neuropathy[118].

2.3 | CHRONIC KIDNEY DISEASE

The role of sedentary behavior and exercise on GFR and albuminuria, or both, has been extensively studied[119−123]. Sedentary behavior increases the risk of developing CKD, while physical exercise reduces this risk[124−126]. In a prospective analysis of the Cardiovascular Health Study, greater baseline physical activity was associated with a lower risk of GFR decline >3 mL/min/1.73 m2 per year over 7 years of follow-up[127]. In the Second National Health and Nutritional Examination Survey, highly active people, when compared with inactive people, demonstrated a reduced risk for developing kidney failure or dying of CKD over a mean of 13 years[128]. A recent study has also confirmed the preventive benefits of exercise in CKD[129] .

Once CKD has developed, physical activity in the affected individual slows down[130]. This deterioration in physical performance is evidenced by a decreased walking capacity, muscle strength, balance, and fine motor skills[131−134]. With the initiation of dialysis, physical functioning does not improve[135] and continues to deteriorate[136] usually becoming a major disability[137]. The National Kidney Foundation recommends that patients with CKD on dialysis be "counseled and regularly encouraged by nephrology and dialysis staff to increase their level of physical activity"[138]. This is because several studies have demonstrated that physical activity benefits patients with CKD[139]. Exercise in these patients is associated with not only a slower decline in eGFR, but often an improvement[140,141]. In a meta-analysis of 13 RCTs totaling 421 patients with CKD, Zhang et al concluded that exercise therapy was associated with a +2.6 mL/min increase in eGFR[142]. Greenwood et al in a retrospective longitudinal cohort study estimated that each extra hour of sedentary behavior was associated with a worsening of kidney function, while each extra hour of total physical activity was associated with a better kidney function[143]. Exercise training in dialysis patients prevents muscle atrophy and improves functional capacity and quality of life[144,145]. Benefits of exercise have also been noted in renal transplant patients[146].

Besides the benefits for the kidneys, exercise in CKD patients improves aerobic and functional capacity[147,148]. It improves peak/maximum oxygen consumption, strength, fine motor skills, and balance[149,150]. There is a reduction in cardiovascular outcomes[151]. Several benefits have also been noted with exercise following renal transplantation[152]. Overall, exercise in CKD patients imparts a better prognosis, a better quality of life, and better survival[153−155]. Exercise (aerobic, resistance, and flexibility) has been recommended for CKD patients by major kidney organizations[156−158]. Exercise is usually feasible, and well-tolerated in CKD patients, including those on dialysis and those following renal transplantation[159−161].

Physical activity may be associated with GFR and albuminuria via mechanisms such as modulation of inflammation, endothelial function, the renin-angiotensin system, and renal sympathetic nerve activity[162−164]. The beneficial change in GFR and albuminuria may also be mediated by modification of risk factors such as T2DM blood pressure, adiposity, and dyslipidemia, by increased physical activity[165−168].

2.4 | ALZHEIMER'S DISEASE

Exercise and brain health are intricately associated[169]. Several cross-sectional, longitudinal observational studies and narrative reviews have discussed the benefits of exercise on cognitive function[170−172]. Meta-analytic reviews have concluded that older adults are protected against cognitive decline if they engage in exercise[173−175]. Northey and his group noted after analyzing 36 studies that physical exercise, in people over the age of 50, improved cognitive function, irrespective of their baseline cognitive status[173]. Falck et al conducted a systematic review and meta-analysis of 48 studies involving adults aged 60 or older and noted that exercise was associated with an improvement in cognitive function[174]. Chen et al recently performed a meta-analysis of 33 RCT studies and concluded that exercise interventions improve executive function[175]. Executive functions mainly originate in the prefrontal cortex and include attentional control, working memory, inhibition, and problem-solving. They are all important aspects of cognition.

Hamer and Chida in a systematic review involving 163,000 non-psychotic participants found that the risk of dementia and AD was lowered by 28% and 45% with physical activity[176]. Lautenschlager et al found that in older adults with mild cognitive impairment, 142 minutes of extra exercise per week improved cognition[177]. Two more recent meta-analyses have also confirmed the slowing effects of aerobic exercise on cognitive decline, in patients with MCI or even AD[178,179]. Zheng et al evaluated 11 studies involving 1497 participants and found that in patients with MCI, aerobic exercise improved global cognitive ability and memory[178]. Panza and colleagues in a meta-analysis of nineteen studies, which included 1,145 subjects, reported that exercise training may delay the decline in cognitive function that occurs in individuals who are at risk of or have developed AD[179]. In patients with AD, exercise results in an improvement in cognitive function[180], decreased neuropsychiatric symptoms, and a slower decline in activities of daily living[181]. And, consequently, reduced caregiver burden[182]. Patients with AD experience fewer side effects[183] and better adherence to medications[184], with exercise.

The mechanisms behind the exercise-related improvement in brain health have been well studied[185,186]. Exercise preserves neurogenesis[187,188] and helps beneficial neuroplasticity[189]. Exercise also helps improve diabetes, hypertension, obesity, stress, depression, and inflammation, which are also risk factors for dementia[190]. In conclusion, physical activity is inversely associated with the risk of developing and the progression of dementia.

2.5 | ARTHRITIS

The beneficial role of exercise in osteoarthritis is also persuasive[191−195]. Improved pain and functional outcomes after exercise therapy in OA are well demonstrated by numerous meta-analytic studies[191,192]. Goh et al showed that exercise not only significantly reduced pain and improved function in patients with OA, but improved performance and QOL in these patients as compared with usual care at 8 weeks[193]. Both traditional exercises such as aerobic, resistance, and flexibility, and non-traditional exercises such as Tai Chi, Yoga, and aquatics are effective in the management of knee and hip osteoarthritis[194]. In their systematic review of 44 clinical trials involving patients with knee osteoarthritis, there was an improvement in physical function and the quality of life, and these effects lasted up to six months after cessation of land-based therapeutic exercises[195]. Severe hip osteoarthritis is one of the main causes of disabling pain, functional impairment, and reduced quality of life in elderly patients[196]. In a review of 10 RCTs, researchers concluded that land-based therapeutic exercises can reduce pain and improve physical function among people with symptomatic hip OA[197]. Land- and aquatic-based physical activities help patients with both knee and hip OA to reduce pain and increase mobility, muscle strength, joint flexibility, and aerobic endurance[198]. Initially, aquatic exercises may be deployed. The buoyancy of the water decreases joint loading, which can help decrease pain, and warm water may also have a therapeutic effect[199]. Once patients become more mobile, they can transition to land-based exercises. Exercise should be the main intervention for OA patients[193,200]. Weesandt and his group in a review concluded that osteoarthritis can be successfully managed and treated through exercise, with minimal risk of negative consequences[201].

Rheumatoid arthritis also responds well to physical exercise[202−208]. These patients notice an improvement in joint health and mobility. They increase their aerobic work capacity and become more physically active. They notice an improvement in endurance, strength, and dynamic balance. Rheumatoid fatigue and cachexia are reduced. There is also an improvement in psychological well-being. Increased physical activity and exercise also help reduce the impact of systemic manifestations of RA[209], such as increased inflammation, disturbed vascular function, and increased cardiovascular risk in these patients[210−212]. Despite these benefits, RA patients have lower physical activity levels than healthy individuals[213−215], with 71 % of RA patients not participating in regular physical activity[216].

Exercise is relatively safe as compared with pharmacological treatments in the management of arthritis[217]. The American College of Rheumatology/Arthritis Foundation guidelines for the management of arthritis of the hip and knee emphasize the importance of regularly performed physical exercise as an important therapeutic intervention[218].

3 | CONCLUSION

Exercise plays a major preventive and therapeutic role in most non-communicable diseases. It imparts positive physical and psychological health outcomes. It is safe and feasible for most NCD patients. It can help maintain or increase physical independence over time and decrease caregiver burden. Most professional associations of NCDs emphasize the incorporation of exercise for the prevention and management of these diseases.

Acknowledgment: None

Funding: None

Conflict of interest: None

REFERENCES

1. Suzuki K. Chronic Inflammation as an Immunological Abnormality and Effectiveness of Exercise. Biomolecules. 2019 Jun 7;9(6):223. doi: 10.3390/biom9060223.

2. Galán-Martín MA, Montero-Cuadrado F, Lluch-Girbes E, Coca-López MC, Mayo-Iscar A, Cuesta-Vargas A. Pain neuroscience education and physical exercise for patients with chronic spinal pain in primary healthcare: a randomised trial protocol. BMC Musculoskelet Disord. 2019 Nov 3;20(1):505. doi: 10.1186/s12891-019-2889-1.

3. Lauersen J.B., Bertelsen D.M., Andersen L.B. The effectiveness of exercise interventions to prevent sports injuries: a systematic review and meta-analysis of randomised controlled trials. Br J Sports Med. 2014;48:871–877.

4. Tong X, Chen X, Zhang S, Huang M, Shen X, Xu J, Zou J. The Effect of Exercise on the Prevention of Osteoporosis and Bone Angiogenesis. Biomed Res Int. 2019 Apr 18;2019:8171897. doi: 10.1155/2019/8171897.

5. Eckert KG, Abbasi-Neureither I, Köppel M, Huber G. Structured physical activity interventions as a complementary therapy for patients with inflammatory bowel disease - a scoping review and practical implications. BMC Gastroenterol. 2019;19(1):115. doi:10.1186/s12876-019-1034-9.

6. Tambosco L, Percebois-Macadré L, Rapin A, Nicomette-Bardel J, Boyer FC. Effort training in Parkinson's disease: a systematic review. Ann Phys Rehabil Med. 2014 Mar;57(2):79-104. doi: 10.1016/j.rehab.2014.01.003.

7. Frese S., Petersen J.A., Ligon-Auer M., Mueller S.M., Mihaylova V., Gehrig S.M. Exercise effects in Huntington disease. J Neurol. 2017;264:32–39.

8. Baird JF, Sandroff BM, Motl RW. Therapies for mobility disability in persons with multiple sclerosis. Expert Rev Neurother. 2018 Jun;18(6):493-502. doi: 10.1080/14737175.2018.1478289.

9. Herring M.P., Jacob M.L., Suveg C., Dishman R.K., O'Connor P.J. Feasibility of exercise training for the short-term treatment of generalized anxiety disorder: a randomized controlled trial. Psychother Psychosom. 2012;81:21–28.

10. Lynch WJ, Peterson AB, Sanchez V, Abel J, Smith MA. 2013. Exercise as a novel treatment for drug addiction: A neurobiological and stage-dependent hypothesis. Neurosci Biobehav Rev 37: 1622–1644.

11. Utter A, Goss F. Exercise and gall bladder function. Sports Med. 1997 Apr;23(4):218-27. doi: 10.2165/00007256-199723040-00002.

12. Sharma A, Madaan V, Petty FD. Exercise for mental health. Prim Care Companion J Clin Psychiatry. 2006;8(2):106. doi:10.4088/pcc.v08n0208a.

13. Flausino NH, Da Silva Prado JM, de Queiroz SS, Tufik S, de Mello MT. Physical exercise performed before bedtime improves the sleep pattern of healthy young good sleepers. Psychophysiology. 2012 Feb;49(2):186-92. doi: 10.1111/j.1469-8986.2011.01300.x.

14. Awick EA, Ehlers DK, Aguiñaga S, Daugherty AM, Kramer AF, McAuley E. Effects of a randomized exercise trial on physical activity, psychological distress and quality of life in older adults. Gen Hosp Psychiatry. 2017 Nov;49:44-50. doi: 10.1016/j.genhosppsych.2017.06.005.

15. Li Y, Pan A, Wang DD, et al. . Impact of healthy lifestyle factors on life expectancies in the US population. Circulation. 2018;138(4):345-355. doi:10.1161/CIRCULATIONAHA.117.032047.

16. Cavanaugh A.R., Schwartz G.J., Blouet C. Global Health Estimates (2015). Deaths by Cause, Age, Sex, by Country and by Region, 2000–2015. World Health Organization; Geneva, Switzerland: 2015.

17. Jackson-Morris A, Nugent R. Tailored support for national NCD policy and programme implementation: an over-looked priority. BMJ Glob Health. 2020 Aug;5(8):e002598. doi: 10.1136/bmjgh-2020-002598.

18. Benziger CP, Roth GA, Moran AE. The Global Burden of Disease Study and the Preventable Burden of NCD. Glob Heart. 2016 Dec;11(4):393-397. doi: 10.1016/j.gheart.2016.10.024.

19. https://www.cdc.gov/chronicdisease/about/index.htm - accessed May 25, 2021.

20. Ng R, Sutradhar R, Yao Z, Wodchis WP, Rosella LC. Smoking, drinking, diet and physical activity-modifiable lifestyle risk factors and their associations with age to first chronic disease. Int J Epidemiol. 2020;49(1):113-130. doi:10.1093/ije/dyz078.

21. Rosella L, Kornas 25K, Huang A, Bornbaum C, Henry D, Wodchis WP. Accumulation of chronic conditions at the time of death increased in Ontario from 1994 to 2013. Health Aff 2018;37:1–9.

22. NCD Countdown 2030 collaborators. NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. Lancet. 2018 Sep 22;392(10152):1072-1088. doi: 10.1016/S0140-6736(18)31992-5.

23. World Health Organization. Noncommunicable Diseases Country Profiles 2018. Available at: https://www.who.int/nmh/publications/ncd-profiles-2018/en/ - Accessed August 12, 2020.

24. https://www.who.int/health-topics/noncommunicable-diseases#:~:text=Noncommunicable%20diseases%20(NCDs)%2C%20including,70%25%20of%20all%20deaths%20worldwide – accessed June 11, 2021.

25. Matheson GO, Klügl M, Dvorak J, et al. Responsibility of sport and exercise medicine in preventing and managing chronic disease: applying our knowledge and skill is overdue. Br J Sports Med. 2011 Dec;45(16):1272-82. doi: 10.1136/bjsports-2011-090328.

26. Barker K, Eickmeyer S. Therapeutic Exercise. Med Clin North Am. 2020 Mar;104(2):189-198. doi: 10.1016/j.mcna.2019.10.003.

27. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1789–858. doi: 10.1016/S0140-6736(18)32279-7.

28. https://www.who.int/cancer/PRGlobocanFinal.pdf?ua=1 – accessed July 2, 2021.

29. Javier Cortes, Jose Manuel Perez-García, Antonio Llombart-Cussac, et al. Enhancing global access to cancer medicines. CA: A Cancer Journal for Clinicians Volume 70, Issue 2 p. 105-124. https://doi.org/10.3322/caac.21597.

30. Schmidt AM. Highlighting Diabetes Mellitus: The Epidemic Continues. Arterioscler Thromb Vasc Biol. 2018 Jan;38(1):e1-e8. doi: 10.1161/ATVBAHA.117.310221.

31. Classification and Diagnosis of Diabetes. American Diabetes Association. Diabetes Care. 2015;38:S8–S16.

32. Hakonarson H. and Grant S.F. (2011) Genome-wide association studies (GWAS): impact on elucidating the aetiology of diabetes. Diabetes Metab. Res. Rev. 27, 685–696 10.1002/dmrr.1221.

33. Graves LE, Donaghue KC. Vascular Complication in Adolescents With Diabetes Mellitus. Front Endocrinol (Lausanne). 2020;11:370. doi:10.3389/fendo.2020.00370.

34. GBD 2013 Mortality. Causes of Death Collaborators Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: A systematic analysis for the Global Burden of Disease

Study 2013. Lancet. 2015;385:117–171. doi: 10.1016/S0140-6736(14)61682-2.

35. Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, Hobbs FD. Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. PLoS One. 2016 Jul 6;11(7):e0158765. doi: 10.1371/journal.pone.0158765.

36. GBD Chronic Kidney Disease Collaboration. Global, regional, and national burden of chronic kidney disease, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2020 Feb 29;395(10225):709-733. doi: 10.1016/S0140-6736(20)30045-3.

37. Tsai WC, Wu HY, Peng YS, et al. Risk Factors for Development and Progression of Chronic Kidney Disease: A Systematic Review and Exploratory Meta-Analysis. Medicine (Baltimore). 2016 Mar;95(11):e3013. doi: 10.1097/MD.0000000000003013.

38. Liyanage T, Ninomiya T, Jha V. Worldwide access to treatment for end-stage kidney disease: a systematic review. Lancet. 2015;385:1975–1982

39. Go A.S., Chertow G.M., Fan D. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med. 2004;351:1296–1305

40. Pavkov ME, Collins AJ, Coresh J, et al. editors. Diabetes in America. 3rd ed. Bethesda (MD): National Institute of Diabetes and Digestive and Kidney Diseases (US); 2018 Aug. CHAPTER 22.

41. Patterson C. Alzheimer's Disease International; London: 2018. World Alzheimer report 2018.

42. De-Paula V.J., Radanovic M., Diniz B.S., Forlenza O.V. Alzheimer's disease. Sub-Cell. Biochem. 2012;65:329–352. doi: 10.1007/978-94-007-5416-4_14.

43. Yiannopoulou K.G., Papageorgiou S.G. Current and future treatments in alzheimer disease: An update. J. Cent. Nerv. Syst. Dis. 2020:12. doi: 10.1177/1179573520907397.

44. Tang CH. Research of Pathogenesis and Novel Therapeutics in Arthritis. Int J Mol Sci. 2019;20(7):1646. Published 2019 Apr 2. doi:10.3390/ijms20071646.

45. Lawrence RC, Helmick CG, Arnett FC, et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. Arthritis Rheum. 1998;41:778–799. doi: 10.1002/1529-0131(199805)41:5<778::AID-ART4>3.0.CO;2-V.

46. Zhang Y, Jordan JM. Epidemiology of osteoarthritis. Clin Geriatr Med. 2010;26:355–369. doi: 10.1016/j.cger.2010.03.001.

47. Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PW, Kelly-Hayes M, Wolf PA, Kreger BE, Kannel WB. The effects of specific medical conditions on the functional limitations of elders in the Framingham study. Am J Public Health. 1994;84:351–358. doi: 10.2105/AJPH.84.3.351.

48. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016 Oct 22;388(10055):2023-2038. doi: 10.1016/S0140-6736(16)30173-8.

49. Jawaheer D., Seldin M.F., Amos C.I., Chen W., Shigeta R., Etzel C., Damle A., Xiao X., Chen N., Lum R.F., et al. Screening the genome for rheumatoid arthritis susceptibility genes: A replication study and combined analysis of 512 multicase families. Arthritis Rheum. 2003;48:906–916. doi: 10.1002/art.10989.

50. Kushner RF, Sorensen KW. Lifestyle medicine: the future of chronic disease management. Curr Opin Endocrinol Diabetes Obes. 2013 Oct;20(5):389-95. doi: 10.1097/01.med.0000433056.76699.5d.

51. Parekh S, Vandelanotte C, King D, Boyle FM. Design and baseline characteristics of the 10 Small Steps Study: a randomised controlled trial of an intervention to promote healthy behaviour using a lifestyle score and personalised feedback. BMC Public Health. 2012;12:179. Published 2012 Mar 12. doi:10.1186/1471-2458-12-179.

52. Winningham ML, MacVicar MG, Burke CA. Exercise for cancer patients: Guidelines and precautions. Phys Sportsmed 1986;14:125–134.

53. Behrens G, Gredner T, Stock C, Leitzmann MF, Brenner H, Mons U. Cancers Due to Excess Weight, Low Physical Activity, and Unhealthy Diet. Dtsch Arztebl Int. 2018;115(35-36):578-585. doi:10.3238/arztebl.2018.0578.

54. Islami, F., Goding Sauer, A., Miller, et al. (2018), Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. CA: A Cancer Journal for Clinicians, 68: 31-54. doi:10.3322/caac.21440.

55. Rezende LFM, Sá TH, Markozannes G, Rey-López JP, Lee IM, Tsilidis KK, Ioannidis JPA, Eluf-Neto J. Physical activity and cancer: an umbrella review of the literature including 22 major anatomical sites and 770 000 cancer cases. Br J Sports Med. 2018;52:826–833.

56. Kruk J, Czerniak U. Physical activity and its relation to cancer risk: updating the evidence. Asian Pac J Cancer Prev. 2013;14:3993–4003.

57. Pizot C, Boniol M, Mullie P, et al. Physical activity, hormone replacement therapy and breast cancer risk: A meta-analysis of prospective studies. European Journal of Cancer 2016; 52:138-154.

58. Mahmood S, English DR, MacInnis RJ, Karahalios A, Owen N, Milne RL, Giles GG, Lynch BM. Domain-specific physical activity and the risk of colorectal cancer: results from the Melbourne Collaborative Cohort Study. BMC Cancer. 2018;18:1063.

59. Psaltopoulou T, Ntanasis-Stathopoulos I, Tzanninis IG, et al. Physical activity and gastric cancer risk: A systematic review and meta-analysis. Clinical Journal of Sports Medicine 2016; 26(6):445-464.

60. Moore SC, Lee IM, Weiderpass E, et al. Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. JAMA Internal Medicine 2016; 176(6):816-825.

61. Schmid D, Behrens G, Keimling M, et al. A systematic review and meta-analysis of physical activity and endometrial cancer risk. European Journal of Epidemiology 2015; 30(5):397-412.

62. Sprague BL, Trentham-Dietz A, Newcomb PA, Titus-Ernstoff L, Hampton JM, Egan KM. Lifetime recreational and occupational physical activity and risk of in situ and invasive breast cancer. Cancer Epidemiol Biomarkers Prev. 2007 Feb;16(2):236-43. doi: 10.1158/1055-9965.EPI-06-0713.

63. Friedenreich CM. The role of physical activity in breast cancer etiology. Semin Oncol. 2010 Jun;37(3):297-302. doi: 10.1053/j.seminoncol.2010.05.008.

64. Behrens G, Leitzmann MF. The association between physical activity and renal cancer: systematic review and meta-analysis. Br J Cancer. 2013;108:798–811.

65. Boyle T, Keegel T, Bull F, Heyworth J, Fritschi L. Physical activity and risks of proximal and distal colon cancers: a systematic review and meta-analysis. J Natl Cancer Inst. 2012;104:1548–1561.

66. Ashcraft KA, Peace RM, Betof AS, Dewhirst MW, Jones LW. Efficacy and Mechanisms of Aerobic Exercise on Cancer Initiation, Progression, and Metastasis: A Critical Systematic Review of In Vivo Preclinical Data. Cancer Res. 2016 Jul 15;76(14):4032-50. doi: 10.1158/0008-5472.CAN-16-0887

67. Radak Z, Gaal D, Taylor AW, Kaneko T, Tahara S, Nakamoto H, et al. Attenuation of the development of murine solid leukemia tumor by physical exercise. Antioxidants & redox signaling. 2002;4(1):213–219.

68. Singh F, Newton RU, Galvao DA, Spry N, Baker MK. A systematic review of pre-surgical exercise intervention studies with cancer patients. Surg Oncol. 2013;22(2):92–104.

69. Sebio Garcia R, Yáñez Brage MI, Giménez Moolhuyzen E, Granger CL, Denehy L. Functional and postoperative outcomes after preoperative exercise training in patients with lung cancer: a systematic review and meta-analysis. Interact Cardiovasc Thorac Surg. 2016 Sep;23(3):486-97. doi: 10.1093/icvts/ivw152.

70. Cheema B, Gaul CA, Lane K, Fiatarone Singh MA. Progressive resistance training in breast cancer: a systematic review of clinical trials. Breast cancer research and treatment. 2008;109(1):9–26.

71. Schmitz KH, Courneya KS, Matthews C et al. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc 2010;42:1409–1426.

72. Hilfiker R, Meichtry A, Eicher M et al. Exercise and other non-pharmaceutical interventions for cancer-related fatigue in patients during or after cancer treatment: A systematic review incorporating an indirect-comparisons meta-analysis. Br J Sports Med 2018;52:651–658.

73. Carvalho AP, Vital FM, Soares BG. Exercise interventions for shoulder dysfunction in patients treated for head and neck cancer. Cochrane Database of Systematic Reviews. 2012;(4) N.PAG-N.PAG.

74. Juvet LK, Thune I, Elvsaas IKØ, Fors EA, Lundgren S, Bertheussen G, Leivseth G, Oldervoll LM. The effect of exercise on fatigue and physical functioning in breast cancer patients during and after treatment and at 6 months follow-up: A meta-analysis. Breast. 2017 Jun;33:166-177. doi: 10.1016/j.breast.2017.04.003.

75. Matthews EE, Janssen DW, Djalilova DM, Berger AM. Effects of exercise on sleep in women with breast cancer: a systematic review. Sleep Med Clin. 2018. ;13:395-417.

76. Cramer H, Lange S, Klose P, Paul A, Dobos G. Yoga for breast cancer patients and survivors: A systematic review and meta-analysis. BMC cancer. 2012:12.

77. Harder H, Parlour L, Jenkins V. Randomised controlled trials of yoga interventions for women with breast cancer: A systematic literature review. Supportive Care in Cancer. 2012;20(12):3055–3064.

78. Jones LW, Eves ND, Peterson BL, Garst J, Crawford J, West MJ, Mabe S, Harpole D, Kraus WE, Douglas PS. Safety and feasibility of aerobic training on cardiopulmonary function and quality of life in postsurgical nonsmall cell lung cancer patients: a pilot study. Cancer. 2008 Dec 15;113(12):3430-9. doi: 10.1002/cncr.23967.

79. Wolff G., Davidson S.J., Wrobel J.K. & Toborek M. (2015) Exercise maintains blood-brain barrier integrity during early stages of brain metastasis formation. Biochem. Bioph. Res. Co. 463, 811–817.

80. Meyerhardt JA, Heseltine D, Niedzwiecki D et al. Impact of physical activity on cancer recurrence and survival in patients with stage III colon cancer: Findings from CALGB 89803. J Clin Oncol 2006;24:3535–3541.

81. Wilk M, Kepski J, Kepska J, et al.Exercise interventions in metastatic cancer disease: a literature review and a brief discussion on current and future perspectives. BMJ Supportive & Palliative Care Published Online First: 17 September 2020. doi: 10.1136/bmjspcare-2020-002487.

82. Meyerhardt JA, Giovannucci EL, Holmes MD, Chan AT, Chan JA, Colditz GA & Fuchs CS (2006) Physical activity and survival after colorectal cancer diagnosis. J Clin Oncol 24, 3527–3534.

83. Friedenreich CM, Neilson HK, Farris MS & Courneya KS (2016). Physical activity and cancer outcomes: a precision medicine approach. Clin Cancer Res 22, 4766–4775.

84. Rock CL, Doyle C, Demark-Wahnefried W, et al. Nutrition and physical activity guidelines for cancer survivors. CA Cancer J Clin. 2012;62:242-274.

85. Schmitz KH, Courneya KS, Matthews C, et al. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc. 2010;42:1409-1426.

86. Hayes SC, Newton RU, Spence RR, Galvao DA. The Exercise and Sports Science Australia position statement: exercise medicine in cancer management. J Sci Med Sport. Published online May 10, 2019. doi:10.1016/j.jsams.2019.05.003.

87. Segal R, Zwaal C, Green E, et al. Exercise for people with cancer: a clinical practice guideline. Curr Oncol. 2017;24:40-46.

88. Cormie P, Atkinson M, Bucci L, et al. Clinical Oncology Society of Australia position statement on exercise in cancer care. Med J Aust. 2018;209:184-187.

89. Leitzmann M, Powers H, Anderson AS, et al. European Code Against Cancer 4th edition: physical activity and cancer. Cancer Epidemiol. 2015;39 Suppl 1:S46–S55. ;World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR). Diet, Nutrition, Physical Activity and Cancer: A Global Perspective. Continuous Update Project Expert Report 2018. London, UK: WCRF International; 2018. wcrf.org/diet and cancer/contents. Accessed June 5, 2018.

90. Ashcraft KA, Warner AB, Jones LW, Dewhirst MW. Exercise as Adjunct Therapy in Cancer. Semin Radiat Oncol. 2019 Jan;29(1):16-24. doi: 10.1016/j.semradonc.2018.10.001.

91. Edwards BK, Noone AM, Mariotto AB, et al. Annual Report to the Nation on the status of cancer, 1975-2010, featuring prevalence of comorbidity and impact on survival among persons with lung, colorectal, breast, or prostate cancer. Cancer. 2014;120:1290–1314.

92. Carver JR, Shapiro CL, Ng A et al. American Society of Clinical Oncology clinical evidence review on the ongoing care of adult cancer survivors: cardiac and pulmonary late effects. Journal of Clinical Oncology. 2007. September 1;25(25):3991–4008.

93. Jones LW, Habel LA, Weltzien E, Castillo A, Gupta D, Kroenke CH, Kwan ML, Quesenberry CP Jr, Scott J, Sternfeld B, Yu A, Kushi LH, Caan BJ. Exercise and Risk of Cardiovascular Events in Women With Nonmetastatic Breast Cancer. J Clin Oncol. 2016 Aug 10;34(23):2743-9. doi: 10.1200/JCO.2015.65.6603.

94. Scott JM, Adams SC, Koelwyn GJ, Jones LW. Cardiovascular Late Effects and Exercise Treatment in Breast Cancer: Current Evidence and Future Directions. Can J Cardiol. 2016 Jul;32(7):881-90. doi: 10.1016/j.cjca.2016.03.014.

95. Crandall J, et al.; Diabetes Prevention Program Research Group. The influence of age on the effects of lifestyle modification and metformin in prevention of diabetes. J Gerontol A Biol Sci Med Sci. 2006;61(10):1075–1081.

96. Schellenberg ES, Dryden DM, Vandermeer B, Ha C, Korownyk C. Lifestyle interventions for patients with and at risk for type 2 diabetes: a systematic review and meta-analysis. Ann Intern Med 2013;159:543–551.

97. Church TS, Blair SN, Cocreham S, et al. . Effects of aerobic and resistance training on

hemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial. JAMA 2010;304:2253–2262.

98. Yoon U, Kwok LL, Magkidis A. Efficacy of lifestyle interventions in reducing diabetes incidence in patients with impaired glucose tolerance: a systematic review of randomized controlled trials. Metabolism. 2013 Feb;62(2):303-14. doi: 10.1016/j.metabol.2012.07.009.

99. Balk EM, Earley A, Raman G, Avendano EA, Pittas AG, Remington PL. Combined diet and physical activity promotion programs to prevent type 2 diabetes among persons at increased risk: a systematic review for the community preventive services task force. Ann Intern Med 2015;163:437–451.

100. Colberg S.R., Sigal R.J., Yardley J.E. Physical activity/exercise and diabetes: A position statement of the American diabetes association. Diabetes Care. 2016;39:2065–2079. doi: 10.2337/dc16-1728.

101. Chimen M, Kennedy A, Nirantharakumar K, Pang TT, Andrews R, Narendran P. What are the health benefits of physical activity in type 1 diabetes mellitus? A literature review. Diabetologia 2012;55:542–551.

102. Snowling NJ, Hopkins WG. Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients: a meta-analysis. Diabetes Care 2006;29:2518–2527.

103. Colberg SR, Albright AL, Blissmer BJ, et al. Exercise and type 2 diabetes: American College of Sports Medicine and the American Diabetes Association: joint position statement. Exercise and type 2 diabetes. Med Sci Sports Exerc. 2010;42(12):2282–2303.

104. Gordon BA, Benson AC, Bird SR, Fraser SF. Resistance training improves metabolic health in type 2 diabetes: a systematic review. Diabetes Res Clin Pract 2009;83:157–175.

105. American Diabetes Association Standards of medical care in diabetes-2020. 5. Facilitating behavior change and well-being to improve health outcomes. Diabetes Care. 2020;43(Suppl. S1):S48–S65. doi: 10.2337/dc20-S005.

106. Marwick T.H., Hordern M.D., Miller T. Exercise training for type 2 diabetes mellitus. Impact on cardiovascular risk. A scientific statement from the American Heart Association. Circulation. 2009;119:3244–3262. doi: 10.1161/CIRCULATIONAHA.109.192521.

107. Strain WD, Paldánius PM. Diabetes, cardiovascular disease and the microcirculation. Cardiovasc Diabetol. 2018 Apr 18;17(1):57. doi: 10.1186/s12933-018-0703-2.

108. Rejeski WJ, et al.; Look AHEAD Research Group. Lifestyle change and mobility in obese adults with type 2 diabetes. N Engl J Med. 2012;366(13):1209–1217.

109. Garber CE, Blissmer B, Deschenes MR, et al.; American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011;43:1334–1359.

110. Yardley JE, Kenny GP, Perkins BA, et al. Resistance versus aerobic exercise: acute effects on glycemia in type 1 diabetes. Diabetes Care 2013;36:537–542.

111. Abate M, Schiavone C, Pelotti P, Salini V. Limited joint mobility in diabetes and ageing: recent advances in pathogenesis and therapy. Int J Immunopathol Pharmacol 2010;23:997–1003.

112. Herriott MT, Colberg SR, Parson HK, Nunnold T, Vinik AI. Effects of 8 weeks of flexibility and resistance training in older adults with type 2 diabetes. Diabetes Care 2004;27:2988–2989.

113. Alam U, Riley DR, Jugdey RS, Azmi S, Rajbhandari S, D'Août K, Malik RA. Diabetic Neuropathy and Gait: A Review. Diabetes Ther. 2017 Dec;8(6):1253-1264. doi: 10.1007/s13300-017-0295-y.

114. Morrison S, Colberg SR, Mariano M, Parson HK, Vinik AI. Balance training reduces falls risk in older individuals with type 2 diabetes. Diabetes Care 2010;33:748–750.

115. Innes KE, Selfe TK. Yoga for adults with type 2 diabetes: a systematic review of controlled trials. J Diabetes Res 2016;2016:6979370.

116. Ahn S, Song R. Effects of tai chi exercise on glucose control, neuropathy scores, balance, and quality of life in patients with type 2 diabetes and neuropathy. J Altern Complement Med 2012;18:1172–1178.

117. Sluik D, Buijsse B, Muckelbauer R, et al. Physical activity and mortality in individuals with diabetes mellitus: a prospective study and meta-analysis. Arch Intern Med 2012;172:1285–1295.

118. Colberg SR, Albright AL, Blissmer BJ, et al. Exercise and type 2 diabetes: American College of Sports Medicine and the American Diabetes Association: joint position statement. Exercise and type 2 diabetes. Med Sci Sports Exerc. 2010;42(12):2282–2303.

119. White SL, Dunstan DW, Polkinghorne KR, Atkins RC, Cass A, Chadban SJ. Physical inactivity and chronic kidney disease in Australian adults: the AusDiab study. Nutr Metab Cardiovasc Dis. 2011;21(2):104–12.. doi: 10.1016/j.numecd.2009.08.010.

120. Bharakhada N, Yates T, Davies MJ, Wilmot EG, Edwardson C, Henson J, et al. Association of sitting time and physical activity with CKD: a cross-sectional study in family practices. Am J Kidney Dis. 2012;60(4):583–90.

121. Herber-Gast GC, Hulsegge G, Hartman L, Verschuren WM, Stehouwer CD, Gansevoort RT, et al. Physical Activity Is not Associated with Estimated Glomerular Filtration Rate among Young and Middle-Aged Adults: Results from the Population-Based Longitudinal Doetinchem Study. PloS one. 2015;10(10):e0133864 doi: 10.1371/journal.pone.0133864.

122. Robinson ES, Fisher ND, Forman JP, Curhan GC. Physical activity and albuminuria. Am J Epidemiol. 2010;171(5):515–21. doi: 10.1093/aje/kwp442.

123. Bharakhada N, Yates T, Davies MJ, Wilmot EG, Edwardson C, Henson J, et al. Association of sitting time and physical activity with CKD: a cross-sectional study in family practices. Am J Kidney Dis. 2012;60(4):583–90. doi: 10.1053/j.ajkd.2012.04.024.

124. Pike M, Taylor J, Kabagambe E, Stewart TG, Robinson-Cohen C, Morse J, Akwo E, Abdel-Kader K, Siew ED, Blot WJ, Ikizler TA, Lipworth L (2019) The association of exercise and sedentary behaviours with incident end-stage renal disease: the Southern Community Cohort Study. BMJ Open 9(8):e030661.

125. Robinson-Cohen C. Katz R. Mozaffarian D.et al. Physical activity and rapid decline in kidney function among older adults. Arch Intern Med. 2009; 169: 2116-2123.

126. Stengel B, Tarver-Carr ME, Powe NR, Eberhardt MS, Brancati FL. Lifestyle factors, obesity and the risk of chronic kidney disease. Epidemiology. 2003 Jul;14(4):479-87. doi: 10.1097/01.EDE.0000071413.55296.c4.

127. Robinson-Cohen C. Katz R. Mozaffarian D.et al. Physical activity and rapid decline in kidney function among older adults. Arch Intern Med. 2009; 169: 2116-2123.

128. Stengel B, Tarver-Carr ME, Powe NR, Eberhardt MS, Brancati FL. Lifestyle factors, obesity and the risk of chronic kidney disease. Epidemiology. 2003 Jul;14(4):479-87. doi: 10.1097/01.EDE.0000071413.55296.c4.

129. Kaushik Parvathaneni, Aditya Surapaneni. Shoshana H. Ballew et al. Association Between Midlife Physical Activity and Incident Kidney Disease: The Atherosclerosis Risk in Communities (ARIC) Study American Journal of Kidney Diseases,.VOLUME 77, ISSUE 1, P74-81, JANUARY 01, 2021.DOI:https://doi.org/10.1053/j.ajkd.2020.07.020.

130. Reese PP, et al. Physical performance and frailty in chronic kidney disease. Am. J. Nephrol. 2013;38(4):307–315. doi: 10.1159/000355568.

131. Hiraki K, Yasuda T, Hotta C, Izawa KP, Morio Y, Watanabe S, et al. Decreased physical function in pre-dialysis patients with chronic kidney disease. Clin Exp Nephrol. 2013;17:225–231. doi: 10.1007/s10157-012-0681-8.

132. Hellberg M, Wiberg EM, Simonsen O, Hoglund P, Clyne N. Small distal muscles and balance predict survival in end-stage renal disease. Nephron Clin Pract. 2014;126(3):116–23. odi:10.1159/000358431.

133. Hellberg M, Hoglund P, Svensson P, Abdulahi H, Clyne N. Decline in measured glomerular filtration rate is associated with a decrease in endurance, strength, balance and fine motor skills. Nephrology (Carlton). 2017;22(7):513–9. doi: 10.1111/nep.12810.

134. Clyne N, Hellberg M, Kouidi E, Deligiannis A, Hoglund P. Relationship between declining glomerular filtration rate and measures of cardiac and vascular autonomic neuropathy. Nephrology (Carlton). 2016;21(12):1047–55. doi:10.1111/nep.12706.

135. Hiraki K, et al. Decreased physical function in pre-dialysis patients with chronic kidney disease. Clin. Exp. Nephrol. 2013;17(2):225–231. doi: 10.1007/s10157-012-0681-8.

136. Johansen KL. Exercise in the end-stage renal disease population. J Am Soc Nephrol. 2007;18:1845–1854.

137. Johansen KL, Chertow GM, Ng AV, Mulligan K, Carey S, Schoenfeld PY, Kent-Braun JA: Physical activity levels in patients on hemodialysis and healthy sedentary controls. Kidney Int 57: 2564–2570, 2000.

138. KDOQI clinical practice guidelines for cardiovascular disease in dialysis patients. Am J Kidney Dis 45: 16–153, 2005.

139. Greenwood SA, et al. Mortality and morbidity following exercise-based renal rehabilitation in patients with chronic kidney disease: the effect of programme completion and change in exercise capacity. Nephrol. Dial Transplant. 2019;34(4):618–625. doi: 10.1093/ndt/gfy351.

140. Alkerwi Ala'a, Sauvageot N, El Bahi I, et al. Prevalence and related risk factors of chronic kidney disease among adults in Luxembourg: evidence from the observation of cardiovascular risk factors (ORISCAV-LUX) study. BMC Nephrol 2017;18:358 10.1186/s12882-017-0772-6.

141. Martens RJH, van der Berg JD, Stehouwer CDA, et al. Amount and pattern of physical activity and sedentary behavior are associated with kidney function and kidney damage: the Maastricht study.PLoS One 2018;13:e0195306 10.1371/journal.pone.0195306.

142. Zhang L, Wang Y, Xiong L. et al. Exercise therapy improves eGFR, and reduces blood pressure and BMI in nondialysis CKD patients: evidence from a meta-analysis. BMC Nephrol 2019; 29; 20: 398.

143. Martens RJH, van der Berg JD, Stehouwer CDA, et al. Amount and pattern of physical activity and sedentary behavior are associated with kidney function and kidney damage: The Maastricht Study. PLoS One. 2018 Apr 4;13(4):e0195306. doi: 10.1371/journal.pone.0195306.

144. Deligiannis A, D'Alessandro C, Cupisti A. Exercise training in dialysis patients: impact on cardiovascular and skeletal muscle health. Clin

Kidney J. 2021 Jan 11;14(Suppl 2):ii25-ii33. doi: 10.1093/ckj/sfaa273.

145. Hoshino J. Renal Rehabilitation: Exercise Intervention and Nutritional Support in Dialysis Patients. Nutrients. 2021 Apr 24;13(5):1444. doi: 10.3390/nu13051444.

146. Masiero L, Puoti F, Bellis L, Lombardini L, Totti V, Angelini ML, Spazzoli A, Nanni Costa A, Cardillo M, Sella G, Mosconi G. Physical activity and renal function in the Italian kidney transplant population. Ren Fail. 2020 Nov 10;42(1):1192-1204. doi: 10.1080/0886022X.2020.1847723.

147. Calella P, et al. Exercise training in kidney transplant recipients: a systematic review. J. Nephrol. 2019;32(4):567–579. doi: 10.1007/s40620-019-00583-5.

148. Villanego F, Naranjo J, Vigara LA, Cazorla JM, Montero ME, García T, Torrado J, Mazuecos A. Impact of physical exercise in patients with chronic kidney disease: Sistematic review and meta-analysis. Nefrologia. 2020 May-Jun;40(3):237-252. English, Spanish. doi: 10.1016/j.nefro.2020.01.002.

149. Nakamura K, Sasaki T, Yamamoto S, Hayashi H, Ako S, Tanaka Y. Effects of exercise on kidney and physical function in patients with non-dialysis chronic kidney disease: a systematic review and meta-analysis. Sci Rep. 2020;10(1):18195. doi:10.1038/s41598-020-75405-x.

150. Hellberg M, Höglund P, Svensson P, Clyne N. Comparing effects of 4 months of two self-administered exercise training programs on physical performance in patients with chronic kidney disease: RENEXC - A randomized controlled trial. PLoS One. 2018 Dec 20;13(12):e0207349. doi: 10.1371/journal.pone.0207349.

151. T Wilkinson. Physical activity reduces 10-year cardiovascular disease risk through improvement in blood pressure regulation in patients with chronic kidney disease. Nephrol Dial Transplant. 2019:34. gfz101.SaO008 doi:101093/ndt/gfz101 SaO008.

152. Senthil Kumar TG, Soundararajan P, Maiya AG, Ravi A. Effects of graded exercise training on functional capacity, muscle strength, and fatigue after renal transplantation: a randomized controlled trial. Saudi J Kidney Dis Transpl. 2020 Jan-Feb;31(1):100-108. doi: 10.4103/1319-2442.279929.

153. MacKinnon HJ, et al. The association of physical function and physical activity with all-cause mortality and adverse clinical outcomes in non-dialysis chronic kidney disease: a systematic review. Ther. Adv. Chronic Dis. 2018;9(11):209–226. doi: 10.1177/2040622318785575.

154. Pei G, Tang Y, Tan L, Tan J, Ge L, Qin W. Aerobic exercise in adults with chronic kidney disease (CKD): a meta-analysis. Int Urol Nephrol. 2019 Oct;51(10):1787-1795. doi: 10.1007/s11255-019-02234-x.

155. Ikizler TA, et al. Metabolic effects of diet and exercise in patients with moderate to severe CKD: a randomized clinical trial. J. Am. Soc. Nephrol. 2018;29(1):250–259. doi: 10.1681/ASN.2017010020.

156. Eknoyan G., Lameire N., Eckardt K.U. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic kidney disease. Kidney Int. Suppl. 2013;3:136–150.

157. Smart N.A., Williams A.D., Levinger I., Selig S., Howden E., Coombes J.S., Fassett R.G. Exercise & Sports Science Australia (ESSA) position statement on exercise and chronic kidney disease. J. Sci. Med. Sport. 2013;16:406–411. doi: 10.1016/j.jsams.2013.01.005.

158. Ferguson B. ACSM's Guidelines for Exercise Testing and Prescription 9th Ed. 2014. J. Can. Chiropr. Assoc. 2014;58:328.

159. Huang M, Lv A, Wang J, Xu N, Ma G, Zhai Z, Zhang B, Gao J, Ni C. Exercise Training and

Outcomes in Hemodialysis Patients: Systematic Review and Meta-Analysis. Am J Nephrol. 2019;50(4):240-254. doi: 10.1159/000502447.

160. Wilkinson TJ, McAdams-DeMarco M, Bennett PN, Wilund K; Global Renal Exercise Network. Advances in exercise therapy in predialysis chronic kidney disease, hemodialysis, peritoneal dialysis, and kidney transplantation. Curr Opin Nephrol Hypertens. 2020 Sep;29(5):471-479. doi: 10.1097/MNH.0000000000000627.

161. Senthil Kumar TG, Soundararajan P, Maiya AG, Ravi A. Effects of graded exercise training on functional capacity, muscle strength, and fatigue after renal transplantation: a randomized controlled trial. Saudi J Kidney Dis Transpl. 2020 Jan-Feb;31(1):100-108. doi: 10.4103/1319-2442.279929.

162. Henson J, Yates T, Edwardson CL, Khunti K, Talbot D, Gray LJ, et al. Sedentary time and markers of chronic low-grade inflammation in a high risk population. PloS one. 2013;8(10):e78350 Epub 2013/11/10. doi: 10.1371/journal.pone.0078350.

163. Padilla J, Simmons GH, Bender SB, Arce-Esquivel AA, Whyte JJ, Laughlin MH. Vascular effects of exercise: endothelial adaptations beyond active muscle beds. Physiology (Bethesda). 2011;26(3):132–45. doi: 10.1152/physiol.00052.2010.

164. Goessler K, Polito M, Cornelissen VA. Effect of exercise training on the renin-angiotensin-aldosterone system in healthy individuals: a systematic review and meta-analysis. Hypertens Res. 2015.. doi: 10.1038/hr.2015.100.

165. Aune D, Norat T, Leitzmann M, Tonstad S, Vatten LJ. Physical activity and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis. Eur J Epidemiol. 2015;30(7):529–42. Epub 2015/06/21. doi: 10.1007/s10654-015-0056-z.

166. Huai P, Xun H, Reilly KH, Wang Y, Ma W, Xi B. Physical activity and risk of hypertension: a meta-analysis of prospective cohort studies. Hypertension. 2013;62(6):1021–6. doi: 10.1161/HYPERTENSIONAHA.113.01965.

167. Zhang L, Wang Y, Xiong L. et al. Exercise therapy improves eGFR, and reduces blood pressure and BMI in nondialysis CKD patients: evidence from a meta-analysis. BMC Nephrol 2019; 29; 20: 398.

168. Kelley GA, Kelley KS. Aerobic exercise and lipids and lipoproteins in men: a meta-analysis of randomized controlled trials. J Mens Health Gend. 2006;3(1):61–70.

169. Etnier JL, Chang YK. Exercise, cognitive function, and the brain: advancing our understanding of complex relationships. J Sport Health Sci. 2019;8(4):299–300. doi: 10.1016/j.jshs.2019.03.008. ; Audiffren M, Andre N. The exercise-cognition relationship: a virtuous circle. J Sport Health Sci. 2019;8(4):339–347. doi: 10.1016/j.jshs.2019.03.001.

170. Falck RS, Landry GJ, Best JR, Davis JC, Chiu BK, Liu-Ambrose T. Cross-sectional relationships of physical activity and sedentary behavior with cognitive function in older adults with probable mild cognitive impairment. Phys Ther. 2017;97(10):975–984. doi: 10.1093/ptj/pzx074.

171. Engeroff T, Ingmann T, Banzer W. Physical activity throughout the adult life span and domain-specific cognitive function in old age: a systematic review of cross-sectional and longitudinal data. Sports Med. 2018;48(6):1405–1436. doi: 10.1007/s40279-018-0920-6.

172. Brini S, Sohrabi HR, Peiffer JJ, Karrasch M, Hamalainen H, Martins RN, et al. Physical activity in preventing alzheimer's disease and cognitive decline: a narrative review. Sports Med. 2018;48(1):29–44. doi: 10.1007/s40279-017-0787-y.

173. Northey JM, Cherbuin N, Pumpa KL, Smee DJ, Rattray B. Exercise interventions for cognitive function in adults older than 50: a systematic

review with meta-analysis. Br J Sports Med. 2017;52(3):154–160. doi: 10.1136/bjsports-2016-096587.

174. .Falck RS, Davis JC, Best JR, Crockett RA, Liu-Ambrose T. Impact of exercise training on physical and cognitive function among older adults: a systematic review and meta-analysis. Neurobiol Aging. 2019;79:119–130. doi: 10.1016/j.neurobiolaging.2019.03.007.

175. Chen FT, Etnier JL, Chan KH, Chiu PK, Hung TM, Chang YK. Effects of Exercise Training Interventions on Executive Function in Older Adults: A Systematic Review and Meta-Analysis. Sports Med. 2020 Aug;50(8):1451-1467. doi: 10.1007/s40279-020-01292-x.

176. Hamer M., Chida Y. (2009). Physical activity and risk of neurodegenerative disease: a systematic review of prospective evidence. Psychol. Med. 39 3–11. 10.1017/S0033291708003681.

177. Lautenschlager NT, Cox KL, Flicker L, et al. Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: a randomized trial [published correction appears in JAMA. 2009;301(3):276]. JAMA. 2008;300(9):1027–1037.

178. Zheng G, Xia R, Zhou W, Tao J, Chen L. Aerobic exercise ameliorates cognitive function in older adults with mild cognitive impairment: a systematic review and meta-analysis of randomised controlled trials. Br J Sports Med. 2016;50:1443–1450. doi: 10.1136/bjsports-2015-095699.

179. Panza GA, Taylor BA, MacDonald HV, Johnson BT, Zaleski AL, Livingston J, Thompson PD, Pescatello LS. Can exercise improve cognitive symptoms of Alzheimer's disease? J Am Geriatr Soc. 2018;66:487–495. doi: 10.1111/jgs.15241.

180. Farina N., Rusted J., Tabet N. (2014). The effect of exercise interventions on cognitive outcome in Alzheimer's disease: a systematic review. Int. Psychogeriatr. 26 9–18. 10.1017/s1041610213001385.

181. Forbes D, Forbes SC, Blake CM, Thiessen EJ, Forbes S. Exercise programs for people with dementia. Cochrane Database Syst Rev. 2015 Apr 15;(4):CD006489. doi: 10.1002/14651858.CD006489.pub4.

182. Forbes D, Forbes SC, Blake CM, Thiessen EJ, Forbes S. Exercise programs for people with dementia. Cochrane Database Syst Rev. 2015;(4):CD006489.

183. Ströhle A., Schmidt D. K., Schultz F., Fricke N., Staden T., Hellweg R., et al. (2015). Drug and exercise treatment of Alzheimer disease and mild cognitive impairment: a systematic review and meta-analysis of effects on cognition in randomized controlled trials. Am. J. Geriatr. Psychiatry 23 1234–1249. 10.1016/j.jagp.2015.07.007.

184. Cass SP. Alzheimer's Disease and Exercise: A Literature Review. Curr Sports Med Rep. 2017 Jan/Feb;16(1):19-22. doi: 10.1249/JSR.0000000000000332.

185. Kennedy G, Hardman RJ, MacPherson H, Scholey AB, Pipingas A. How does exercise reduce the rate of age-associated cognitive decline? A review of potential mechanisms. J Alzheimers Dis. 2016;55:1–18. doi: 10.3233/JAD-160665.

186. Macpherson H, Teo WP, Schneider LA, Smith AE. A life-long approach to physical activity for brain health. Front Aging Neurosci 2017;9:PMC5440589. doi: 10.3389/fnagi.2017.00147.

187. Yau SY, Gil-Mohapel J, Christie BR, So KF. Physical Exercise-Induced Adult Neurogenesis: A Good Strategy to Prevent Cognitive Decline in Neurodegenerative Diseases? Biomed Res Int. 2014;2014:403120. doi: 10.1155/2014/403120.

188. Ma CL, Ma XT, Wang JJ, Liu H, Chen YF, Yang Y. Physical exercise induces hippocampal neurogenesis and prevents cognitive decline. Behav Brain Res. 2017;317:332–339. doi: 10.1016/j.bbr.2016.09.067.

189. Hötting K, Röder B. Beneficial effects of physical exercise on neuroplasticity and cognition. Neurosci Biobehav Rev. 2013;37:2243–2257. doi: 10.1016/j.neubiorev.2013.04.005.

190. Livingston G, Sommerlad A, Orgeta V, et al. Dementia prevention, intervention, and care. Lancet. 2017;2017:S0140–S6736. doi: 10.1016/S0140-6736(17)31363-6.

191. Uthman O.A., van der Windt D.A., Jordan J.L. Exercise for lower limb osteoarthritis: systematic review incorporating trial sequential analysis and network meta-analysis. BMJ. 2014;48:1579–1679.

192. Li Y., Su Y., Chen S. The effects of resistance exercise in patients with knee osteoarthritis: a systematic review and meta-analysis. Clin Rehabil. 2016;30:947–959.

193. Goh SL, Persson MSM, Stocks J, Hou Y, Lin J, Hall MC, Doherty M, Zhang W. Efficacy and potential determinants of exercise therapy in knee and hip osteoarthritis: A systematic review and meta-analysis. Ann Phys Rehabil Med. 2019 Sep;62(5):356-365. doi: 10.1016/j.rehab.2019.04.006.

194. Wellsandt E., Golightly Y. Exercise in the management of knee and hip osteoarthritis. Curr. Opin. Rheumatol. 2018;30:151–159. doi: 10.1097/BOR.0000000000000478.

195. Fransen M, McConnell S, Hernandez-Molina G, Reichenbach S. Exercise for osteoarthritis of the hip. Cochrane Database Syst Rev. 2009 Jul 8;(3):CD007912. doi: 10.1002/14651858.CD007912.

196. Dimitriou D, Antoniadis A, Flury A, Liebhauser M, Helmy N. Total Hip Arthroplasty Improves the Quality-Adjusted Life Years in Patients Who Exceeded the Estimated Life Expectancy. J Arthroplasty 2018;33:3484–9. https://doi.org/10.1016/j.arth.2018.07.005.

197. Fransen M., McConnell S., Harmer A.R., Van der Esch M., Simic M., Bennell K.L. Exercise for osteoarthritis of the knee: A Cochrane systematic review. Br. J. Sports Med. 2015;49:1554–1557. doi: 10.1136/bjsports-2015-095424.

198. Fransen M, McConnell S, Harmer AR, Van der Esch M, Simic M, Bennell KL. Exercise for osteoarthritis of the knee. Cochrane Database Syst Rev. 2015;(1):CD004376.

199. Bartels EM, Juhl CB, Christensen R, et al. Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane Database Syst Rev. 2016;(3):CD005523.

200. Nelson A.E., Allen K.D., Golightly Y.M. A systematic review of recommendations and guidelines for the management of osteoarthritis: the chronic osteoarthritis management initiative of the U.S. bone and joint initiative. Semin Arthritis Rheum. 2014;43:701–712.

201. Wellsandt E, Golightly Y. Exercise in the management of knee and hip osteoarthritis. Curr Opin Rheumatol. 2018 Mar;30(2):151-159. doi: 10.1097/BOR.0000000000000478.

202. Cooney JK, Law RJ, Matschke V, et al. Benefits of exercise in rheumatoid arthritis. J Aging Res. 2011;2011:681640. doi: 10.4061/2011/681640.

203. Summers GD, Metsios GS, Stavropoulos-Kalinoglou A, et al. Rheumatoid cachexia and cardiovascular disease. Nat Rev Rheumatol. 2010;6(8):445–451. doi: 10.1038/nrrheum.2010.105.

204. Metsios GS, Stavropoulos-Kalinoglou A, Veldhuijzen van Zanten JJ, et al. Rheumatoid arthritis, cardiovascular disease and physical exercise: a systematic review. Rheumatology (Oxford) 2008;47(3):239–248. doi: 10.1093/rheumatology/kem260.

205. Metsios GS, Stavropoulos-Kalinoglou A, Sandoo A, et al. Vascular function and inflammation in rheumatoid arthritis: the role of physical activity. Open Cardiovasc Med J. 2010;4:89–96.

206. Cramp F, Hewlett S, Almeida C, et al. Non-pharmacological interventions for fatigue in rheumatoid arthritis. Cochrane Database Syst Rev. 2013;8:CD008322.

207. Pope JE. Management of Fatigue in Rheumatoid Arthritis. RMD Open. 2020 May;6(1):e001084. doi: 10.1136/rmdopen-2019-001084.

208. Lange E, Kucharski D, Svedlund S, Svensson K, Bertholds G, Gjertsson I, Mannerkorpi K. Effects of Aerobic and Resistance Exercise in Older Adults With Rheumatoid Arthritis: A Randomized Controlled Trial. Arthritis Care Res (Hoboken). 2019 Jan;71(1):61-70. doi: 10.1002/acr.23589.

209. Metsios GS, Kitas GD. Physical activity, exercise and rheumatoid arthritis: Effectiveness, mechanisms and implementation. Best Pract Res Clin Rheumatol. 2018 Oct;32(5):669-682. doi: 10.1016/j.berh.2019.03.013.

210. Metsios GS, Stavropoulos-Kalinoglou A, Kitas GD. (2015). The role of exercise in the management of rheumatoid arthritis. Expert Rev Clin Immunol, 11(10): 1121–30.

211. Agca R, Heslinga SC, Rollefstad S, et al. (2017). EULAR recommendations for cardiovascular disease risk management in patients with rheumatoid arthritis and other forms of inflammatory joint disorders: 2015/2016 update. Ann Rheum Dis, 76(1): 17–28.

212. Metsios GS, Stavropoulos-Kalinoglou A, Veldhuijzen van Zanten JJ, et al. (2014). Individualised exercise improves endothelial function in patients with rheumatoid arthritis. Ann Rheum Dis, 73(4): 748–51.

213. Law RJ, Markland DA, Jones JG, et al. Perceptions of issues relating to exercise and joint health in rheumatoid arthritis: a UK-based questionnaire study. Musculoskeletal Care. 2012;11(3):147–158. doi: 10.1002/msc.1037.

214. Henchoz Y, Zufferey P, So A. Stages of change, barriers, benefits, and preferences for exercise in RA patients: a cross-sectional study. Scand J Rheumatol. 2013;42(2):136–145. doi: 10.3109/03009742.2012.724707.

215. Tierney M, Fraser A, Kennedy N. Physical activity in rheumatoid arthritis: a systematic review. J Phys Act Health. 2012;9(7):1036–1048.

216. Sokka T, Hakkinen A, Kautiainen H, et al. Physical inactivity in patients with rheumatoid arthritis: data from twenty-one countries in a cross-sectional, international study. Arthritis Rheum. 2008;59(1):42–50. doi: 10.1002/art.23255.

217. Nelson A.E., Allen K.D., Golightly Y.M. A systematic review of recommendations and guidelines for the management of osteoarthritis: the chronic osteoarthritis management initiative of the U.S. bone and joint initiative. Semin Arthritis Rheum. 2014;43:701–712.

218. Kolasinski S.L., Neogi T., Hochberg M.C., et al. 2019 American college of rheumatology/arthritis foundation guideline for the management of osteoarthritis of the hand, hip, and knee. Arthritis Care Res. 2020;72:149–162. doi: 10.1002/acr.24131.

How to cite this article: Agarwal S.K,, MD, **Exer-cise and Non-Communicable Diseases: Part II Cancer, Diabetes Mellitus, Kidney Diseases, Alzheimer's Disease, Arthritis**. Clinical Medicine Insights. 2021;124−143. https://doi.or g /10.52845/CMI/2021-2-2-5