Review Article Pol J Public Health, Vol. 134 (2024): 42-46

KAROLINA MAKOWSKA[1], MARTA BILLEWICZ[2], LAURA LIS[3], ALEKSANDRA MARCZYK[1], SEBASTIAN PERWEJNIS[4], JULIA PIETRZYKOWSKA[3], ADAM POPIOŁEK[3], ALEKSANDRA TUREK[5], OKSANA ZATORSKA[1]

The influence of aquatic activity on osteoarthritis

Abstract

Introduction. In 2020, osteoarthritis (OA) affected up to 595 million people in the world, which is 7% of the population. Three quarters of them are over 55 years old and 60% are women. The pathophysiological basis of degenerative disease is a disturbance in the balance between the processes of formation and degradation of articular cartilage. Additionally, degeneration processes affect other elements of the musculoskeletal system, such as the synovial capsule, ligaments and muscles around the joint. Due to the severe pain, degenerative disease leads to a significant reduction in the quality of life and limited mobility. In the final stage it leads to disability. Arthritis most often involves the knee, hip joints, arms as well as vertebral column. To slow down the degenerative processes and minimize the complications of the disease, effective preventive methods should be implemented as soon as possible. Especially since there is currently no effective drug available for this disease. A popular method of combating pain is aquatic activity. The physical properties of water have a positive effect on the musculoskeletal and nervous systems. This review article assessed the effectiveness of aquatherapy depending on risk factors and the stage of osteoarthritis.

Aim. Review and presentation of the current state of knowledge about water exercises on the course of osteoporosis, taking into account groups at risk of degenerative disease.

Material and methods. Analysis of the studies available on open access sources at PubMed, Google Scholar, National Library of Medicine and Coachrane. The research was conducted through word analysis key words such as: "arthritis", „aquatic activity", „osteoarthritis". Selection criteria for articles included consideration of their title, abstract, and publication date, with a focus on English-language publications.

Conclusion and results. This article demonstrates the positive impact of water exercises on the course of osteoporosis, as well as their preventive effect. The relationship between hydrotherapy and OA in individual risk groups was presented. Aquatic activity has been shown to be effective in inhibiting degenerative processes, reducing joint stiffness, improving walking distance, and mental condition.

Keywords: osteoarthritis, aquatic activity, arthritis, WOMAC, degenerative disease, DALY.

DOI: 10.12923/2083-4829/2024-0010

INTRODUCTION

In 2020, osteoarthritis (OA) affected up to 595 million people in the world, which is 7% of the population [1]. Three quarters of them are over 55 years old and 60% are women [2]. The pathophysiological basis of degenerative disease is a disturbance in the balance between the processes of formation and degradation of articular cartilage. Additionally, degeneration processes affect other elements of the musculoskeletal system, such as the synovial capsule, ligaments and muscles around the joint [3]. Arthritis most often involves the knee, hip joints, arms as well as vertebral column. When at least three joints are affected in the above locations, it is called a generalized process. The disease manifests itself with the so-called „starting pain" - the greatest intensity of pain occurs when starting to move after resting [4]. Joint mobility is also limited, and as the disease progresses, the surrounding muscles atrophy. Due to the severe pain, degenerative disease leads to a significant reduction in the quality of life and limited mobility. In the final stage it leads to disability. According to the Global Burden of Disease Study 2019, the worldwide DALY rate for osteoarthritis increased by 114.48% from 1990 to 2019, with an age-standardized DALY increase of 3.3% [5]. Moreover, OA has a significant impact on the market economy [6]. This includes both direct costs related to diagnosis, treatment, pharmacotherapy, physiotherapy, and indirect costs, i.e. all financial losses and loss of productivity. In 2019, it was calculated that the average annual cost of OA treatment worldwide was $700-$15,600 per patient [7]. The 2017 Healthcare Cost and Utilization Project (HCUP) statistical study examined

[1] St. John Paul II Municipal Hospital in Elblag, Poland
[2] District Health Center in Brzeziny, Poland
[3] Medical University of Lodz, Poland
[4] Department of Pulmonary Diseases, St. John Paul II Municipal Hospital in Elblag, Poland
[5] The District Medical Centre in Grójec, Poland

hospitalization costs in the United States using the National Inpatient Sample (NIS). OA took 2nd place in this ranking with an average cost of $19.907 million incurred by the treatment unit [8]. Given the age structure of the population, cases of osteoarthritis will become more and more common. To slow down the degenerative processes and minimize the complications of the disease, effective preventive methods should be implemented as soon as possible. Especially since there is currently no effective drug available for this disease. A popular method of combating pain is aquatic activity. The literature describes the impact of hydrotherapy on the treatment of osteoarthritis, taking into account risk factors, progression of the disease and the intensity of physical exercise.

MATERIAL AND METHODS

Analysis of the studies available on open access sources at PubMed, Google Scholar, National Library of Medicine and Coachrane. The research was conducted through word analysis key words such as: “arthritis”, „aquatic activity”, „osteoarthritis”. Selection criteria for articles included consideration of their title, abstract, and publication date, with a focus on English-language publications.

State of knowledge

Physiologically, the bone and joint elements are equipped with elements that absorb mechanical forces and minimize friction. The subchondral layer (made of type I collagen) together with the articular cartilage (made of type II collagen and proteoglycans, mainly aggrecan) create a stable joint surface, and the top layer of cartilage additionally playing a role in regulating water content [9]. Therefore, its damage may lead to reduced hydration. In addition, the joint apparatus consists of menisci (made of water-binding proteoglycans and collagen) and the synovial membrane. This membrane is composed of macrophages and fibroblasts producing synovial fluid rich in hyaluronic acid and proteoglycan 4.

The pathophysiological mechanisms of osteoarthritis are complex and involve interactions between immunological, genetic and cellular factors [10]. As a result, the balance between chondroblast and chondroclast activity is disturbed. Dominant catabolic processes lead to the release of damage-associated molecular patterns (DAMPs) binding to pattern recognition receptors (PRRs). This triggers a cascade of responses from the innate immune system. Macrophages secrete inflammatory cytokines, and in response to this signal, chondrocytes produce degradative enzymes such as thrombospondin-like motifs (ADAMT) and metalloproteinases (MMPs) [11]. Interactions of MMPs with the ECM lead to the production of extracellular DAMPs from ECM components, which maintains the “vicious circle” of the inflammatory reaction between cartilage and the synovium. Subsequently, chondrocytes undergo apoptosis and the trabeculae forming the subchondral bone become thinner due to increased bone turnover. Remodeling leads to the formation of osteophytes and exposure of nerve endings, which, together with synovitis, causes pain [12]. This process is ongoing and the changes made are irreversible. The literature describes a positive effect on slowing down the progression of degeneration through aquatic activity.

Hydrotherapy is a broad term that primarily covers exercises in warm water. The physical properties of water have a positive effect on the musculoskeletal and nervous systems [13]. Buoyancy reduces the load on the joints, pressure and turbulent forces affect thermal receptors and mechanoreceptors, which block nociception and reduce pain [14]. The heat of the water promotes muscle relaxation, improves microcirculation, which reduces swelling and disperses allogeneic substances. These activities lead to reduction of pain, improvement of mobility and well-being [15].

Many studies have been described in the literature confirming the effectiveness of hydrotherapy in relieving pain. The Cochrane database contains the results of randomized control trials on the effect of aquatic activity on osteoarthritis of the knee and hip, mostly mild and moderately advanced [16]. Thirteen studies conducted until 2013 were included, involving 1,190 patients with degenerative disease lasting an average of 6.7 years. The study included patients aged from 62 to 74 years (average 68 years) with a body mass index (BMI) ranging from 26.6 to 33 (average 29.4). When it comes to 75% of the participants, they were women. Water exercises lasted 6-20 weeks (mean 12 weeks, and mean adherence rate was 87% (standard deviation (SD) 5.4%).

The so-called “favorable outcome measures” recommended by OMERACT III were assessed: pain, disability, quality of life, x-rays, and serious adverse events from all included studies. Methodological domains were assessed in accordance with the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions. The effects of the exercises were measured immediately after the intervention and at follow-up. Analysis of the results showed that water exercises have a small but clinically significant effect on reducing pain, improving quality of life and disability. Compared to the control group, the research group showed 5 points less pain and disability, as well as 7 points higher quality of life. Importantly, any side effects after hydrotherapy are minor and irrelevant to treatment compliance. Despite the positive short-term effects, there are still too few randomized studies on the long-term effect of aquatic exercises on the degenerative process. Further research on this topic is necessary.

A cross-sectional study, called the osteoarthritis initiative (OAI), examined the preventive effect of leisure swimming on the development of radiographic (ROA) and symptomatic knee osteoarthritis (SOA) [17]. The study was conducted in 2004-2006 and included 4,796 participants aged 45-79. Participants were divided into 3 groups: (1) those who had no evidence of or symptoms of knee OA, (2) those who had risk factors for SOA but did not meet criteria for recognition in either knee, (3) and those, who had SOA in at least one knee [18]. They were asked to complete questionnaires taking into account their past physical activity. The questionnaires included 4 age groups (12-18, 19-34, 35-49 and ≥50 years). Among 37 different sports, respondents had to select the discipline they performed at least 10 times in their lives for at least 20 minutes on a given day. If swimming was one of the 3 most common activities in a given age group, participants were defined as “swimmers”. Logistic regression was then performed. Any swimming history and swimming history in specific age groups were taken into account. It turned out that swimming at any time in the past was associated with a reduced risk of knee pain 37.2% (34.3-40.1%) compared to the control group 41.2% (38.8-43.6%). Moreover, the risk of ROA was also reduced from 60.3% (57.8-62.7%) in the control group to 54.4% (51.4-57.4%) for people who had ever swum. A statistically significant difference was found in the age group 19-34.

Regarding SOA, dose-response analyzes were significant but unfortunately not statistically significant. To investigate the effect of swimming on the development of OA in older age groups, further prospective studies are necessary. However, this study confirms that swimming, especially if undertaken before the age of 35, is beneficial for the condition of the knee joint.

In order to slow down the progression of degenerative disease, strengthening the muscles surrounding the joint, especially the hip and knee, plays an important role. The influence of water activity on muscle functionality in patients with OA was examined [19] . The meta-analysis included 170 RCTs. In the work reported by Wyatt et al. (2001), Silva et al. (2007), Wang et al. (2007; 2011), Wallis et al. (2014), Bressel et al. (2014) and Fisken et al. (2015) it was showed that water activity lasting 45-60 minutes undertaken 2-3 times a week for a minimum of 6 weeks significantly improves walking speed and the distance that can be covered. Unfortunately, due to methodological differences, it is difficult to establish a universal exercise program, so it is important to estimate the individual exercise intensity and safe load.

Interesting results were obtained when examining the influence of swimming on catabolic processes contributing to the pathogenesis of knee OA [20]. A team of researchers linked the destruction of chondrocytes to the progression of degenerative disease. The aim of the study was to understand the mechanisms responsible for chondrocyte apoptosis and to develop activities that could inhibit this process. In an experimental study in 40 mice C57BL/6 (12 weeks old), the phosphoinositide 3-kinase (PI3K)/AKT signaling pathway was investigated. Anterior cruciate ligament transection (ACLT) surgery in the right leg of mice was considered as a model for moderate OA, and the surgical protocol was described in previous studies [21,22]. Among the mice, a blind group (n=8), an ACLT group (n=16), and a sham group (n=16) were randomly selected, in which the ligament was not completely torn, but only with a 1.5 cm long incision. At 2 weeks after surgery, mice from the sham and ACLT groups were divided into those that swam and those that did not participate in swimming. The water exercise program included an adaptation phase that started with 15 minutes and lasted 60 minutes on the last day. The aim of this phase was to reduce water stress so that it did not affect the outcome of the training phase. The rest of the program lasted 5 weeks, and each mouse exercised 5 days a week for 60 minutes. After completing the exercise program, knee tissues were collected and then subjected to numerous tests. Histopathological analysis by hematoxylin-eosin (HE) and safranin-O (SO) staining was performed using the OARSI score. It has been shown that swimming reduces the development of osteoarthritis in the ACLT group. To assess ECM synthesis and chondrocyte degradation, anti-ADAMTS5 and anti-COL-II expression was examined by using immunochemistry. In the ACLT + swimming group, the expression of CoI-II increased significantly, in contrast to the ACLT group where the expression even decreased. This proves the therapeutic role of swimming, which stimulates the synthesis and delays the degradation of ECM. This is extremely important because chondrocyte apoptosis and ECM degradation are the key stages leading to this degradation [23]. To check the relationship between swimming and chondrocyte apoptosis, terminal deoxynucleotidyl transferase dUTP staining, nick end labeling (TUNNEL) was performed. The apoptosis rate was higher in the ACLT group (35.53%±3.87%) compared to the blank and sham groups, while a significant decrease was noted in the ACLT + swim group (22.62%±3.30%, $p<0.01$). The expression of Beclin-1 and LC3II/LC3I (autophagy markers) was examined using western blot. Autophagy is an important process regulating cell functioning, but when it is severe, it may lead to non-apoptotic cell death [24]. Scientists have termed the processes of autophagy and apoptosis as chondroptosis. In the ACLT + Swim group there was a significant decrease in the expression of these markers compared to blank, while in the ACLT group they were increased. An important stage of the study was to examine the effect of swimming on the PI3K/AKT pathway, which plays an important role in proliferation and cartilage growth [25]. In the ACLT + Swim group, increased phosphorylation was observed in relation to Blank and decreased in ACLT. Activation of this pathway inhibited the processes of chondroptosis. The above study showed that swimming slows down the osteoporotic processes of mouse knee joints and also inhibits the death processes of chondrocytes.

Activation of chondroptosis processes is associated with various risk factors, including obesity, female sex, elderly people, location (knee and hip joints), genetic predispositions, and injuries [26]. Although not all of these factors are modifiable, knowledge of them will allow us to target specific groups of patients with preventive measures.

A RCT investigated the effect of 12 weeks of aquatic exercise on cardiorespiratory fitness, knee isokinetic function, and Western Ontario and McMaster University (WOMAC) osteoarthritis index in women with knee osteoarthritis [27]. Among 17 women from Seul, a control group (n=8, age 61.25±1.91SD) was created, and a research group (n=9, age 60.89±5.06), who participated in a water exercise program lasting 1 hour, 3 times a week, for 12 months. Exercise intensities of 13-14 (lightly vigorous) using the RPE were used. The risk of metabolic syndrome was assessed based on BMI and laboratory tests from the patients' blood. The assessment of cardiorespiratory fitness was based on VO2max according to the modified Balke K protocol. Biodex System 3 measured the isokinetic function of the knee. In addition, patients were asked to complete questionnaires assessing functioning (WOMAC) [28]. The tests were performed before starting exercise and after a 12-month period of exercise. It turned out that in the research group there was a significant improvement in the isokinetic functions of the knee extensor muscles and joint stiffness, compared to the control group. The HbA 1c value also decreased in the study group. Moreover, another studies have been described in the literature confirming the positive impact of aquatic exercise on walking speed [29], psychomotor skills and well-being in perimenopausal women [30].

Another risk group are the elderly. An RCT investigated the role of aquatic exercise in the treatment of knee osteoarthritis in older adults [31] . The study included 32 men with knee osteoarthritis aged ≥60 years and of similar height and weight. They were divided into a control group (n=16) and a research group (n=16), which participated in water activity for 60 minutes three times a week for 8 weeks. Exercises took place in water at approximately 32°C, and the session included a 10-15-minute warm-up, 35 minutes of strength training, and 10 minutes of cool-down exercises. Pain (analog scale), range of motion (goniometry), static balance (60-second Romberg test) and dynamic balance, gait parameters (Casio FH20 camera) and clinical and radiological features of degenerative disease were taken into account. The tests were carried out before and 2 months after the exercises. It turned out that in the study group there was a significant improvement in pain from 74.1 (11.5) to 64.3 (19.0) (compared to the control group from 74.2 (24.1) to 74.1 (38.3)), as well as static and dynamic balance, step length. In this group of patients, additional mobilization plays an important role not only in alleviating the pain, but above all it contributes to maintaining physical and intellectual fitness for as long as possible and is a source of life satisfaction [32] .

A particularly vulnerable group of patients are obese people. Excessive body weight is associated with the overproduction of interleukins (IL) 1β, IL-6, tumor necrosis factor (TNF-α) and C-reactive protein by adipocytes [33] . This results in a generalized inflammatory process that promotes the initiation of degenerative processes. That is why weight reduction is so important in obese people. The research team developed a set of exercises for these patients [34]. The study included people with a BMI>25 kg/m(2), abdominal circumference greater than 90 cm (men) or 85 cm (women), and clinically diagnosed osteoarthritis on the Kellgren-Lawrence scale 2. or higher on radiographic examinations and independent walking status. They were divided into 3 groups: control group (n=24), aquatic exercise (AQE) (n=26) and land exercise (LBE) group (n=25). The exercises took place 3 times a week for 8 weeks. Before and after the exercises, fat tissue analysis, pain, WOMAC, the Short Form-36 [35]. questionnaire and the range of motion of the knee joint (isokinetic tests) were assessed. After the intervention, the body fat content in the AQE group decreased significantly, and disability and quality of life improved. Although pain improved in both AQE and LQE, it was significantly better in AQE.

Aquatic exercise plays an important role in recovery after surgery for OA. Of course, surgery in this disease is the final stage of treatment. The recovery process after implantation of a total knee prosthesis (TKA) was examined [36]. The aim was to compare the effectiveness of hydrotherapy with land-based exercises on gait, pain, stiffness, joint balance, muscle strength and inflammation. The RCT included 98 patients after PTR for non-traumatic knee osteoarthritis. Patients aged >60 years were divided into a swimming group (n=49) and a conventional group exercising on land (n=49). In the first phase of the study, both groups were subjected to 15 LBE sessions lasting 60 minutes. In the second phase, the conventional group performed 15 exercise sessions on land and the AQE group in the pool. Patients were examined before the start of the study, after completion of phase 1 and after phase 2. After the first stage, improvement in gait (6-minute walk test) and functional capacity (WOMAC) was observed in both groups. At the end of phase two, differences between groups were significant, favoring AQE. After the first stage, improvement in gait (6-minute walk test) and functional capacity (WOMAC) was observed in both groups. After the end of the second phase, the differences between the groups were significant, with benefits for AQE – the average distance covered in the AQE group was 41.5 m greater, reduction in stiffness, improvement in joint balance in the bend of the operated knee and in the strength of flexor muscles. Although the study has some limitations, such as the lack of blinding of the intervention, it was conducted in accordance with the Consort Guide [37] and is an innovation of existing therapeutic methods.

CONCLUSIONS

Numerous RCTs confirm the thesis that aquatic activity is an effective form of therapy in alleviating pain, stiffness, and physical disability. It improves gait, increases distance covered and enhances muscle strength. If undertaken before the age of 35, it may even play a preventive role against OA. Hydrotherapy is also an effective form of recovery after orthopedic procedures. Despite the many benefits that hydrotherapy brings, further, more detailed research is necessary on the impact of aquatic activity on degenerative processes. The exact mechanisms contributing to the benefits of this form of therapy are still unknown.

Abbreviations: OA – osteoarthritis; DALY – disability adjusted life-years; DAMPs – damage-associated molecular patterns; PRRs – pattern recognition receptors; ADAMT – thrombospondin-like motifs; MMPs – metalloproteinases; ECM – extracellular matrix; RCT – Randomized controlled trial; BMI – body mass index; SD – standard deviation; OAI – osteoarthritis initiative, AQE – aquatic exercise; LBE – land exercise

REFERENCE

1. Steinmetz JD, Culbreth GT, Haile LM, et al. Global, regional, and national burden of osteoarthritis, 1990-2020 and projections to 2050: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet Rheumatology. 2023;(9):e508-e522.
2. VizHubGBD Results Institute for health metrics and evaluation. [https://vizhub.healthdata.org/gbd-results/] (access: 5.06.2024)
3. Bliddal H. Definition, pathology and pathogenesis of osteoarthritis. Ugeskrift for Laeger. 2020;182(42).
4. Zimmermann-Górska I, Goncerz GG, Szczepański LS. Choroba zwyrodnieniowa stawów. [https://www.mp.pl/interna/chapter/B16.II.16.13] (access: 5.06.2024).
5. Ding Y, Liu X, Chen C, et al. Global, regional, and national trends in osteoarthritis disability-adjusted life years (DALYs) from 1990 to 2019: a comprehensive analysis of the global burden of disease study. Public Health. 2024:261-72.
6. Leifer VP, Katz JN, Losina E. The burden of OA-health services and economics. Osteoarthritis Cartilage 2022;(1):10-16.
7. Vos T. Global Burden of Disease Collaborative Network. Global burden of disease study 2019 (GBD 2019) results. The Lancet. 2019;396(10258):1204-22.
8. Liang L, Moore B, Soni A. National inpatient hospital costs: The most expensive conditions by payer, 2017. HCUP Statistical Brief #261. Agency for Healthcare Research and Quality, Rockville; 2020.
9. Kuyinu EL, Narayanan G, Nair LS, Laurencin CT. Animal models of osteoarthritis: classification, update, and measurement of outcomes. J Orthop Surg Res. 2016;11:19.
10. Restuccia R, Ruggieri D, Magaudda L, Talotta R. The preventive and therapeutic role of physical activity in knee osteoarthritis. Reumatismo. 2022;(1).
11. Szponder T, Latalski M, Danielewicz A, et al. Osteoarthritis: Pathogenesis, animal models, and new regenerative therapies. J Clin Med. 2023;12(1):5.
12. Vincent TL, Alliston T, Kapoor M, et al. Osteoarthritis Pathophysiology. Clin Geriatr Med. 2022;(2):193-219.
13. Hall J, Swinkels A, Briddon J, et al. Does aquatic exercise relieve pain in adults with neurologic or musculoskeletal disease? A systematic review and meta-analysis of randomized controlled trials. Arch Phys M. 2008;(5):873-83.
14. Kamioka H, Tsutani K, Okuizumi H, et al. Effectiveness of aquatic exercise and balneotherapy: A summary of systematic reviews based on randomized controlled trials of water immersion therapies. J Epidemiol. 2010;(1):2-12.
15. Bender T, Karagulle Z, Balint GP, et al. Hydrotherapy, balneotherapy, and spa treatment in pain management. Rheumatol Int. 2004;(3):220-4.
16. Bartels EM, Juhl CB, Christensen R, et al. Aquatic exercise for the treatment of knee and hip osteoarthritis. CDSR. 2016;(3).

17. Lo GH, Ikpeama UE, Driban JB, et al. Evidence that Swimming May Be Protective of Knee Osteoarthritis: Data from the Osteoarthritis Initiative. PM R 2019;(6):529-537.
18. Nevitt MC, Felson DT, Lester G. Osteoarthritis Initiative (OAI) Study Protocol. NDA. [https://nda.nih.gov/oai/study-details] (access: 5.06.2024).
19. Mattos F de, Leite N, Pitta A, et al. Effects of aquatic exercise on muscle strength and functional performance of individuals with osteoarthritis: a systematic review. Rev Bras Reumatol Engl Ed. 2016;(6):530-42.
20. Qian J, Zhao P, Xu Q, et al. Swimming prevents cell death of chondrocytes via PI3K/AKT pathway in an experimental model. J Orthop Surg Res. 2023;(1).
21. Kamekura S, Hoshi K, Shimoaka T, et al. Osteoarthritis development in novel experimental mouse models induced by knee joint instability. Osteoarthritis Cartilage. 2005;(7):632-41.
22. Xu WM, Qian JJ, Han L. Effects of Wenjing Tongluo Decoction on cartilage morphological changes and expression of VEGF, MMP 13 and HIF-1 in mice with knee osteoarthritis. Chin Med. 2020; 37(6):6-12.
23. Almonte-Becerril M, Navarro-Garcia F, Gonzalez-Robles A, et al. Cell death of chondrocytes is a combination between apoptosis and autophagy during the pathogenesis of Osteoarthritis within an experimental model. Apoptosis. 2010;15:631-8.
24. Tong J, Yan X, Yu L. The late stage of autophagy: cellular events and molecular regulation. Protein Cell. 2010;(10):907-15.
25. Ulici V, Hoenselaar KD, Gillespie JR, et al. The PI3K pathway regulates endochondral bone growth through control of hypertrophic chondrocyte differentiation. BMC Dev Biol. 2008;(1).
26. Allen KD, Thoma LM, Golightly YM. Epidemiology of osteoarthritis. Osteoarthritis Cartilage. 2022;(2):184-95.
27. Ha G-C, Yoon J-R, Yoo C-G, et al. Effects of 12-week aquatic exercise on cardiorespiratory fitness, knee isokinetic function, and Western Ontario and McMaster University osteoarthritis index in patients with knee osteoarthritis women. J Exerc Rehabil. 2018;(5):870-6.
28. Bellamy N, Buchanan W, Goldsmith CH, et al. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15(12):1833-40.
29. Waller B, Munukka M, Rantalainen T, et al. Effects of high intensity resistance aquatic training on body composition and walking speed in women with mild knee osteoarthritis: a 4-month RCT with 12-month follow-up. Osteoarthritis Cartilage. 2017;(8):1238-46.
30. Kim J-H, Ha M-S, Ha S-M, Kim D-Y. Aquatic Exercise Positively Affects Physiological Frailty among Postmenopausal Women: A Randomized Controlled Clinical Trial. Healthcare. 2021;(4):409.
31. Azizi S, Dadarkhah A, Rezasoltani Z, et al. Randomized controlled trial of aquatic exercise for treatment of knee osteoarthritis in elderly people. Interv Med Appl Sci. 2020;(3):161-7.
32. Farinha C, Teixeira AM, Serrano J, et al. Impact of different aquatic exercise programs on body composition, functional fitness and cognitive function of non-institutionalized elderly adults: A randomized controlled trial. Int J Environ Res Public Health. 2021;(17):8963.
33. Compher C, Badellino KO. Obesity and Inflammation: Lessons From Bariatric Surgery. J Parenter Enteral. 2008;(6):645-7.
34. Lim J, Tchai E, Jang S. Effectiveness of aquatic exercise for obese patients with knee osteoarthritis: A randomized controlled trial. PMR. 2010;(8):723-31.
35. Jenkinson C, Coulter A, Wright L. Short form 36 (SF36) health survey questionnaire: normative data for adults of working age. BMJ. 1993;(6890):1437-40.
36. Alonso-Rodríguez, A, Sánchez-Herrero, H, Nunes-Hernández, S, et al. Efficacy of hydrotherapy versus gym treatment in primary total knee prosthesis due to osteoarthritis: a randomized controlled trial. Anales del Sistema Sanitario de Navarra. 2021;(2):225-41.
37. Butcher NJ, Monsour A, Mew EJ, et al. Guidelines for Reporting Outcomes in Trial Reports. JAMA. 2022;(22):2252.

Corresponding author
Karolina Makowska
St. John Paul II Municipal Hospital in Elbląg
35 Komeńskiego St., 82-300 Elbląg
e-mail: makowska.ka@gmail.com