НИРКИ KIDNEYS

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Analysis of the use of artificial intelligence systems for the development of physical exercise programs during rehabilitation of nephrology patients

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Abstract. ***Background.*** *Artificial intelligence (AI) is a direction of mathematical computer modeling based on the abstract essence of mathematical thinking. Chronic kidney disease (CKD) is a nosological unit, its final stage (end-stage renal disease) has seen an exponential increase over the past decade and is considered by the World Health Organization as a global problem by cause of death. The global healthcare industry is one of the main planes for practical application of modern developments in the field of AI thanks to machine learning algorithms that provide new opportunities for solving the most complex problems of medicine and pharmacy. The purpose was to analyze the possibility of using physical exercise complexes (PECs) created by AI system in patients with CKD undergoing renal replacement therapy and to compare PECs created by AI with the list of PECs used in clinical practice (systematic reviews and meta-analyses) for rehabilitation care in nephrology.* ***Materials and methods.*** *Scientometric analysis of professional literature from electronic databases PubMed, Embase, Scopus and Web of Science, Cochrane CENTRAL was conducted. According to the purpose of the study, the following methods were used: bibliosemantic, systematic approach, descriptive modeling using AI systems — Gemini and ChatGPT.* ***Results.*** *AI systems (Gemini and ChatGPT) proposed exercise programs for patients with CKD that take into account different stages of rehabilitation (respiratory, aerobic, strength, stretching and relaxation). At the time of the descriptive modeling, the database used by Gemini and ChatGPT is sufficient for their routine use in the development of exercise therapy complexes for the rehabilitation of nephrological patients with different nosologies.* **Conclusions.** *Artificial intelligence is a tool in the hands of a physician to provide medical care; the quality of this tool will depend on the qualifications of the physician who will teach (machine learning) AI to use their knowledge and competencies to optimize the process of creating rehabilitation complexes for patients with kidney disease from the standpoint of evidence-based medicine.*

Keywords: *physical exercises; chronic kidney disease; rehabilitation aid; artificial intelligence*

Introduction

Artificial intelligence (AI) is a field of mathematical computer modeling based on the abstract essence of mathematical thinking. The history of the formation and development of AI, a term officially coined in 1956 by John McCartney [1], is rather ambiguous, distinguishing between the forerunners of formation, the stage of inception, the stages of rapid development — boom and the stages of decline — "winters" [2–4].

Chronic kidney disease (CKD) is a nosological unit of kidney disease that has seen an exponential increase in patients with end-stage renal disease over the past decade

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and is considered by the World Health Organization to be a global problem by cause of death [5–7].

The global healthcare industry is one of the main "planes" of practical application of modern AI developments. At the initial stages of AI development, the focus was on the development of machine learning algorithms. Thanks to them, new opportunities were created to solve the most complex problems in medicine [8–14] and pharmacy [15, 16]. Recently, Chatbot's have been widely used in medicine to automate various types of tasks, from making an appointment with a doctor to receiving basic first aid recommendations and even psychological assistance. Currently, the most advanced AI Chatbot's are two competing neural networks — Gemini by Google and ChatGPT by OpenAI. They are capable of generating texts in various subject areas (including medical), translating, creating creative content, and answering user questions in an informative manner.

The purpose. To analyze the use of physical exercise complexes (PECs) created by the AI system for use in patients with CKD undergoing renal replacement therapy for rehabilitation care and to compare these PECs with the list of PECs used in clinical practice according to the scientometric search of research results (systematic reviews and meta-analyses) on rehabilitation care in nephrology practice.

Materials and methods

The study was performed within the framework of the scientific theme of the Department of Pediatrics, Neonatology and Perinatal Medicine of Bukovinian State Medical University on the subject "Chronobiological and adaptive aspects and peculiarities of vegetative regulation with pathological conditions in children of various age groups". The state registration No. 0122U002245, the deadline: 01.01.2022 — 31.12.2026. Scientometric analysis of professional literature of electronic databases PubMed, Embase, Scopus and Web of Science, Cochrane CENTRAL. According to the purpose of the study, the following methods were used: bibliosemantic, systematic approach, descriptive modeling using AI systems: Gemini and ChatGPT.

Results

These days, AI, through the use of mathematical methods to predict or classify various types of medical data, structured or unstructured, has made significant changes in a number of professional areas in the medical field [8–14], and nephrology is no exception [17, 18].

According to the objective, the study consisted of two stages. At the first stage of our study, we tasked two AI systems, Gemini and ChatGPT, with suggesting a set of exercises that would be best for patients with CKD on hemodialysis. Both programs emphasized the importance of consulting a doctor before starting exercises and having a physiotherapist monitor the exercises. The exercise sets suggested by the AI included aerobic exercises, strength exercises, and exercises.

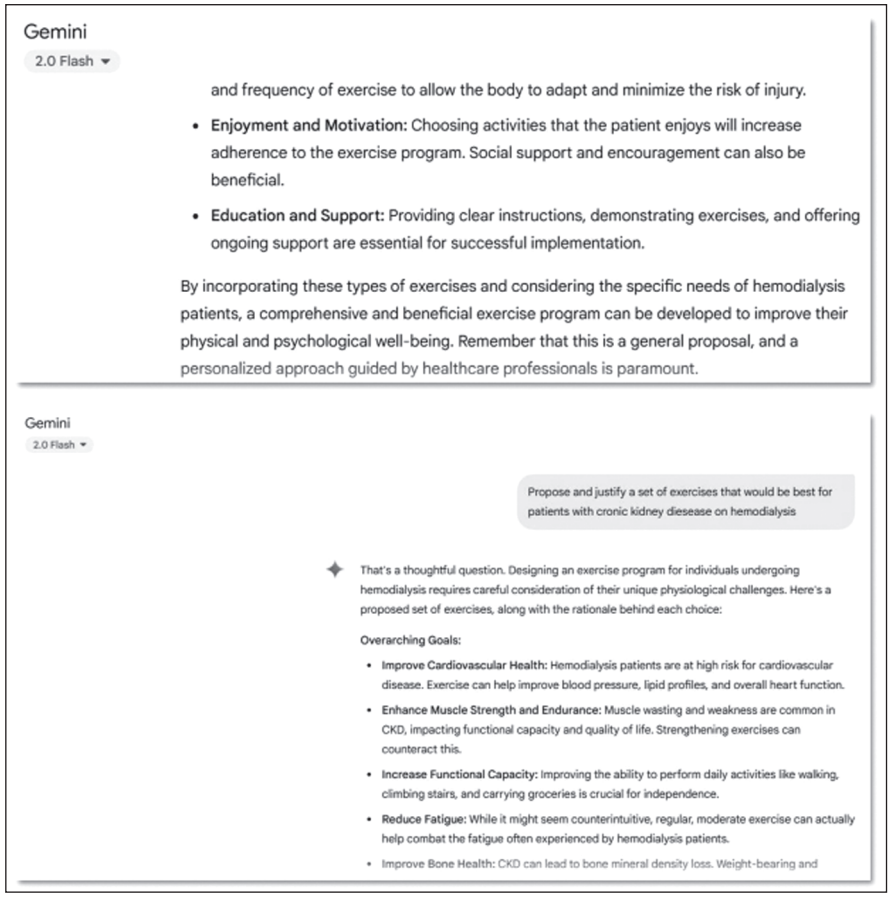

Figure 1. Gemini AI suggested the following exercises

Gemini AI suggested the following exercises (Fig. 1):

1. Aerobic exercises (walking, cycling, swimming) 20–30 minutes, 3–5 times a week to improve cardiovascular function, increase endurance, improve mood and sleep quality.

2. Strength exercises (chair lifting, arm bending with dumbbells or water bottles, leg extensions, exercises with an elastic band) 2–3 times a week to strengthen muscles, improve metabolism, and maintain bone density.

3. Flexibility exercises (stretching of neck, shoulder, back, and leg muscles) daily to improve joint mobility, reduce the risk of injury, and relieve muscle tension.

ChatGPT AI suggested the following set of exercises (Fig. 2, 3):

1. Breathing exercises (daily, 5–10 minutes) to improve blood oxygenation and reduce stress.

2. Warm-up (slow walking on the spot, circular movements of arms, shoulders, feet) 5–7 minutes.

3. Aerobic exercises (walking on the spot or on a treadmill, exercise bike, soft stepping) for 10–15 mi-

nutes to improve cardiovascular function.

4. Exercises for muscle strength (squatting to a chair, extending and bending the legs in a sitting position, lifting the arms with a small weight, elbow plank) for 10–15 minutes to prevent muscle atrophy.

5. Stretching and relaxation (stretching calf muscles, stretching back, relaxation) 5–10 minutes to improve flexibility, reduce the risk of muscle spasms and improve psycho-emotional state.

At the second stage of the study, during a systematic review and scientometric analysis of the professional literature of the electronic databases PubMed, Embase, Scopus, Web of Science, Cochrane CENTRAL, we selected and summarized the results of 3 meta-analyses, which included 131 scientific studies evaluating the effect of physical activity on the condition of patients with CKD on renal replacement therapy (5780 patients with CKD) [19, 20, 22].

The authors of meta-analyses have found that among the possible options for physical activity, aerobic and strength exercises, as well as their combinations, give the best results. To evaluate the

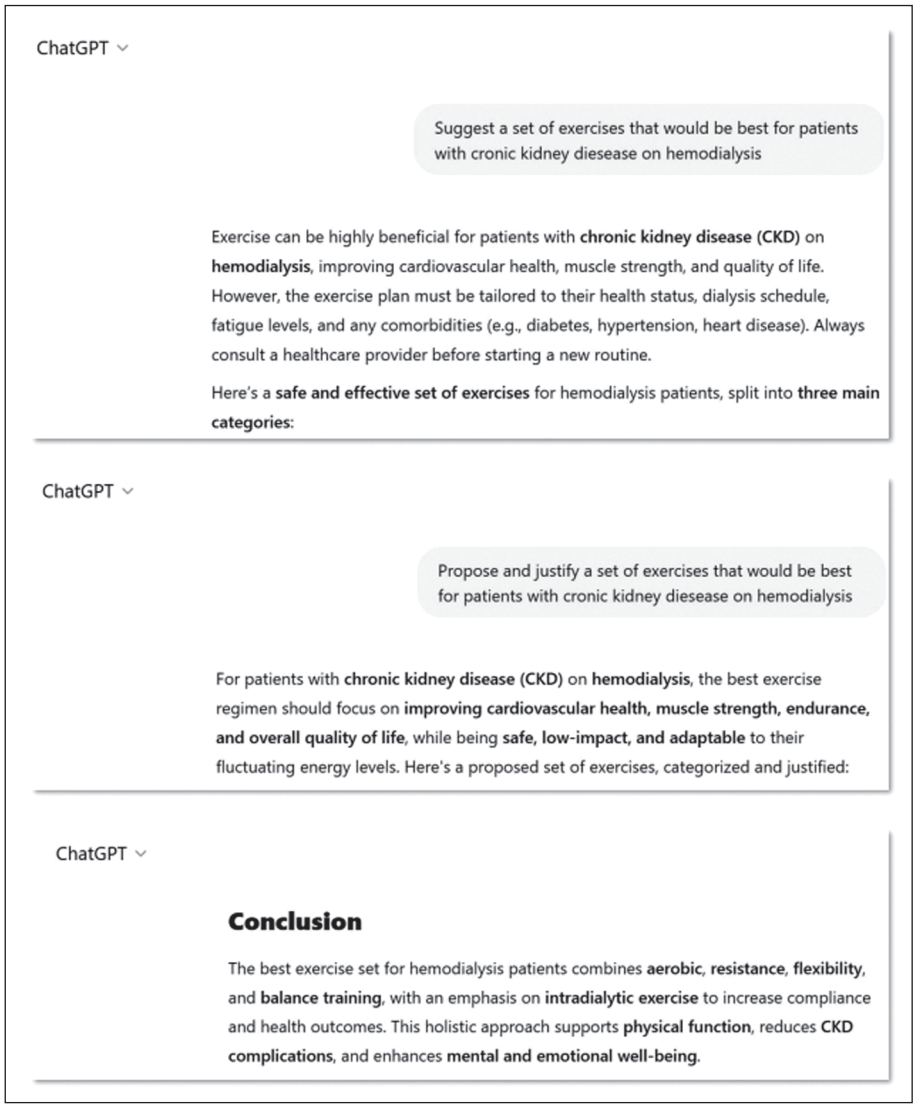

Figure 2. ChatGPT AI suggested the following set of exercises

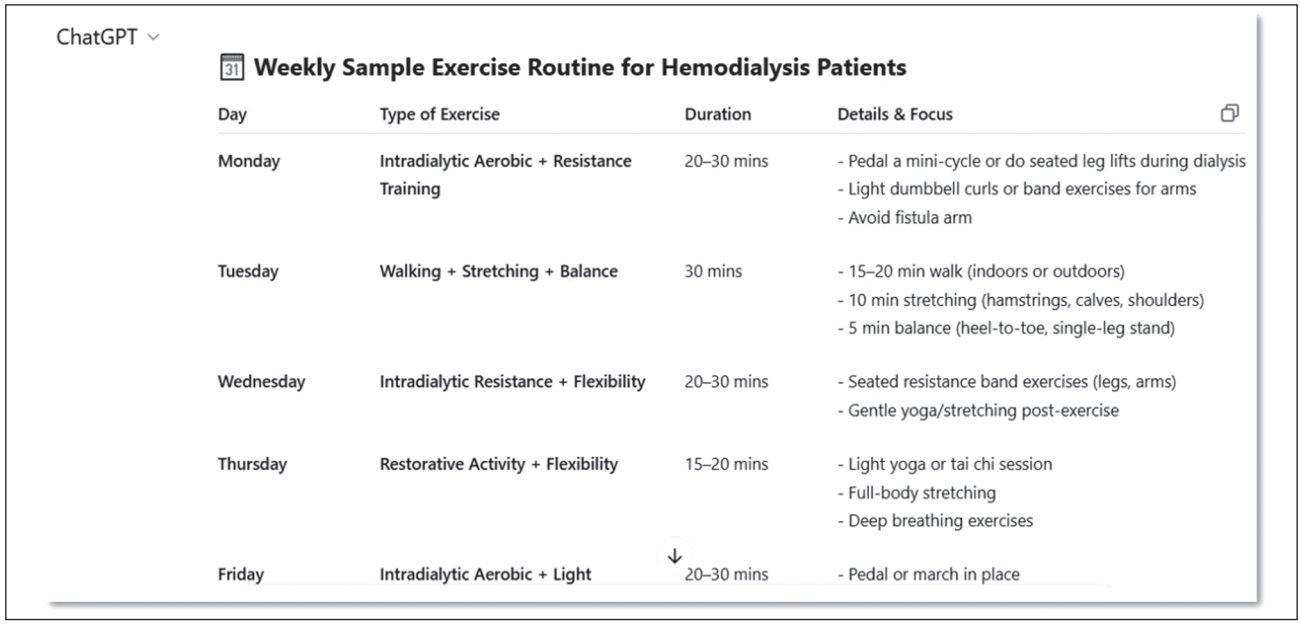

Figure 3. ChatGPT AI suggested the following set of exercises for patients with CKD on hemodialysis

results, the authors of scientific studies most often used the 6-minute walk test and quality of life, and it should be noted that physical activity did not show a significant improvement in quality of life in patients with CKD. In most studies, aerobic and strength training alone and together (both interdialytic and intradialytic) significantly improved the results of the 6-minute walk test [19, 20, 22].

Using Gemini AI, we summarized the physical exercises proposed by the authors of the articles included in the meta-analyses [19, 20, 22]. The exercises were used both individually and in combination. They differed in duration (from 10 minutes to an hour), frequency (from daily to 2–3 times a week), and intensity (which was regulated by the Borg scale or maximum heart rate and gradually increased).

A set of exercises for patients with CKD on hemodialysis:

1. Aerobic:

— cycling ergometry;

— walking;

— jogging;

— aerobic movements with range of motion: wrist rotation, ankle flexion and extension;

— exercises without resistance;

— pedaling. Strength exercises;

— exercises for the upper extremities: chest press, biceps curls, triceps extensions, dumbbell press, incline deadlift, overhead dumbbell press;

— exercises for the lower extremities: squats, knee extension and flexion, leg press, plantar flexion of the foot, hip abduction and adduction, hip flexion, lower leg raises, lower extremity raises;

— exercises for the core muscles: abdominal exercises, pelvic lifting;

— specialized exercises: exercises with an elastic ball;

— stretching: exercises to stretch the lower extremities.

2. Combined training:

— aerobic + strength. Aerobic exercises are represented by cycling, walking, step aerobics, circuit training. Strength exercises include exercises with weights, elastic bands, bodyweight exercises, dynamic exercises;

— aerobic + stretch/flexibility. Combine cycling ergometry with stretching and flexibility exercises;

— strength + stretching/flexibility. Combine strength exercises with stretching and flexibility exercises;

— aerobic + strength + stretching/flexibility + balance exercises. The most comprehensive combination that includes all the main components of physical fitness.

Summarizing the results of the second stage of our study, we can conclude that the set of physical activities proposed by AI corresponds to the physical exercises provided by the authors of meta-analyses that included 131 scientific studies assessing the effect of physical activity on the condition of patients with CKD undergoing renal replacement therapy [19, 20, 22].

Discussion

Both AI systems proposed PT complexes for CKD patients requiring renal replacement therapy that take into account different stages of rehabilitation (respiratory, aerobic, strength, stretching, and relaxation). Thus, the knowledge base inherent in Gemini AI and ChatGPT AI is sufficient to be used in the development of physical activity programs for the rehabilitation of patients with different diagnoses [17, 18, 23–29].

Currently, the issue of the legal framework for the use of artificial intelligence in medical practice remains unresolved in Ukrainian legislation, while there is hope that this issue will be resolved with the availability of international experience and recommendations [30, 31].

Prospects for further research. Clinical analysis of physical rehabilitation methods for patients with CKD created using AI.

Conclusions

Artificial intelligence is a tool in the hands of a doctor to provide medical care, the quality of this tool will also depend on the qualifications of the doctor who will teach (machine learning) AI to use the doctor's knowledge and competencies to optimize the process of creating complexes of exercise therapy for rehabilitation purposes for patients with kidney disease.

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Authors' contributions. V.V. Bezruk — conceptualization, methodology, validation, original draft preparation, review and editing, supervision, project administration; M. Ivanchuk — validation, formal analysis, data curation, original draft preparation, review and editing; D.D. Ivanov, P. Ivanchuk, I.S. Seman-Minko, O. Pervozvanska — resources; I.D. Shkrobanets — resources, original draft preparation. All authors have read and agreed to the published version of the manuscript.

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Аналіз використання систем штучного інтелекту для розробки програм фізичних вправ під час реабілітації нефрологічних пацієнтів

Резюме. Актуальність. Штучний інтелект (ШІ) — це напрям математичного комп'ютерного моделювання, що базується на абстрактній сутності математичного мислення. Хронічна хвороба нирок (ХХН) є нозологічною одиницею, кількість пацієнтів з термінальною стадією якої за останнє десятиріччя експоненційно зросла, тому Всесвітня організація охорони здоров'я визнає її глобальною проблемою за показником смертності. Світова індустрія охорони здоров'я є одним із основних напрямів практичного застосування сучасних розробок у сфері ШІ завдяки алгоритмам машинного навчання, які відкривають нові можливості для вирішення найскладніших завдань медицини та фармації. **Мета:** проаналізувати можливість використання комплексів фізичних вправ (КФВ), створених системами ШІ, у пацієнтів із ХХН, які проходять замісну ниркову терапію, та порівняти КФВ, запропоновані ШІ, зі списком КФВ, що застосовуються в клінічній практиці (систематичні огляди та метааналізи) для реабілітаційної допомоги в нефрології. **Матеріали та методи.** Було проведено наукометричний аналіз професійної літератури з електронних баз даних PubMed, Embase, Scopus та Web of Science, Cochrane CENTRAL. Відповідно до мети дослідження використано такі методи: бібліосемантичний, системний підхід, описове моделювання з використанням систем ШІ — Gemini та ChatGPT. **Результати.** Системи ШІ (Gemini та ChatGPT) запропонували програми вправ для пацієнтів із ХХН, що враховують різні етапи реабілітації (дихальні, аеробні, силові, розтяжка та релаксація). На момент описового моделювання база даних, що використовується Gemini та ChatGPT, є достатньою для їхнього рутинного використання при розробці комплексів фізичних вправ для реабілітації нефрологічних пацієнтів із різними нозологіями. **Висновки.** Штучний інтелект є інструментом у руках лікаря для надання медичної допомоги; якість цього інструмента залежатиме від кваліфікації лікаря, який навчатиме (машинне навчання) ШІ використовувати свої знання та компетенції для оптимізації процесу створення реабілітаційних комплексів для пацієнтів із захворюваннями нирок з позиції доказової медицини.

Ключові слова: фізичні вправи; хронічна хвороба нирок; реабілітаційна допомога; штучний інтелект