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საერთაშორისო, რეცენზირებადი, რეფერირებადი
სამეცნიერო ჟურნალი

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მთავარი რედაქტორისაგან
From the Editor-in-Chief

ძვირფასო კოლეგებო!

შემოთავაზებული სამეცნიერო ნაშრომთა ჟურნალი განკუთვნილია მედიცინის, ეკონომიკის, მენეჯმენტის, ფიზიკური მედიცინისა და რეაბილიტაციის დარგის სპეციალისტებისათვის.

ჩვენ ვიმედოვნებთ, რომ ავტორთა მიერ წარმოდგენილი ნაშრომები ხელს შეუწყობს სამეცნიერო პოტენციალის გაძლიერებას.

მარინა ფირცხალავა
ბიოლოგიურ მეცნიერებათა დოქტორი,
პროფესორი, აკადემიკოსი,
უნივერსიტეტ გეომედის რექტორი

Dear colleagues!

The proposed scientific journal is intended for specialists in medicine, management, physical medicine and rehabilitation, economics.

We hope that the works presented by the authors will help to strengthen the scientific potential.

Marina Pirtskhalava
Doctor of Biological Sciences,
Professor, Academician,
Rector of University Geomedi

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Original Research Article

VR technologies in the medical education

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Abstract

With the widespread adoption of modern technology, particularly computer simulations, medicine is also actively using technologies that allow students to master essential skills quickly and easily. Simulating complications that do not occur every day and representing rare events is a crucial component for improvement of knowledge of medical students. To address these critical issues for the development of medical education, we conducted an analysis and comparison between the groups of students to understand whether new technology improves necessary skills.

Keywords: VR technology, medical education, simulation teaching.

Introduction

The use of modern methods allows future doctors to develop their skills throughout their medical education. The use of virtual learning methods and a well-equipped simulation center contributes to increased patient safety (since not all procedures can be performed on a patient, even with the consent), and reduces the burden on medical institutions from large groups of students who find it difficult to develop certain clinical skills through direct contact with the patient during the preclinical stage of training [1].

Modern medical education is focused on training professional personnel, while also ensuring tha t patient protection is taken into account. The growing num ber of medical students must not compromise patient safety. Some skills cannot be practiced on patients during undergraduate studies, requiring the creation of simulations using various methods [3] [4].

Virtual reality in education is an environment in which students are immersed in a multimedia 3D, simulated environment that looks like reality and let students to interact, learn teamwork, practice skills and collaboration skills, manipulate medical equipment, and make diagnostic decisions [1], [2], [5]. The VR Environment includes sensory stimulation

and is designed to prevent learners from perceiving real- world influences beyond the simulation.

Simulations can be broadly viewed as educational experiences that replicate real-world situations students will encounter in their practice [5]. Virtual patient is a type of VR that provides limited immersion, in which learners interact with a computer simulation of a patient situation [4]. Learners assume the role of a healthcare professional in the form of an avatar, such as a nurse or doctor, and make clinical decisions based on their assessment of the virtual patient. Trainees learn the role of the specialist they represent in terms of assessment, clinical diagnosis, treatment, and patient care, just as they would interact with a real patient [4]. A similar situation exists in the aviation industry, where it is impossible to demonstrate to students all the critical situations and tasks that need to be solved on board an aircraft. Just as in the aviation industry, a well-trained specialist is the foundation of preserving human lives, so in medicine, a well-trained physician is the foundation of safe and life-saving work in the professional field [1].

Patient safety is paramount in clinical education, and the long-standing "see-do-teach" teaching method is no longer considered acceptable by educators. Therefore, simulations play a key role in the ethically responsible education of physicians. This broad definition, encompassing the use of mannequins and various types of VR environments, distinguishes simulation environments by their ability to represent scenarios that medical students might not necessarily encounter during their practical training. This includes crisis situations, such as cardiac arrest and resuscitation—a core competency that requires maximum student engagement, which is difficult to achieve in a real-life situation for an undergraduate student [6].

Unlike videos or mannequins, virtual reality places students in a clinical situation. New technologies have been used for some time in medical education, either to train participants in specific medical procedures or to teach them how to use specific medical devices. It is very interesting to compare two main modern methods that improve skill acquisition [2]. These methods are: working with simulated dummies and working with VR technology. Virtual reality can provide trainees with the opportunity to immerse themselves in a designed, realistic, and, most importantly, safe environment where they can practice skills, interact and collaborate with peers or other specialists, make decisions regarding care and interventions, and manipulate equipment without fear of harming the patient [7]. VR simulations can be used in any area of clinical practice, but are particularly useful in settings with limited access to expertise, such as natural disasters or the perioperative period [3], [2].

Comparison of VR simulation with Mannequin-based simulation in medical education

VR simulation: Fully immersive digital environment, unlimited scenario variety

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(ED, ICU, disaster, home care, rare cases). Same scenario can be perfectly repeated for every student. Excellent for clinical reasoning, decision-making, sequence of actions, crisis management. Limited tactile (hands-on) feedback unless haptics is added. High initial setup cost, low long-term cost per student, minimal space required, scalable to large student groups. Psychological stress through immersion, less physical stress [4], [5]. Strong for leadership, communication, Interprofessional training, some loss of real human non-verbal cues [1]. Zero patient risk, safe environment to make serious mistakes. Ideal for novices. Automatic performance tracking: time to intervention, error rate, correct clinical pathways, objective scoring possible.

Mannequin simulation: Physical simulation lab, limited by mannequin capabilities and room setup, variability between sessions and instructors. Excellent for hands-on psychomotor skills, airway management, IV access, CPR depth and force, real instruments used. Feedback mainly instructor-based, subjective, varies by assessor, video review often required [4]. High realism stress (noise, crowding, physical presence). Real people in real space, better non-verbal communication and stress realism. High purchase cost, ongoing maintenance, dedicated simulation lab needed [2] [5]. Limited number of students at a time. Also safe, but limited number of attempts, equipment wears and instructor supervision required.

VR wins for objective assessment, for standardization and scenario diversity, for scalability and long-term efficiency, due to unlimited practice. Mannequin wins for stress fidelity, for human interaction realism, for tactile and procedural realism. (Table 1).

Table 1. Comparison of VR simulation with Mannequin-based simulation in medical education

Aspect	*VR Simulacion*	*Mannequim Simulation*
Environment	Virtual, immersive	Physical, lab-based
Repetition	Unlimited	Limited
Hands-on skills	Limited	Excellent
Decision-making	Excellent	Good
Feedback	Automated, objective	Instructor-based
Cost efficiency	High (long-term)	Lower scalability
Rare scenarios	Excellent	Limited
Team interaction	Good	Excellent
Maintenance	Low	High

Material and methods

To address these critical issues for the development of medical education, we conducted an analysis and comparison between two groups of students. Each group included two groups of 20 students, for a total of 40 students.

Our study utilized reinforcement of two

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skills: arterial catheterization and venous catheterization, both with blood sampling for subsequent analysis to diagnose pathological conditions.

The study included third-year university students who completed pathology modules along with skills learned in parallel with the study of pathological processes. In one case, training was conducted using dummies in a simulation center; in the second case, training was conducted first on dummies and then reinforcement of acquired knowledge using immersion VR technology.

Assessment in both groups was conducted using the OSCE exam, which allowed for the assessment of acquired knowledge. An Objective Structured Clinical Examination (OSCE) is a performance-based assessment used in healthcare education to evaluate clinical competence, including skills, communication, and decision-making. Candidates rotate through timed, standardized stations, interacting with simulated patients or mannequins while being rated by examiners using objective checklists.

Students were randomly selected from their third year of study, having already completed the norms and pathology modules, as well as the clinical skills included in these modules. This meant they had also completed training in venipuncture and arterial puncture with blood sampling. The selected students were then divided into two groups. One group of students was required to perform venipuncture with blood sampling for a complete blood count, while the other was required to collect blood for blood gas analysis.

The OSCE checklist was used for the assessment, and 10 competencies were assessed at each assessment station. (Table 2, Table 3). As we've observed, both groups achieved good results, with high grades, but the group using new technologies showed better results, indicating the university is taking the right path to improve student training.

An independent samples t-test demonstrated significantly higher OSCE scores in the moulage + VR group compared to the moulage-only group, $p < 0.001$.

Table 2. OSCE checklist for evaluating groups trained in Venous catheterization

N	Competencies	Blood Sample Collection (Venipuncture) using moulages	Blood Sample Collection (Venipuncture) using moulages +VR technology
1.	Performs hand hygiene, putting on gloves, introduces self and confirms patient identity	20	20
2.	Explaining the stages of the manipulation to the patient, Obtaining the patient's consent to the manipulation	20	20
3.	Applies tourniquet correctly	19	20

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4.	Selects appropriate vein	18	20
5.	Clean the insertion site with an antiseptic solution (chlorhexidine or alcohol-based)	17	20
6.	Selects correct catheter size	19	19
7.	Flushes catheter and tubing, removes air	17	20
8.	Venipuncture, Insertion of a peripheral venous catheter	17	20
9.	Collect blood	18	19
10.	Removes needle safely	18	18
11.	Expels air bubbles from syringe	17	19
12.	Releases tourniquet at correct time	17	19
13.	Caps syringe correctly	16	20
14.	Common complications of Venous sampling Hematoma, thrombosis, infection, pain (student must pronounce	18	18
	Total score:	**252**	**270**

Table 3. OSCE checklist for evaluating groups trained in Arterial catheterization

N	**Competencies**	**Blood Sample Collection Arterial for ABG using moulages**	**Blood Sample Collection (Venipuncture) using moulages +VR technology**
1.	Performs hand hygiene, putting on gloves, introduces self and confirms patient identity	20	20
2.	Explaining the stages of the manipulation to the patient, Obtaining the patient's consent to the manipulation	19	19
3.	Applies tourniquet correctly	19	20
4.	Selects appropriate vein	18	20
5.	Clean the insertion site with an antiseptic solution (chlorhexidine or alcohol-based)	17	20
6.	Selects correct catheter size	19	19
7.	Flushes catheter and tubing, removes air	17	20
8.	Venipuncture, Insertion of a peripheral venous catheter	18	20
9.	Collect blood	18	20
10.	Removes needle safely	18	18
11.	Expels air bubbles from syringe	19	19
12.	Releases tourniquet at correct time	17	19
13.	Caps syringe correctly	18	20
14.	Common complications of Venous sampling Hematoma, thrombosis, infection, pain (student must pronounce	18	18
	Total score:	**255**	**269**

The tables show that in most cases, students in the VR group scored the maximum 2

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percent, which is 100%. This result was partly achieved with the help of a virtual simulator, which does notallow students to move on to the next step without completing the previous one. As we can see, this proved to be very effective at these stages of medical education. We observed that students achieved good results in both groups, with high grades. New technologies allow for the development of even complex skills, such as arterial catheterization and blood sampling for ABG. Figure 1.

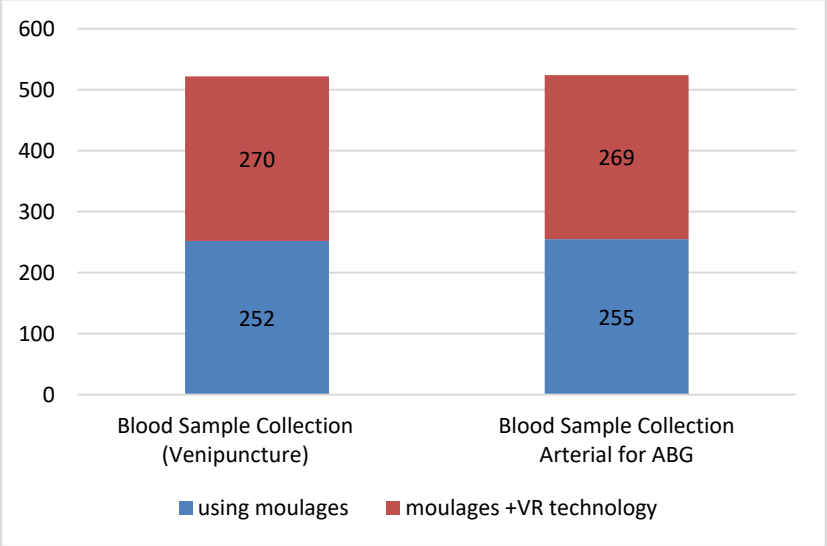

Figure 1: OSCE checklist for evaluating groups trained in Arterial catheterization and venipuncture

VR technologies not only enable student learning but also enable instructors to develop assessment capabilities at various stages of learning. Compared to the OSCE, VR technologies can be integrated into a more complex stage of performance assessment, the stage when instructors demonstrate their skills as part of a complex, integrated scenario. Figure 2.

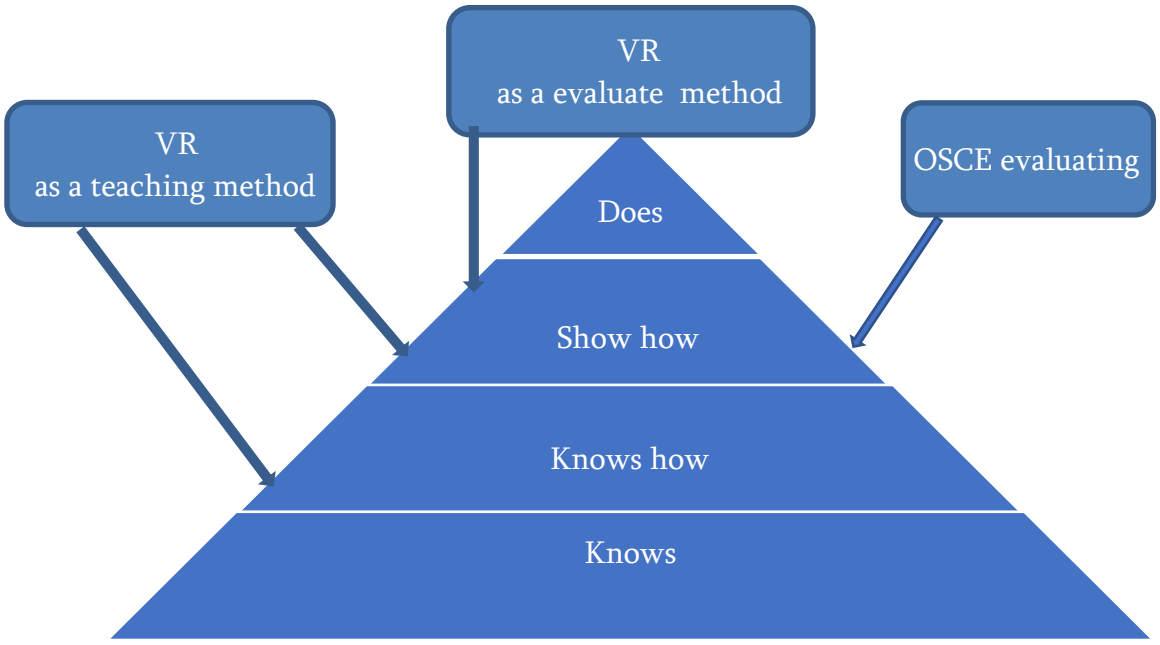

Figure 2: VR technologies

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Analyzing the obtained data, we can conclude that the use of new technologies is justified and produces results that are extremely important for the training of experienced, well-trained and erudite specialists in medicine.

Conclusions

The obtained results, although they allow for drawing conclusions, require further extensive research to determine the feasibility of new teaching methods, and also require the involvement of a larger number of students at both the undergraduate and residency levels and the creation of more complex scenarios for evaluation.

Although VR is a powerful technological tool in medical education, its impact on self-awareness and how digital experiences can influence our choices and moral and ethical

Rights remains unclear and a subject of debate.

With advances in technology, including augmented reality and haptic feedback, which create realistic sensations of touch and manipulation of equipment in virtual procedures, these technologies are the future of medical education and are likely to remain so for a long time.

Future research is definitely needed to evaluate the development of these skills across educational stages, in other courses, and in the integration of other skills in other subjects, such as emergency medicine, critical care. The role of new technologies is being thoroughly investigated, and whether they lead to student overload and burnout. It's also important to evaluate the time spent on immersive technologies, and determine whether VR technology increases or decreases learning time.

Acknowledgement

Our university offers students the most modern educational opportunities, from modern literature and 3D anatomical systems to models and immersive VR technologies. Students graduating University “Geomedi” are successfully passing challenging international exams and advancing to the next level of education. Thousands of them have already completed their educational journeys and are successfully fighting for the lives and well-being of patients. Some of them are even teachers themselves, teaching at top universities around the world.

This article is dedicated to Mr. Tamaz, Vice Rector for Organizational Affairs. This represents his enormous contribution to the development of modern teaching methods at our university, starting with one of the largest simulation centers in the Caucasian region for using cutting-edge VR technologies.

VR ტექნოლოგიები სამედიცინო განათლებაში

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აბსტრაქტი

თანამედროვე ტექნოლოგიების, განსაკუთრებით კომპიუტერული სიმულაციების ფართოდ გავრცელებასთან ერთად, მედიცინა აქტიურად იყენებს ტექნოლოგიებს, რომლებიც სტუდენტებისათვის საშუალებაა სწრაფად და მარტივად დაეუფლონ აუცილებელ უნარებს. მედიცინის განვითარებისათვის და გართულებების შემცირების მიზნით, სიმულაცია, ისეთი გართულებების მოდელირება, რომლებიც ყოველდღიურად არ ხდება და იშვიათ შემთხვევებს წარმოადგენენ, უმნიშვნელოვანესი კომპონენტია.

დასახული მიზნის მისაღწევად, ჩავატარეთ კვლევა, რათა გაგვერკვია, აუმჯობესებს თუ არა ახალი ტექნოლოგია სამედიცინო სტუდენტებში საჭირო უნარებს ინფორმაციის ასათვისებლად. მისი შედეგების ანალიზმა დაადასტურა კვლევის მიზანი.

საკვანძო სიტყვები: VR ტექნოლოგია, სამედიცინო განათლება, სიმულაციური სწავლება.

References

1. Chukwuka Elendu, Dependable C Amaechi, Alexander U Okatta, Emmanuel C Amaechi, Tochi C Elendu, Chiamaka P Ezeh, Ijeoma D Elendu, The impact of simulation-based training in medical education: A review, Medicine (Baltimore). 2024 Jul 5;103(27)

2. Peivand Mahnaz Samadbeik, Donya Yaaghobi, Bastani, Shahabeddin Abhari, Rita Rezaee, Ali Garavand, The Applications of Virtual Reality Technology in Medical

3. Groups Teaching, J Adv Med Educ Prof. 2018 Jul;6(3):123–129.

4. Tim Swanwick, Kirsty Forrest, Bridget C. O'Brien, Understanding Medical Education: Evidence, Theory, and Practice 3rd Edition, Wiley-Blackwell January 4, 2019 600 pages

5. Gabrielle Finn, Helen Church, Megan Brown, Matthew Byrne, Dr Neel Sharma, Oxford Handbook of Medical Education in Practice (Oxford Professional Practice) 3rd Edition, Oxford University Press May 12, 2025 464 pages

DOI: 10.56580/GEOMEDI74

6. Tejinder Singh, Piyush Gupta, Daljit Singh, Principles of Medical Education Fifth Edition e J.P. Medical Ltd 2021.

7. Shruti Goswami, Gunjan Badwaik, Anjali Borka, Pratibha Deshmukh, Integration of Artificial Intelligence and Virtual Reality in Undergraduate Medical Education: A Review of Emerging Trends and Applications European Journal of Cardiovascular Medicine, Volume 15 Issue 6 (June, 2025) | Pages 219 – 221

8. Siyu Zhou, Diane Gromala, Leyu Wang, Ethical Challenges of Virtual Reality Technology Interventions for the Vulnerabilities of Patients With Chronic Pain: Exploration of Technician Responsibility, J Med Internet Res,. 2023 Dec 4;25

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Original Research Article

Methodological Modifications for Crude *Thymus tiflisiensis* Leaf Extract Screening for *In Vitro* Anti-Inflammatory and Antibacterial Activities

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Abstract

Thymus tiflisiensis Klokov & Des.-Shost. (Lamiaceae) is a medicinal plant traditionally used in the Caucasus region for inflammatory conditions and infectious diseases. However, standard *in vitro* assays often require methodological modifications when applied to crude plant extracts due to interference from coloured phytochemicals, tannins, and other matrix components. This study aimed to: (1) optimize the bovine serum albumin (BSA) denaturation assay for crude plant extracts by determining the optimal buffer pH and denaturation temperature, and (2) compare the broth microdilution (liquid culture) method versus disk diffusion (agar) method for antibacterial screening of plant extracts, and to demonstrate the superiority of liquid culture over agar diffusion for MIC determination. Leaves of *T. tiflisiensis* were extracted by maceration using 80% methanol. For BSA denaturation optimization, buffer pH (6.0-7.4) and denaturation temperature (65 °C, 70 °C, 75 °C) were systematically evaluated using a fixed BSA concentration (1 %). Optimal conditions were identified as pH 6.4 and incubation at 37 °C for 20 minutes, followed by heating at 70 °C for an additional 20 minutes. For antibacterial screening, broth microdilution is unequivocally superior to disk diffusion for crude plant extracts, as it eliminates diffusion-related artifacts and provides quantitative MIC data required for meaningful comparison. These optimized protocols provide a validated framework for ethnopharmacological screening of Caucasian medicinal plants.

Keywords: *Thymus tiflisiensis*; BSA denaturation assay modification; broth microdilution; disk diffusion comparison; methodological optimization.

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Introduction

The screening of plant extracts for anti-inflammatory and antibacterial activities is fundamental to ethnopharmacological research. The most common and accessible *in vitro* assays are the bovine serum albumin (BSA) denaturation inhibition assay for anti-inflammatory activity and the disk diffusion (Kirby-Bauer) method for antibacterial screening. However, these standard protocols frequently yield unreliable or irreproducible results when applied to crude plant extracts, representing complex mixtures containing pigments, tannins, polysaccharides, and other matrix components.

An *in vitro* anti-inflammatory assay can be conducted to measure the activity of natural substances before animal testing using various methods. One of these methods is the protein denaturation inhibition method using bovine serum albumin (BSA), which is stable and non-reactive. The BSA denaturation assay is based on the principle that heat-induced protein denaturation mimics the protein unfolding that occurs during inflammatory tissue damage. Compounds that prevent this denaturation are considered potential anti-inflammatory agents [1]. The absorbance of the turbidity caused by protein denaturation at its maximum wavelength is measured using a UV-Vis spectrophotometer and anti-inflammatory activity is expressed as the half-maximal inhibitory concentration (IC50) [2].

Standard protocols of this method typically employ phosphate buffer at pH 6.5-7.0 and denaturation temperatures of 57-70 °C [3], [4]. However, crude plant extracts introduce two major confounders: coloured compounds (chlorophyll, anthocyanins, flavonoids) that absorb at the measurement wavelength (660 nm), artificially elevating absorbance readings [5]; and problems associated with pH. BSA has an isoelectric point (pI) of approximately 4.7 to 5.5 [6]. When assay buffers or acidic crude plant extracts drop too close to the pI, the protein loses electrostatic stability and spontaneously aggregates [7]. This causes falsely high denaturation readings, masking the true anti-denaturing effects of the extracts.

Similarly, the disk diffusion method presents critical limitations for crude plant extracts. Hydrophobic or high-molecular-weight compounds may fail to diffuse through agar, leading to false-negative results [8]. Furthermore, the method provides only qualitative or semi-quantitative data (e.g., zones of inhibition), whereas studies of medicinal plants quite often require quantitative minimum inhibitory concentration (MIC) values to enable direct potency comparisons between extracts, fractions, or isolated compounds [9]. Beyond these well-recognized drawbacks, the disk diffusion technique is also extremely sensitive to several experimental variables that are difficult to standardize when working with complex plant matrices. Factors such as the rate of compound diffusion (influenced bymolecular size, agar composition, and

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temperature), the inoculum density, and the choice of culture medium can significantly alter the resulting inhibition zones. Moreover, pigmented or turbid crude extracts may obscure the visibility of faint inhibition halos, introducing subjective interpretation bias. Consequently, reliance on disk diffusion alone for screening medicinal plants risks both false negatives (due to poor diffusion) and false positives (caused by non-specific effects or physical interference), making it an inappropriate method for rigorous antimicrobial evaluation. Therefore, complementary broth-based dilution methods, for example microdilution are strongly recommended, particularly when working with hydrophobic, high-molecular-weight, or coloured phytochemical preparations.

This study addresses these methodological challenges using leaf extracts of *Thymus tiflisiensis* Klokov & Des.-Shost.

This study aimed to optimize and validate methodological approaches for the anti-inflammatory and antibacterial screening of extracts of Caucasian medicinal plants. The specific objectives were:

1. To determine optimal conditions (buffer pH and denaturation temperature) for the BSA denaturation assay when applied to crude plant extracts.

2. To compare the broth microdilution and disk diffusion methods for assessing the antibacterial activity of plant extracts.

3. To develop validated protocols suitable for future ethnopharmacological screening based on the above findings.

Materials and Methods

Plant material and authentication

Thymus tiflisiensis Klokov & Des.-Shost. plants were collected in July 2025 in the National Botanical Garden of Georgia, Tbilisi, Georgia. Five plants were collected, placed in paper bags, and transported to the laboratory within 1 h. Fully expanded leaves were collected from all plants. Samples of fresh plant material were frozen in liquid nitrogen and stored at –80 °C.

Drying process

The leaves (5 g) were freeze-dried using a DW-10N freeze dryer (Drawell, China) in a 500 mL vacuum flask at 10 Pa and a final condenser temperature of –55 °C, until constant weight was achieved, as was determined by measuring the dry weight.

Extraction of plant samples

The extraction efficiencies of different solvents for plant material were tested previously, and methanol was demonstrated to be the most efficient solvent, allowing the highest DPPH scavenging activity to be obtained [10]. *T. tiflisiensis* leaf samples were homogenized in a ratio of 1:5 with 80% methanol, followed by continuous stirring for 24 h at room temperature using an orbital shaker at 270 rpm. The crude extract was clarified by centrifugation at 5000×*g* for 15 minutes (TD6 Benchtop Centrifuge Drawell, Chongqing, China). Leaf extracts obtained using 80% methanol were rotary evaporated at 50 °C using DW-ORE2000 rotary evaporator (Drawell, Chongqing, China), and the residue was re-dissolved in 150 mM potassium- phosphate buffer,

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pH 7. For antibacterial assays, re-dissolved residues were sterilized through a 0.22 µm sterile filter (Millipore) and then loaded on sterile filter paper disks.

Anti-inflammatory activity

Denaturation of proteins is one of the predominant reasons for inflammatory and arthritic diseases [11]. Therefore, the ability of a substance to prevent protein denaturation may also help to prevent the inflammatory conditions [12]. BSA is widely used as a model protein in many areas of research because it holds similar properties to those of human serum albumin [12]. In this study, ibuprofen, a non-steroidal anti-inflammatory drug, was used as a reference drug, preventing protein denaturation.

In vitro inhibition of albumin denaturation

Inhibition of albumin denaturation was performed by following a standard method with slight modifications [13]. A 1 % (w/v) solution of bovine serum albumin (BSA) was prepared in phosphate-buffered saline (PBS) at a pH ranging from 6.0 to 7.4 by stirring at 400 rpm for 20 minutes. Different concentrations of samples (100 µL) or the standard drug (Ibuprofen) were mixed with 2.9 mL of 1% BSA solution. The resulting samples were incubated at 37 °C for 20 minutes, then heated at 70 °C for an additional 20 minutes. Finally, the samples' absorbance was measured at 660 nm in 10 mm path length quartz cuvettes using a DU-8800 RS spectrophotometer (Drawell, Chongqing, China) to assess the reaction outcomes. Given that BSA unfolds upon heating and undergoes substantial denaturation and aggregation at 70 °C, the thermal protocol used in this assay produces a partially denatured protein population. Accordingly, the UV-Vis binding parameters obtained reflect interactions with partially denatured BSA [14].

A control was established using the same procedure; the sample solution was replaced with 50 µL of phosphate-buffered saline (PBS). The percentage of protein denaturation inhibition was determined using the following formula:

$$I\% = \frac{Ac - As}{Ac} \times 100$$

where I% denotes the percentage of inhibition, A_S represents the absorbance value of the sample, and A_c represents the absorbance value of the control.

Antibacterial activity

Determination of antibacterial activity

The Kirby-Bauer diffusion method was employed for antibacterial activity screening [15]. The *Escherichia coli* ATCC 25922 strain was used in the study. The bacteria were grown in LB broth for 16–18 h at 37 °C (10^9–10^{10} CFU/mL). Sterile blank disks with a 6 mm diameter were individually placed on an LB nutrient agar plate covered with 300 µL of the bacterial strain. Sterile disks were impregnated with 20 µL of extract solutions at concentrations of 500, 1000, and 2000 µg/mL. The plates were incubated at 37 °C for 24 h. The antimicrobial activity was determined in triplicate by measuring the diameter of the inhibition zone (IZ, mm). Amoxycillin (5 µg/ disk) was used as the positive control.

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Dimethyl sulfoxide (10%) was used as a negative control.

Determination of minimal inhibitory concentration (MIC)

The antibacterial activity of the plant extracts was determined using sterile test tubes (modified from [16]). Tubes were filled with sterilized LB broth and corresponding concentration of the plant extract, to create a concentration sequence from 0.01 mg/mL to 15 mg/mL.

The negative control received no extract; the positive control received amoxicillin (0.1 mg/mL). 5% v/v inoculum was added into the tubes. The tubes were incubated for 24 h at 37 °C. Turbidity was assessed after 24 h by measuring optical density at 600 nm using a DU-8800 RS spectrophotometer. The MIC was defined as the lowest concentration with no visible growth. At least three replicates were run for each assay. According to Bussmann et al[17], strong antibacterial activity was defined as MIC < 5 mg/mL.

Results

BSA denaturation assay – methodological optimisation

Preliminary screening: Initial experiments (data not shown) identified that coloured compounds in both extracts significantly interfered with absorbance readings at 660 nm, and tannin-like constituents caused protein precipitation even without heating. This necessitated systematic optimisation.

pH optimization

Buffer systems were prepared at four pH values:

6.0 (1X phosphate-buffered saline (PBS))
6.4 (1X phosphate-buffered saline (PBS))
7.0 (1X phosphate-buffered saline (PBS))
7.4 (1X phosphate-buffered saline (PBS))

BSA (1 % w/v) was dissolved separately in each buffer.

Critical: Colour controls (extract + buffer without BSA, heated identically) were prepared for each extract at each pH.

The anti-denaturation activity of *Thymus tiflisiensis* leaf extract was strongly pH-dependent, with maximum inhibition (70.3 ± 1.8%) observed at pH 6.4 (1× PBS) using 0.25 mg/mL extract (Fig. 1). At pH 6.0 and 7.4, inhibition decreased to 43.5 ± 1.9% and 55.9 ± 1.2%, respectively, while pH 7.0 gave 68.9 ± 2.8%. Ibuprofen (0.05 mg/mL) also showed its highest inhibition at pH 6.4 (47.8 ± 0.9%). Importantly, colour interference from the extract was reduced by 42% at pH 6.4 compared to pH 7.4 ($p < 0.01$).

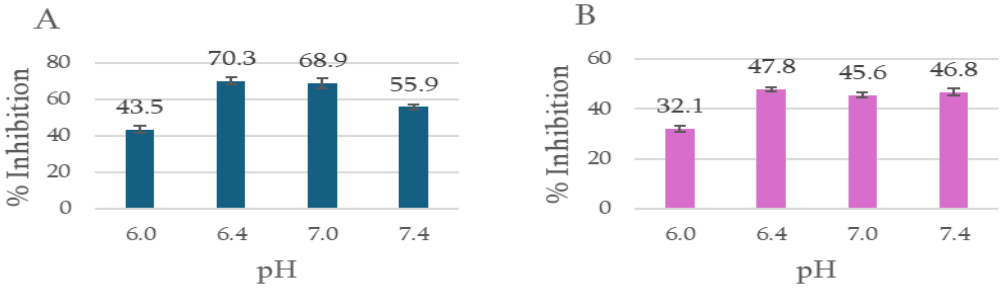

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Fig. 1. Effect of pH on the anti-denaturation activity of *Thymus tiflisiensis* leaf extracts (0.25 mg/mL, A) and ibuprofen (0.05 mg/mL, B) in the BSA denaturation assay performed at incubation at 37 °C for 20 minutes followed by incubation at 70 °C for 20 minutes.

Extract concentration was selected based on preliminary dose-response data. Values represent mean of three independent experiments ± standard deviation (n=3).

Note: Colour controls (extract + buffer without BSA, heated identically) were subtracted for each extract at each pH to correct for extract colour interference.

Temperature Optimization

Using the optimal pH identified (6.4), the denaturation temperature was systematically varied in experiments (Table 1):

65 °C for 20 minutes;
70 °C for 15 minutes;
70 °C for 20 minutes;
75 °C for 15 minutes

The highest anti-denaturation activity for *Thymus tiflisiensis* leaf extract (70.3 ± 1.8%) was achieved at 70 °C with a 20-minute incubation. Lower inhibition was observed at 65 °C (59.4 ± 1.3%), while both 70 °C with 15 minutes incubation (63.7 ± 0.6%) and 75°C with 15 minutes incubation (67.3 ± 2.5%) produced intermediate values, confirming 70 °C for 20 minutes as optimal.

Statistical Analysis

All experiments performed in triplicate on three independent occasions (n=9 technical replicates across 3 biological replicates). Results expressed as mean ± standard deviation. Comparisons between methods used paired *t*-test (disk diffusion vs. broth microdilution results for identical extract-bacteria combinations). The analysis of the obtained data indicated that final incubation at 70 °C for 20 minutes increased assay sensitivity while maintaining thermal stability of extract components.

Table 1. Effect of temperature and exposure time on the anti-denaturation activity of *Thymus tiflisiensis* leaf extracts and ibuprofen in the BSA denaturation assay.

Sample	Temperature (°C)	Incubation Time (minutes)	Concentration (mg/mL)[i]	% Inhibition (Mean ± SD)[ii]
T. tiflisiensis leaf extract	65	20	0.25	59.4 ± 1.3
T. tiflisiensis leaf extract	70	15	0.25	63.7 ± 0.6
T. tiflisiensis leaf extract	70	20	0.25	70.3 ± 1.8
T. tiflisiensis leaf extract	75	15	0.25	67.3 ± 2.5

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Sample	Temperature (°C)	Incubation Time (minutes)	Concentration (mg/mL)[i]	% Inhibition (Mean ± SD)[ii]
Ibuprofen	65	20	0.05	30.2 ± 0.7
Ibuprofen	70	15	0.05	38.1 ± 1.5
Ibuprofen	70	20	0.05	47.8 ± 0.9
Ibuprofen	75	15	0.05	43.1 ± 1.9

[i]Extract concentration (0.25 mg/mL) was selected based on preliminary dose-response data and maintained constant across all temperature conditions.

[ii]Values represent mean of three independent experiments ± standard deviation (n=3). Assays were performed at pH 6.4 (1X PBS).

Note: Colour controls (extract + buffer without BSA, heated identically) were subtracted for each temperature condition to correct for extract colour interference.

Based on optimization results, the following protocol was adopted (Table 2).

Table 2. Final optimized protocol for the determination of anti-denaturation activity of Georgian medicinal plants

Parameter	Standard protocol	Protocol, optimized for plant extracts
Buffer	Phosphate buffer pH 6.8	1xPBS pH6.4
BSA concentration	0.5-1 %	**1%**
Pre-incubation	37 °C, 15-20 minutes	**37 °C, 20 minutes**
Denaturation	65-75 °C, 15-25 minutes	**70 °C, 20 minutes**
Color control	Usually omitted	**Mandatory** (extract + buffer, no BSA)
Wavelength	660 nm	660 nm

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Parameter	Standard protocol	Protocol, optimized for plant extracts
Positive control	Ibuprofen (10-200 μg/mL)	Ibuprofen (10-200 μg/mL)

Complete procedure for the determination of anti-denaturation activity of Georgian medicinal plants

1. Prepare extract dilutions in 150 mM potassium-phosphate buffer, pH=7 (10-1000 μg/mL)
2. For each sample both sample measurement (2900 μL BSA + 100 μL extract) and colour control measurements (2900 μL buffer + 100 μL extract) should be taken.
3. Positive control: ibuprofen (10, 25, 50, 100, 200 μg/mL) should be measured without colour control (negligible colour)
4. Negative control: 2900 μL BSA + 100 μL buffer
5. All samples should be incubated at 37 °C for 20 minutes
6. The incubation should be followed up by incubation at 70 °C for 20 minutes
7. Samples should be cooled to room temperature for 10 minute
8. Absorbance should be measured at 660 nm
9. Corrected absorbance should be calculated: $OD_{corrected} = OD_{sample} - OD_{color\ control}$
10. Acordingly, % inhibition should be calculated based on corrected absorbance

Complete procedure for the determination of antibacterial activity of Georgian medicinal plants by disk diffusion method and broth microdilution method

Disk Diffusion Method (Kirby- Bauer)

Procedure (CLSI M02 standard):

1. LB plates (150 mm diameter) were inoculated by swabbing with bacterial suspension (0.5 McFarland)
2. Sterile filter paper disks (6 mm diameter, Whatman) were impregnated with 20 μL of leaf extract solutions (concentrations: 500, 1000, 2000 μg/mL in 10% DMSO)
3. Disks were air-dried for 15 minutes to evaporate solvent
4. Disks placed on inoculated agar (max 6 disks per plate)
5. Positive control: amoxicillin (5 μg/disk)
6. Negative control: 10% DMSO disk
7. Incubate at 37 °C for 24 hours
8. Measure inhibition zone diameters (mm) including disk diameter (6 mm)

Interpretation: No zone = no activity; zone ≤8 mm = weak; 9-14 mm = moderate; ≥15 mm = strong (modified from standard criteria for plant extracts)

Broth Microdilution Method

Procedure (CLSI M07 standard):

1.Two-fold serial dilutions of extracts in LB (containing 0.5% DMSO final).

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Concentration range: 3.9, 7.8, 15.6, 31.25, 62.5, 125, 250, 500 µg/mL

2.Dispense 100 µL of each dilution into 96- well plate

3.Add 100 µL bacterial suspension (~5 × 10^5 CFU/mL)

4.Positive controls: amoxicillin (0.1 mg/mL)

5.Growth control: LB + bacteria (no extract)

6.Sterility control: LB + extract (no bacteria)

7.Solvent control: LB + bacteria + 0.5% DMSO

8.Incubate at 37 °C for 24 hours

9.Read MIC as lowest concentration with no visible turbidity (as OD, 600 nm wavelength).

10.MBC determination: subculture 10 µL from clear wells onto LB agar, incubate 24 hours; MBC = lowest concentration with ≥99.9% killing (no colonies).

Table 3 demonstrates results of growth inhibition for 2 methods. MIC for extracts is estimated as 125.0 µg/mL. The comparison of antibacterial testing methods revealed a clear discrepancy between disk diffusion and broth microdilution. Disk diffusion produced small, highly variable inhibition zones for *Thymus tiflisiensis* leaf extract at 2000 µg/disk (12 ± 4.81 mm), with root extract showing similarly inconsistent results (11 ± 3.71 mm). In contrast, broth microdilution demonstrated concentration-dependent activity with excellent reproducibility. Leaf extract achieved 91 ± 4.32% inhibition at 60.5 µg/mL and complete (100%) inhibition at 125.0 µg/mL, establishing the MIC at 125.0 µg/mL for both extracts. Broth microdilution produced low standard deviations (typically <10% of the mean), whereas disk diffusion gave highly variable outcomes, indicating that the latter substantially underestimates the true antibacterial potential of crude plant extracts.

Table 3. Comparison of results of growth inhibition obtained for two methods of determination of antibacterial activity of Georgian medicinal plants

Disk diffusion method		
Extract	**Concentration, µg/mL**	**Inhibition zone, mm (mean value ± standard deviation)**
Leaf	500	7±1.17
	1000	10±4.60
	2000	12±4.81
Root	500	6±1.89
	1000	8±2.79
	2000	11±3.71
Amoxicillin	5 µg/disk	24±4.12
DMSO	10%	0
Broth microdilution method		

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Extract	Concentration, µg/mL	% inhibition (mean value ± standard deviation)
Leaf	3.9	46±7.02
	7.5	50±5.10
	15.0	59±1.11
	30.0	75±5.31
	60.5	91±4.32
	125.0	100
Root	3.9	37±4.27
	7.5	42±3.23
	15.0	49±5.72
	30.0	68±1.90
	60.5	85±5.18
	125.0	100
Amoxicillin	100	100
DMSO	10%	0

Method Comparison Criteria

Disk diffusion method produced small and highly variable inhibition, while broth microdilution method revealed clear, concentration-dependent antibacterial activity. The two antibacterial testing methods were compared based on the following criteria: quantitative output, requirement of extract diffusion, susceptibility to extract colour interference, susceptibility to extract hydrophobicity, dependence on agar composition, time requirements, and availability of standardized interpretation (Table 4).

Table 4. Method comparison criteria for antibacterial activity

Criterion	Disk diffusion	Broth microdilution
Quantitative output	No (zone diameter only)	Yes (MIC µg/mL)
Requires extract diffusion	Yes	No
Affected by extract colour	No	Yes (can be corrected
Affected by extract hydrophobicity	Yes (major limitation)	No
Affected by agar composition	Yes	N/A

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Criterion	Disk diffusion	Broth microdilution
Time requirements	24 h	24-48 h
Standardized interpretation	No	Yes
CLSI guideline	M02	M07

Discussion

Methodological optimizations for crude plant extracts

This study systematically addressed two critical methodological challenges in ethnopharmacological screening: protein denaturation assays in the presence of coloured, tannin-rich extracts, and the choice of antibacterial screening method for complex plant matrices.

BSA denaturation optimization: pH 6.4 and 70 °C

The shift from standard pH 7.4 to pH 6.4 proved crucial for reducing non-specific interference. At higher pH (7.4), phenolic compounds present in *Thymus* leaf extracts (flavonoids, tannic acid derivatives) may undergo autoxidation, potentially forming coloured products that can interfere with absorbance measurements. Additionally, alkaline conditions promote tannin-protein complexation even without heating, is a well-documented phenomenon where hydrogen bonding between phenolic hydroxyl groups and protein amide groups is maximized at pH 7-8 [18],[19].

By lowering the pH to 6.4, the value well below the pKa values of most phenolic compounds (typically 8.5–10.9) [20], the phenolic hydroxyl groups remain protonated and uncharged, minimizing their autoxidation and subsequent colour formation. This was confirmed by a 42% reduction in colour control absorbance compared to pH 7.4."

The selection of 70 °C denaturation for 20 minutes addresses a different issue: thermal stability of plant-derived anti-inflammatory compounds. Many phenolic compounds exhibit optimal bioactivity at slightly higher temperatures due to improved solubility and molecular unfolding that exposes active sites[21]. At 75 °C, however, degradation became more pronounced, which may be explained by thermal degradation of phenolic compounds, caramelization of sugars, or oxidation of thermolabile constituents [22].

Mandatory colour controls: The most important modification which are quite often omitted in published plant extract studies is the inclusion of extract colour controls (extract + buffer without BSA, heated identically). This correction should be considered mandatory for any plant

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extract containing visible pigments (chlorophyll, anthocyanins, flavonoids).

Antibacterial method comparison: liquid culture superior to disk diffusion

The dramatic discrepancy between disk diffusion and broth microdilution results demands explanation. Three mechanisms explain why disk diffusion fails for crude plant extracts:

1. Diffusion limitation in agar: The aqueous agar matrix (approximately 98% water, 2% agarose) effectively excludes hydrophobic compounds. Many antimicrobial plant metabolites including thymol, carvacrol (from *Thymus*) are lipophilic and partition preferentially into the disk or form micelles rather than diffusing radially. The result is a steep concentration gradient immediately adjacent to the disk, with insufficient compound reaching the bacterial lawn to produce a visible zone even when the MIC in liquid culture is modest.

2. High molecular weight constituents: Crude extracts contain polysaccharides, tannins, and proteinaceous material that cannot diffuse through the agar meshwork (pore size approximately 50-100 nm for 1.5% agar). These components are trapped near the disk, failing to contact bacteria even if they possess antimicrobial activity.

3. Quantitative vs. qualitative output: Disk diffusion provides only a threshold measurement (zone diameter ≥X mm = susceptible). For plant extracts, no standardized breakpoints exist. Broth microdilution provides continuous quantitative data (MIC in μg/mL) allowing comparison across studies, determination of bactericidal vs. bacteriostatic activity (MBC/MIC ratio), and calculation of selectivity indices when cytotoxicity data are available.

According to the previously published results, MIC broth dilution method is more reliable as it provides more standardized results. Thus, it is suggested to use disk diffusion method as a qualitative and/or additional method for estimating the antibacterial activity [9], [23].

In conclusion, this study demonstrates that crude plant extracts require significant methodological modifications for reliable *in vitro* screening. For the BSA denaturation assay, optimal conditions were identified as pH 6.4 with denaturation at 70 °C for 20 minutes, plus mandatory colour controls to correct for pigment interference. For antibacterial testing, broth microdilution proved unequivocally superior to disk diffusion, providing quantitative, reproducible MIC data. These optimized protocols provide a validated framework for future ethnopharmacologic cological screening of Caucasian medicinal plants.

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მეთოდოლოგიური მოდიფიკაციები *Thymus tiflisiensis*-ის (თბილისური ბეგქონდარა) ფოთლის უხეში ექსტრაქტის სკრინინგისთვის *in vitro* ანთების საწინააღმდეგო და ანტიბაქტერიული აქტივობების დასადგენად

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აბსტრაქტი

Thymus tiflisiensis (Lamiaceae-ტუჩოსანთა ოჯახი) სამკურნალო მცენარეა, რომელიც, კავკასიის რეგიონში, ტრადიციულად, გამოიყენება ანთებითი მდგომარეობებისა და ინფექციური დაავადებების სამკურნალოდ. თუმცა, მცენარის უხეში ექსტრაქტების შემთხვევაში, სტანდარტული *in vitro* ანალიზები ხშირად საჭიროებს მეთოდოლოგიურ მოდიფიკაციებს შეფერილი ფიტოქიმიკატების, ტანინებისა და მატრიქსის სხვა კომპონენტების მხრიდან ხელის შეშლის გამო(ინტერფერენცია). მოცემული კვლევის მიზანი იყო: **1.** ხარის შრატის ალბუმინის(BSA) დენატურაციის ანალიზის ოპტიმიზაცია მცენარის უხეში ექსტრაქტებისთვის ბუფერის ოპტიმალური pH-ისა და დენატურაციის ტემპერატურის განსაზღვრის გზით; **2.** ბულიონში მიკროგანზავების(თხევადი კულტურა) მეთოდის შედარება დისკო-დიფუზიურ(აგარი) მეთოდთან მცენარის ექსტრაქტის ანტიბაქტერიული სკრინინგისთვის და თხევადი კულტურის უპირატესობის ჩვენება აგარში დიფუზიასთან შედარებით მინიმალური მაინჰიბირებელი კონცენტრაციის(MIC) დასადგენად. *Thymus tiflisiensis* ექსტრაგირდა მაცერაციის(დალბობა) მეთოდით, 80%-იანი მეთანოლის გამოყენებით. ხარის შრატის ალბუმინის ოპტიმიზაციისთვის, ბუფერის pH(6,0-7,4) და დენატურაციის ტემპერატურა(65°C, 70°C, 75°C) სისტემურად შეფასდა ხარის შრატის ალბუმინის სისტემური კონცენტრაციის(1%) გამოყენებით. ოპტიმალურ პირობებად განისაზღვრა pH=6,4 და ინკუბაცია 37°C-ზე 20წთ-ის განმავლობაში, რასაც მოჰყვა გაცხელება 70°C ტემპერატურაზე დამატებით 20წთ-ის განმავლობაში. ანტიბაქტერიული სკრინინგისთვის, ბულიონში მიკროგანზავების მეთოდი ცალსახად სჯობს დისკო-დიფუზიურ მეთოდს მცენარის უხეში

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ექსტრაქტების შემთხვევაში, ვინაიდან, იგი გამორიცხავს დიფუზიასთან დაკავშირებულ არტეფაქტებს და იძლევა მინიმალური მაინჰიბირებელი კონცენტრაციის(MIC) რაოდენობრივ მონაცემებს, რაც აუცილებელია საფუძვლიანი შედარებისთვის. ეს ოპტიმიზებული პროტოკოლები ვალიდურ ჩარჩოს ქმნის კავკასიური სამკურნალო მცენარეების ეთნოფარმაკოლოგიური სკრინინგისთვის.

საკვანძო სიტყვები: *Thymus tiflisiensis* (თბილისური ბეგქონდარა), BSA-ის (ხარის შრატის ალბუმინი) დენატურაციის ტესტის მოდიფიკაცია, ბულიონში მიკროგანზავების მეთოდი, დისკო-დიფუზიური მეთოდების შედარება, მეთოდოლოგიური ოპტიმიზაცია.

References

1.Wulandari F, Sri Sunarsih E, Musnaini K. Characterisation and phytochemical screening of ethanolic extract Citrus reticulata peel and its anti-inflammatory activity using protein denaturation method. *Pharm Educ*. 2024;24(6):1-6. doi:10.46542/pe.2024.246.16

2. Williams L a. D, O'Connar A, Latore L, et al. The *in vitro* anti-denaturation effects induced by natural products and non-steroidal compounds in heat treated (immunogenic) bovine serum albumin is proposed as a screening assay for the detection of anti-inflammatory compounds, without the use of animals, in the early stages of the drug discovery process. *West Indian Med J*. 2008;57(4):327-331.

3. Ashwini T, Elizabeth AA, Aishwarya S, Josephine IG, Brigida S, Srinivasan R. Sinapis arvensis-Wild Mustard as an AntiSection inflammatory Agent: An In-vitro Study. *JCDR*. Published online 2022. doi:10.7860/JCDR/2022/58609.17301

4. Phukan K, Devi R, Chowdhury D. Green Synthesis of Gold Nano-bioconjugates from Onion Peel Extract and Evaluation of Their Antioxidant, Anti-inflammatory, and Cytotoxic Studies. *ACS Omega*. 2021;6(28):17811-17823. doi:10.1021/acsomega.1c00861

5. Akinpelu LA, Olawuni IJ, Ogundepo GE, Adegoke AM, Olayiwola G, Idowu TO. Spectroscopic analysis and anti-inflammatory effects of Milicia excelsa (Moraceae) leaf and fractions. *GSC Biol and Pharm Sci*. 2019;6(3):051-060. doi:10.30574/gscbps.2019.6.3.0035

6. Comez L, Gentili PL, Paolantoni M, Paciaroni A, Sassi P. Heat-induced self-assembling of BSA at the isoelectric point. *International Journal of Biological Macromolecules*. 2021;177:40-47. doi:10.1016/j.ijbiomac.2021.02.112

7. Li R, Wu Z, Wangb Y, Ding L, Wang Y. Role of pH-induced structural change in protein aggregation in foam fractionation of bovine serum albumin. *Biotechnology*

Reports. 2016;9:46-52. doi:10.1016/j.btre.2016.01.002

8. Cos P, Vlietinck AJ, Berghe DV, Maes L. Anti-infective potential of natural products: How to develop a stronger *in vitro* 'proof-of-concept.' *Journal of Ethnopharmacology*. 2006;106(3):290-302. doi:10.1016/j.jep.2006.04.003

9. Klančnik A, Piskernik S, Jeršek B, Možina SS. Evaluation of diffusion and dilution methods to determine the antibacterial activity of plant extracts. *Journal of Microbiological Methods*. 2010;81(2):121-126. doi:10.1016/j.mimet.2010.02.004

10. Mittova V, Tseskhladze Z, Makalatia K, et al. Antioxidant and antibacterial activity of root extracts of Georgian medicinal plants obtained using different extraction methods. *MIMM*. 2024;28(2):1-34. doi:10.56580/GEOMEDI53

11. Silvestrini B, Silvestrini M. Medical Implications of the Relationships among Protein Denaturation, Necrosis and Inflammation: An Intriguing Story. In: Rosenberg N, ed. *Tendons - Trauma, Inflammation, Degeneration, and Treatment*. IntechOpen; 2023. doi:10.5772/intechopen.108018

12. Nirmala AR, Permatasari L, Muliasari H, Deccati RF. Review: analysis of optimal conditions of bovine serum albumin (BSA) protein denaturation inhibition method in anti-inflammatory activity testing of various plant leaf extracts. *JAFP*. 2023;3(2):101. doi:10.31764/jafp.v3i2.20953

13. Anokwah D, Kwatia EA, Amponsah IK, et al. Evaluation of the anti-inflammatory and antioxidant potential of the stem bark extract and some constituents of Aidia genipiflora (DC.) dandy (rubiaceae). *Heliyon*. 2022;8(8):e10082. doi:10.1016/j.heliyon.2022.e10082

14. Borzova VA, Markossian KA, Chebotareva NA, et al. Kinetics of Thermal Denaturation and Aggregation of Bovine Serum Albumin. Permyakov EA, ed. *PLoS ONE*. 2016;11(4):e0153495. doi:10.1371/journal.pone.0153495

15. Mitra S, Bhesania Hodiwala AV, Kar H. Susceptibility and Synergistic Effects of Guava Plant Extract and Antimicrobial Drugs on Escherichia coli. *Cureus*. Published online January 15, 2024. doi:10.7759/cureus.52345

16. Wiegand I, Hilpert K, Hancock REW. Agar and broth dilution methods to determine the minimal inhibitory concentration (MIC) of antimicrobial substances. *Nat Protoc*. 2008;3(2):163-175. doi:10.1038/nprot.2007.521

17. Bussmann RW, Malca-García G, Glenn A, et al. Minimum inhibitory concentrations of medicinal plants used in Northern Peru as antibacterial remedies. *Journal of Ethnopharmacology*. 2010;132(1):101-108. doi:10.1016/j.jep.2010.07.048

18. Harbertson JF, Kilmister RL, Kelm MA, Downey MO. Impact of condensed tannin size as individual and mixed polymers on bovine serum albumin precipitation. *Food Chemistry*. 2014;160:16-21. doi:10.1016/j.foodchem.2014.03.026

19. Kumar S, Pandey AK. Chemistry and Biological Activities of Flavonoids: An Overview. Lu KP, Sastre J, eds. *The Scientific World Journal*. 2013;2013(1):162750. doi:10.1155/2013/162750

20. Chuchani G, Frohlich A. The pK a values of mono-substituted phenols and benzenethiols and the conjugation of substituents having a strong +K effect. *J Chem Soc, B:*. Published online 1971:1417. doi:10.1039/j29710001417

21. Wang B, Pham LB, Adhikari B. Complexation and conjugation between phenolic compounds and proteins: mechanisms, characterisation and applications as novel encapsulants. *Sustainable Food Technol*. 2024;2(5):1206-1227. doi:10.1039/D4FB00013G

22. Turturică M, Stănciuc N, Bahrim G, Râpeanu G. Investigations on Sweet Cherry Phenolic Degradation During Thermal Treatment Based on Fluorescence Spectroscopy and Inactivation Kinetics. *Food Bioprocess Technol*. 2016;9(10):1706-1715. doi:10.1007/s11947-016-1753-7

23. Othman M, Loh HS, Wiart C, Khoo TJ, Lim KH, Ting KN. Optimal methods for evaluating antimicrobial activities from plant extracts. *Journal of Microbiological Methods*. 2011;84(2):161-166. doi:10.1016/j.mimet.2010.11.008

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Original Research Article

Evaluating the Efficacy of Formative MCQs on Student Learning Outcomes in Cardiovascular System Biochemistry

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Abstract

Medical students often have problems with the application of abstract biochemical concepts to clinical practice, and this problem is especially evident in complex modules such as cardiovascular system biochemistry. Formative multiple-choice questions (MCQs) have shown promise in bridging this gap; however, limited research exists on their integration into cardiovascular biochemistry curricula. This study aimed to evaluate the efficacy of weekly formative MCQs on student engagement, self-assessment, critical thinking, and exam preparedness in a cardiovascular biochemistry module. A prospective, single-cohort educational study was conducted during a 7-week cardiovascular biochemistry module at University Geomedi, Tbilisi, Georgia. Participants were 120 second-year medical students who completed weekly formative MCQs designed to emphasise clinical application across seven topics. After the module and final examination, students completed an anonymous 12-item questionnaire comprising 10 quantitative Likert-scale items and two open-ended questions. The response rate was 100%. Mean scores were high across all domains: engagement (4.77/5), learning and self-assessment (4.66/5), critical thinking (4.58/5), exam preparedness (4.43/5), and overall satisfaction (4.52/5). The highest "Strongly Agree" ratings were obtained for engagement (Question 1, 85.8%), knowledge gap identification (Question 3, 81.7%), and motivation to attend seminars (Question 2, 71.7%). Disagreement rates were minimal (0–2.5% across items). Qualitative thematic analysis revealed four dominant advantages: self-assessment and knowledge gap identification, readiness for exams, clinical reasoning and application, and engagement with active participation. Minor challenges included requests for more clinically complex questions, occasional time constraints, and public participation anxiety for a small number of students. This study demonstrates that weekly formative MCQs in cardiovascular biochemistry are highly accepted by medical students and perceived to enhance engagement, self-directed learning, clinical reasoning, and exam preparedness while reducing exam anxiety. Future research should correlate MCQ performance with final exam scores and assess long-term knowledge retention.

Keywords: formative assessment, multiple-choice questions, MCQs, medical education, cardiovascular biochemistry, student engagement, self-assessment, clinical reasoning, exam preparedness

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Introduction

The transition from foundational science to clinical reasoning represents a persistent challenge in medical education, and the popularity of the integrated curriculum has continuously grown in medical education over the last two decades [1]. Medical students have difficulties applying knowledge about biomedical mechanisms to patient care activities [2], due to the existence of the gap between abstract biochemical and molecular mechanisms and practical bedside medicine. Traditionally, medical curricula have historically separated basic sciences from clinical training, and this is quite often the reason that students perceive basic sciences as subjects with low value, and their capacity to use this knowledge in clinical reasoning is substantially diminished. This problem is particularly acute in disciplines such as biochemistry, which requires students to master complex molecular and metabolic concepts before they can appreciate their clinical relevance. Among various approaches for the prevention of such undesired learning strategies, assessment plays a powerful role. As multiple authors have noted, "assessment drives learning", since the nature, form, and frequency of assessments significantly influence student study strategies and knowledge retention [3]. Traditional summative assessments, typically introduced at the end of a module, quite often encourage memorisation rather than sustained, deep engagement with material [4]. Therefore, medical education is shifting more and more towards frequent formative assessments designed to provide feedback and guide learning rather than simply assigning final grades [5]. Formative assessment, as a key component of assessment for learning (AfL, formative with feedback), has been shown to enhance self-regulated learning, identify knowledge gaps, and promote deeper engagement with course material [6].

Multiple-choice questions (MCQs) have emerged as a particularly effective format for formative assessment in medical education [7]. MCQs offer several advantages: they can test a wide range of knowledge efficiently, provide immediate feedback, and, if MCQs are designed appropriately, they can assess higher-order cognitive skills, including clinical reasoning and application [8]. Recent evidence suggests that well-constructed, clinically integrated MCQs can promote critical thinking and help students bridge the gap between basic science knowledge and clinical practice [9]. Multiple studies have demonstrated the efficacy of formative MCQs in biochemistry education specifically. Thus, Panchbudhe et al. investigated the use of Google Form-based MCQ tests as formative assessment tools following a biochemistry lecture series for 150 Phase I MBBS students [10]. Their study demonstrated significant improvement in student scores between first and second internal assessments, and 99.3% of students reported that the formative MCQs were highly beneficial and motivated their engagement with biochemistry studies[10].

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Similarly, Schwartzman et al. developed a student-faculty partnership workflow (Professor-Reviewed Exam Practice, PREP) to create single-best-response formative MCQs aligned with preclinical curriculum, reporting high usage rates and strong student demand for such resources [11].

The striking example of the module where there is a great gap between abstract biochemical mechanisms and practical bedside medicine is the biochemistry of the cardiovascular system. In this module, students must understand cardiac energy metabolism (including creatine kinase and ATP generation pathways), lipid metabolism, operation of ion channels and receptors, and biochemical markers of cardiovascular disease, and all these topics require integration of basic biochemical principles with clinical scenarios such as myocardial infarction, dyslipidemia, and heart failure [12]. The complexity and volume of this material, combined with the abstract nature of many biochemical concepts, can overwhelm students and lead to undesirable learning strategies focused on memorisation rather than deep conceptual understanding. Despite growing evidence supporting formative MCQs in medical education generally and in biochemistry specifically, limited research has examined their application in cardiovascular system biochemistry modules [13]. Therefore, the cardiovascular system module at University Geomedi provides an Ideal context for examining formative MCQs in this domain. Second-year medical students face the transition from basic science instruction to clinically ntegrated learning, and the cardiovascular module represents one of their first exposures to system-based, clinically oriented biochemistry.

Considering the documented challenges of teaching clinically integrated biochemistry, the demonstrated benefits of formative MCQs in medical education, and the specific gap in cardiovascular biochemistry literature, this study aimed to evaluate the efficiency and benefits and/or disadvantages of integration of weekly formative MCQs into the cardiovascular biochemistry curriculum at University Geomedi.

Materials and Methods

Study Design and Participants

A prospective, single-cohort educational study was conducted during a 7-week cardiovascular biochemistry module. Participants were second-year medical students (n=120) at University Geomedi, Tbilisi, Georgia. No exclusion criteria were applied; all enrolled students participated.

Formative MCQ Intervention

Formative MCQs, specifically designed to emphasise clinical application, were administered weekly during a 7-week cardiovascular biochemistry module for second-year medical students (n=120). The MCQs were categorised according to the following topics: (1) ion channels and contraction of myocardium; (2) adrenergic and cholinergic receptors in cardiac tissue; (3) heart as a secretory organ; (4) vasoactive peptides; (5) cardiac energy metabolism (including creatine kinase and ATP

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generation); (6) lipid metabolism and biochemistry of atherosclerosis; (7) biochemical markers of cardiovascular disease.

Data Collection

After the completion of the module and final examination, students completed an anonymous questionnaire developed by us consisting of 12 questions (Table 1):

10 quantitative items on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The following aspects were covered by these 10 questions: engagement (Questions 1–2), learning/self-assessment (Questions 3–5), critical thinking (Questions 6–7), exam preparedness (Questions 8–9), and overall satisfaction (Question 10).

Two open questions on the advantages and challenges of the MCQ method (Questions 11 and 12, Table 1).

Data Analysis: Quantitative data were analysed using descriptive statistics. Response frequencies (counts and percentages) for each rating (5, 4, 3, 2, 1) were calculated directly from the Excel file (calc sheet). Qualitative open-ended responses were analysed using thematic analysis and are reported.

Ethical Considerations

The study was conducted as part of the routine curriculum evaluation. All responses were anonymous, and participation in the questionnaire did not affect course grades.

Table 1. Questionnaire used in the study.

Quantitative Items (questions 1-10, 1-5 Scale)

(Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Question number	Section	Question Text	Rating (1-5)
1	**Engagement**	The use of MCQs made the biochemistry seminars more engaging.	
2	**Engagement**	I was more motivated to attend seminars knowing that MCQs would be discussed.	
3	**Learning**	Solving MCQs helped me identify gaps in my knowledge (self-assessment) better than just reading notes.	
4	**Learning**	The immediate feedback provided after MCQs helped clarify complex metabolic pathways.	
5	**Learning**	Regular MCQ practice improved my long-term retention of biochemical concepts.	

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Question number	Section	Question Text	Rating (1-5)
6	Critical Thinking	The MCQs encouraged me to apply concepts to clinical scenarios rather than memorise facts.	
7	Critical Thinking	Discussing MCQs in class helped me understand the "why" behind the correct answer.	
8	Assessment Prep	I feel less anxious about the final exams because of regular MCQ practice.	
9	Assessment Prep	The formative MCQs were representative of the difficulty level expected in the exams.	
10	Satisfaction	I believe formative MCQs should be integrated into other pre-clinical subjects.	

Qualitative Items (Open-Ended)

Question number	Section	Question Text
11	Qualitative	What is the biggest advantage of using MCQs in biochemistry teaching?
12	Qualitative	What challenges or disadvantages have you faced with this method? (e.g., time constraints, quality of questions, etc.)

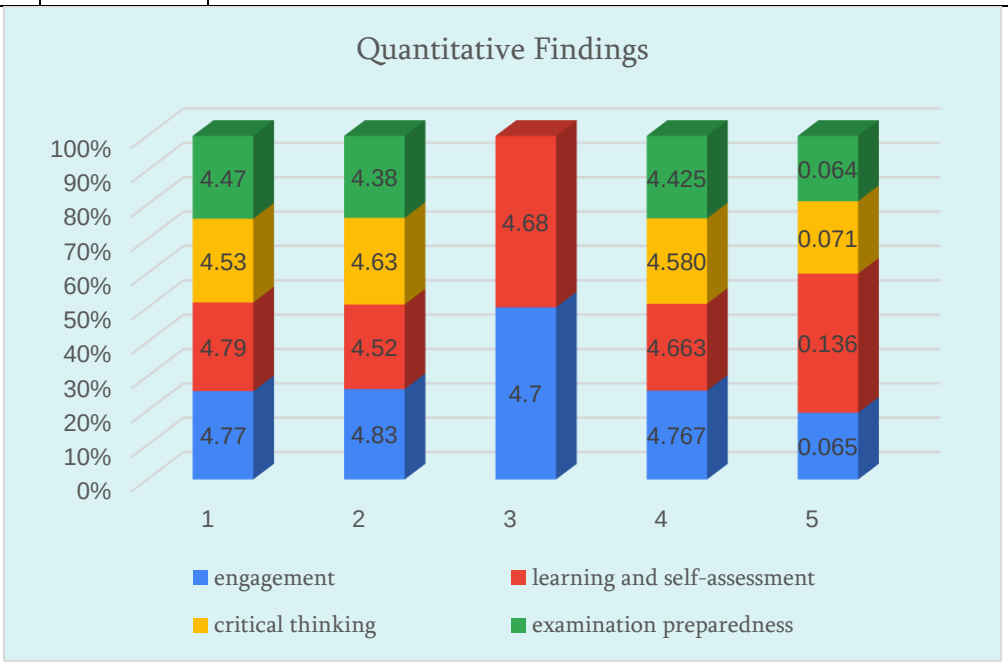

Fig. 1. Quantitative findings of the study.

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Table 2. Student's response distribution (%)

Question	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)
1	85.8	11.7	2.5	0.0	0.0
2	71.7	26.7	1.7	0.0	0.0
3	81.7	15.8	2.5	0.0	0.0
4	65.0	24.2	8.3	1.7	0.8
5	70.8	26.7	2.5	0.0	0.0
6	65.8	23.3	7.5	2.5	0.8
7	70.0	23.3	6.7	0.0	0.0
8	60.0	27.5	10.8	0.8	0.8
9	53.3	31.7	14.2	0.8	0.0
10	65.8	22.5	10.0	1.7	0.0

Results

Quantitative Findings

All 120 students completed the questionnaire (100% response rate). The distribution of responses is shown in Table 2. Mean scores were as follows:

Engagement: 4.77/5 (Question 1: 4.83; Question 2: 4.70);

Learning and self-assessment: 4.66/5 (Question 3: 4.79; Question 4: 4.52; Question 5: 4.68);

Critical thinking: 4.58/5 (Question 6: 4.53; Question 7: 4.63);

Exam preparedness: 4.43/5 (Question 8: 4.47; Question 9: 4.38);

Satisfaction: 4.52/5 (Question 10) (Fig. 1).

Based on the analysis of the obtained results, the following observations were made:

The highest "Strongly Agree" (5) ratings were revealed for Question 1 (85.8%), Question 3 (81.7%), and Question 2 (71.7%). Neutral responses (3) were highest for Questions 9 (14.2% – exam difficulty representation) and 8 (10.8% – exam anxiety). The percentage of answers reflecting disagreement (2 or 1) was very rare (0–2.5% across items).

Qualitative Findings

Thematic analysis of open-ended responses

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(n=120, with many students providing multiple comments) revealed four dominant domains:

Domain 1: Self-assessment and knowledge gap identification

The most frequently reported advantage. Students valued the ability to "identify gaps in knowledge."

Domain 2: Readiness for the exam

Many students noted that formative MCQs reduced anxiety and familiarised them with question formats like the final exam. One student wrote: "I was much less nervous because I had already practised 60+ clinical MCQs."

Domain 3: Clinical reasoning and application

Students appreciated that questions required applying biochemistry to patient cases rather than pure recall. Example quote: "It made me think like a doctor, not just memorise pathways."

Domain 4: Engagement and active participation

Seminars were described as "more interactive" and "less passive."

Reported minor challenges:

A small percentage of students requested more difficult, clinically complex questions. The common drawback mentioned by students also included occasional time constraints during seminars, and a few comments were made regarding public participation anxiety when MCQs were discussed.

Discussion

This study demonstrates that weekly formative MCQs in a cardiovascular biochemistry module are highly accepted by medical students and perceived to enhance engagement, self-directed learning, and clinical reasoning.

Interpretation of Key Findings

The high mean scores for engagement questions (mean 4.77) and learning/self-assessment (mean 4.66) align with the principle that frequent, low-stakes testing encourages continuous study habits. The strong endorsement of Question 3 ("MCQs helped me identify gaps in my knowledge better than just reading notes") supports the self-assessment function of formative assessment. Critical thinking scores (mean 4.58) should be mentioned separately since they reflect perceived application of biochemistry to clinical scenarios, which is eventually a core goal of medical education. The open-ended comments confirmed that students valued clinical integration. Exam preparedness scores were slightly lower (mean 4.43), with the highest percentage of neutral responses (14.2% for Question 9). This finding may indicate that some students found the formative MCQs easier than the final examination, or that they desired even more challenging questions. Nevertheless, most students still agreed/strongly agreed that MCQs helped with exam preparedness.

Our findings align with existing evidence from medical education. For instance, a recent study on formative assessment in biochemistry reported that 99.3% of students found regular MCQ tests highly beneficial for their learning and motivation [10]. Additionally, research has shown that

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disclosing and reusing MCQ items for low-stakes formative purposes can decrease student anxiety while improving feedback and transparency in the learning process [14]. Furthermore, the use of a formative online assessment platform helped 72% of medical students feel more supported in their learning, and 75% identify their own knowledge gaps, both of which are key contributors to building confidence and reducing summative exam stress [15]. However, our study adds domain-specific evidence for cardiovascular biochemistry, a traditionally difficult area due to the integration of metabolism, enzymology, and clinical markers.

Practical Implications and Future Directions

The results of our study indicate the necessity for curriculum integration and clearly demonstrate that formative MCQs should be embedded weekly, not as isolated events. Also, open-ended questions indicated that a small proportion of students requested higher-difficulty questions, indicating that future iterations should include a tiered difficulty system (basic recall versus complex clinical reasoning). The results of our study also allowed us to identify a few students with public participation anxiety, indicating that anonymous digital response systems (clickers or polling apps) should be introduced as a possible choice for this group. We believe that the approach used in this study could be applied to other system-based modules, such as biochemistry of musculoskeletal, gastrointestinal, respiratory, endocrine, reproductive, urinary, and nervous systems.

Limitations of the Study

This study has several limitations, including its single-university, single-cohort design and the absence of a control group. Perceptions were measured post-course immediately, and therefore, the long-term retention was not assessed, and the use of self-report data may overestimate positive effects. Additionally, the study did not directly correlate MCQ performance with final exam scores, which is planned as the next phase.

Thus, as was demonstrated by this study, formative MCQs in cardiovascular biochemistry significantly enhanced student engagement, self-assessment, and clinical reasoning. Students strongly endorse this method and report few challenges. These findings strongly support the broader adoption of active, formative assessment strategies in pre-clinical medical curricula, particularly in system-based disciplines where clinical integration is essential.

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აბსტრაქტი

მედიცინის სტუდენტებს ხშირად უჭირთ აბსტრაქტული ბიოქიმიური კონცეფციების გამოყენება კლინიკურ პრაქტიკაში. ეს პრობლემა განსაკუთრებით თვალსაჩინოა ისეთ კომპლექსურ მოდულებში, როგორიც გულ-სისხლძარღვთა სისტემის ბიოქიმიაა. სასწავლო (განმავითარებელმა) მრავალჯერადი არჩევნის კითხვებმა (MCQs) კარგი შედეგები აჩვენა ამ ხარვეზის აღმოფხვრის კუთხით, თუმცა, გულ-სისხლძარღვთა ბიოქიმიის კურიკულუმში, მათ ინტეგრაციაზე მწირი კვლევებია. წინამდებარე კვლევის მიზანი იყო ყოველკვირეული განმავითარებელი ტესტების ეფექტურობის შეფასება სტუდენტების ჩართულობაზე, თვითშეფასებაზე, კრიტიკულ აზროვნებასა და გამოცდისთვის მზადყოფნაზე გულ-სისხლძარღვთა ბიოქიმიის მოდულში. პროსპექტული, ერთკოჰორტული (დაკვირვებითი ჯგუფი) საგანმანათლებლო კვლევა ჩატარდა 7 კვირიანი გულ-სისხლძარღვთა ბიოქიმიის მოდულის ფარგლებში, უნივერსიტეტ გეომედში (თბილისი, საქართველო). კვლევაში მონაწილეობდა მედიცინის ფაკულტეტის მე-2 კურსის 120 სტუდენტი, რომლებიც, ყოველკვირეულად, განმავითარებელ ტესტებს გადიოდნენ (MCQs). ეს კითხვები შეიქმნა 7 სხვადასხვა თემაში კლინიკური პრაქტიკის მნიშვნელობის ხაზგასმის მიზნით. მოდულისა და დასკვნითი გამოცდის დასრულების შემდეგ, სტუდენტებმა შეავსეს 12 კითხვიანი ანონიმური კითხვარი, რომელიც მოიცავდა 10 რაოდენობრივ (ლიკერტის სკალა) და 2 ღია კითხვას. გამოხმაურების მაჩვენებელი 100% იყო. საშუალო ქულები, ყველა კრიტიკული მიმართულებით, მაღალი იყო: ჩართულობა (4,77/5), სწავლა და თვითშეფასება (4,66/5), კრიტიკული აზროვნება (4,58/5), გამოცდისთვის მზადყოფნა (4,43/5) და საერთო კმაყოფილება (4,52/5). ყველაზე მაღალი შეფასება, „სრულიად ვეთანხმები“, დაფიქსირდა ჩართულობის (კითხვა 1, 85,8%), ცოდნაში არსებული ხარვეზების იდენტიფიცირებისა (კითხვა 3, 81,7%) და სემინარებზე დასწრების მოტივაციის (კითხვა 2, 71,7%) კატეგორიებში. უარყოფითი პასუხების მაჩვენებელი მინიმალური იყო (0-2,5% სხვადასხვა პუნქტში). თვისებრივმა თემატურმა ანალიზმა 4 ძირითადი უპირატესობა გამოავლინა: თვითშეფასება და ცოდნის ხარვეზების იდენტიფიცირება, გამოცდებისთვის მზადყოფნა, კლინიკური მსჯელობა და მიდგომების გამოყენება. ასევე, აქტიური მონაწილეობა და ჩართულობა.

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References

1. Brauer DG, Ferguson KJ. The integrated curriculum in medical education: AMEE Guide No. 96. *Medical Teacher*. 2015;37(4):312-322. doi:10.3109/0142159X.2014.970998

2. Fulton TB, Collins S, Van Der Schaaf M, O'Brien BC. Connecting Biochemistry Knowledge to Patient Care in the Clinical Workplace: Senior Medical Students' Perceptions about Facilitators and Barriers. *Teaching and Learning in Medicine*. 2023;35(4):398-410. doi:10.1080/10401334.2022.2084400

3. Bryan C, Bryan C, Clegg K, eds. *Innovative Assessment in Higher Education*. 0 ed. Routledge; 2006. doi:10.4324/9780203969670

4. Aldosari MS. From Recall to Resilience: Reforming Assessment Practices in Saudi Theory-Based Higher Education to Advance Vision 2030. *Sustainability*. 2025;17(21):9415. doi:10.3390/su17219415

5. Lipnevich AA, Mattern K, Feddock C. Formative assessment and feedback in medical education: A practical guide: AMEE Guide No. 189. *Medical Teacher*. 2026;48(6):921-940. doi:10.1080/0142159X.2025.2569623

6. Lei W, Lei Z. Formative assessment literacy: a systematic review. *Lang Test Asia*. 2025;16(1):7. doi:10.1186/s40468-025-00418-0

7. Steele S, Nayak N, Mohamed Y, Panigrahi D. The Generation and Use of Medical MCQs: A Narrative Review. *AMEP*. 2025;Volume 16:1331-1340. doi:10.2147/AMEP.S513119

8. Reid M, French M, Andreopoulos S, Wong C, Kee N. AI-generated multiple-choice questions in health science education: Stakeholder perspectives and implementation considerations. *Current Research in Physiology*. 2025;8:100160. doi:10.1016/j.crphys.2025.100160

9. Javaeed A. Assessment of Higher Ordered Thinking in Medical Education: Multiple Choice Questions and Modified Essay Questions. *MedEdPublish*. 2018;7:128. doi:10.15694/mep.2018.0000128.1

10. Panchbudhe S, Shaikh S, Swami H, et al. Efficacy of Google Form–based MCQ tests for formative assessment in medical biochemistry education. *Journal of Education and Health Promotion*. 2024;13(1). doi:10.4103/jehp.jehp_981_23

11. Schwartzman WE, Paul SN, Amsterdam C, et al. A Novel, Mutually Beneficial Student-Faculty Partnership to Develop Real-Time Formative Assessments Aligning With the Preclinical Undergraduate Medical Curriculum. *Academic Medicine*. 2025;100(1):33-37. doi:10.1097/ACM.0000000000005801

12. Weiss JN, Yang L, Qu Z. Thematic review series: Systems Biology Approaches to Metabolic and Cardiovascular Disorders. Network perspectives of cardiovascular metabolism. *Journal of Lipid Research*. 2006;47(11):2355-2366. doi:10.1194/jlr.R600023-JLR20

13. Sharif A, Kasemy Z, Aloshari S. Assessment as Learning: A Mixed-Methods Study on Pre-Clinical Medical Student-Led Generation of Scenario-Based Multiple Choice Questions. *AMEP*. 2025;Volume 16:1847-1859. doi:10.2147/AMEP.S549385

14. Appelhaus S, Werner S, Grosse P, Kämmer JE. Feedback, fairness, and validity: effects of disclosing and reusing multiple-choice questions in medical schools. *Medical Education Online*. 2023;28(1):2143298. doi:10.1080/10872981.2022.2143298

15. Kaminski JJ, Franz A, Holzhausen Y, Wedenig HH, Sporn F, Peters H. Establishing TELLme – an online platform for self-directed, formative assessment of knowledge acquisition across an undergraduate medical curriculum. *Medical Teacher*. 2025;47(4):696-704. doi:10.1080/0142159X.2024.2362896

Review

Sport and the Environment: Ecological Responsibility and Sustainable Development Perspectives

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Abstract

The purpose of this study is to systematically evaluate the dual role of the modern sports industry: its negative ecological footprint (carbon emissions, waste, water consumption) and its potential for implementing and advocating sustainable development principles, taking into account both international experience and the Georgian context. The research involves identifying the environmental impacts of sporting events and infrastructure, their effects on athletes' health and event organization, analyzing international "sustainable sport" policies, and examining successful case studies. Furthermore, the work explores the potential of the sports industry to serve as a platform for raising public awareness and strengthening ecological responsibility, subsequently offering strategic recommendations for the effective implementation of sustainability and ecological standards within the Georgian sports system.

Keywords: sustainable sport, ecological footprint, carbon emissions, global warming, Olympic Charter, UNEP.

Introduction

Climate change, atmospheric pollution, and ecosystem degradation represent some of the most critical global challenges of the XXI century. Data indicates the direct impact of these issues on human health: for example, studies by American scientists suggest that air pollution causes approximately 5.5 million premature deaths annually, significantly exceeding mortality rates caused by other risk factors (Smith et al., 2017). On the other hand, according to the World Health Organization (WHO), environmental risk factors are responsible for 24% of global morbidity and 23% of mortality (WHO, 2016).

According to the United Nations Environment Programme (UNEP) report, in 2023, the planet's average temperature was 1.2°C higher than pre-industrial levels, while carbon dioxide levels reached an all-time high of 419 ppm. Air pollution, waste accumulation, deforestation, and biodiversity loss create new social and health challenges.

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Sport, which today has transcended the boundaries of physical activity to become a powerful global industry of culture, business, and social influence (accounting for approximately 5% of the world economy), cannot remain isolated from these processes. It unites hundreds of millions of people and possesses immense potential for social impact. It is simultaneously a contributor to ecological problems and a potential tool for their solution.

The sporting movement's capacity to mobilize millions of people makes it a prospective platform for raising awareness and stimulating responsible behavior.

The purpose of this article is to systematically assess the dual role of the sports industry: its negative ecological footprint and its potential to implement sustainability principles.

Although sport is traditionally associated with health and well-being, mass sporting events and infrastructure exert a significant negative impact on the environment. The International Olympic Committee (IOC) and the United Nations (UN) have long recognized the interaction between sport and the environment as a key priority issue.

Sport, by its very nature, is an energy-intensive and resource-consuming field. Large-scale sporting events require massive infrastructure, transportation, technological resources, and energy. At the same time, sport serves as an effective platform for raising ecological awareness.

Research Aim

To systematically evaluate the dual role of the modern sports industry—its negative ecological footprint (carbon emissions, waste, water consumption and its potential for advocating and implementing sustainable development principles, taking into account international experience and the Georgian context.

Research Objectives

1. To identify and analyze the primary negative environmental impacts of sporting events and infrastructure (specifically: carbon emissions, solid waste generation, and intensive water consumption) based on existing international statistical data.
2. To determine and assess the direct impact of environmental degradation on athletes' health and the viability of hosting sporting events (for instance, in the context of air pollution) through relevant case analyses.
3. To systematically review the concept of "sustainable sport," its integration at the international policy level (IOC, UNEP programs, and Olympic Charter principles), and to analyze successful case studies of mega-sporting events (e.g., the Olympic Games) regarding ecological responsibility.
4. To evaluate the potential of the sports industry to be utilized as an effective platform for advocating sustainable development principles (energy efficiency, waste management, eco-infrastructure) and raising public awareness.
5. To formulate recommendations for the Georgian sports system regarding the implementation of ecological responsibility and sustainability principles (e.g., strengthening Environmental Impact Assessment (EIA) processes, implementing energy efficiency standards).

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Analysis of Environmental Impacts and Case Studies

Carbon Emissions and Energy Consumption

Numerous studies indicate that sporting events significantly increase carbon emissions. For example, during the Tokyo 2021 Olympic Games, energy consumption from accommodation, transport, and infrastructure generated approximately 2.3 million tons of CO2—equivalent to the annual emissions of half a million passenger vehicles.

Similar to the Olympic Games, the FIFA World Cups and Formula 1 races cause not only excessive consumption of energy resources but also the artificial modification of the natural environment. Today, it is essential to implement energy-efficient technologies in sports, including LED lighting systems, solar panels, hybrid transport, and eco-friendly infrastructure.

Waste Generation

Sport is significantly linked to waste generation. Single-use bottles, packaging, plastic equipment, apparel, and other materials are often not recycled. At the 2019 London Marathon, 56,000 participants and spectators left behind 750,000 plastic bottles—approximately 7 tons of waste—in a single day. Similar examples are found in the 2018 FIFA World Cup and American baseball seasonal games, where tons of waste accumulate annually.

To address this issue, sports organizations are increasingly turning to digital ticketing, reusable containers, and the use of recycled materials.

Infrastructure and Ecosystem Degradation

The construction of sports facilities is often associated with ecological damage. During the 2014 FIFA World Cup in Brazil, stadium construction resulted in the deforestation of 1,700 hectares.

The development of mountain sports complexes frequently alters the natural topography and causes soil erosion. A prominent example is the Sochi 2014 Winter Olympics, where the construction of roads and hotels significantly damaged the Caucasus ecosystem.

Furthermore, golf courses, ski slopes, and sports parks require massive amounts of water. On average, a 30-hectare golf course consumes 15,000–30,000 liters of water per day. In world regions already experiencing water scarcity (e.g., the Mediterranean, the Middle East, Central Asia), such trends are ecologically unsustainable. It is imperative to introduce irrigation and technological systems in sports that utilize recycled or rainwater.

Impact of Environmental Degradation on Athletes and Events

Deteriorating air quality poses a direct threat to athletes' physiological functions and performance quality. Carbon monoxide (CO) binds to blood hemoglobin, significantly restricting oxygen delivery to the body.

In 2015, six participants in the Beijing Marathon suffered heart attacks due to heavy smog (Wang et al., 2016). In 2016, air pollution in Singapore led to the cancellation of the FINA Swimming World Cup finals, and in Iran, a sharp decline in air quality halted sporting events for several days. These facts underscore the critical importance of environmental factors for the functioning of sports.

The "Sustainable Sport" Concept and International Frameworks

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In response to the aforementioned challenges, the concept of "green" or "sustainable" sport emerged. This movement aims to design a sporting environment that minimizes ecological harm. Its core principles include: increasing energy efficiency, integrated waste management systems, implementing ecological standards, and fostering social responsibility toward the environment.

In 1994, the United Nations established the United Nations Environment Programme (UNEP), which began working on institutionalizing the relationship between sport and the environment. The Olympic Movement declared environmental protection as the third fundamental dimension of the Olympic Charter. This decision represents a formal recognition of ecological responsibility at the highest level of sport.

Major international events have demonstrated that the implementation of sustainability principles is practically feasible:

- **Sydney 2000 Olympic Games:** Entered history as the "Green Games"; the Olympic Park was built on a former landfill site, setting a precedent for land reclamation.
- **Tokyo 2020 Olympic Games:** Medals were manufactured from recycled electronic waste, demonstrating the effective integration of circular economy principles.
- **Paris 2024 Olympic Games:** Declared as games of "constant sustainability," aiming to use 100% renewable energy and achieve a significant reduction in carbon emissions.

The Context of Georgia: Current State and Perspectives

In Georgia, the interaction between sport and the environment is still in its developmental stages. In recent years, several key initiatives have been implemented:

- Introduction of energy efficiency standards in sports facilities;
- "Green campaigns" in schools and sports federations;
- The eco-friendly format of the Tbilisi Marathon, which incorporates waste recycling and a digital registration system.

However, the ecological management of sports requires a profound strategy and national policy, particularly when planning major infrastructural projects. In Georgia, especially for large-scale sports projects, it is necessary to tighten the Environmental Impact Assessment (EIA) process and fully comply with ecological standards.

Conclusion

Modern sport, as an essential part of the global economy and culture, carries a double responsibility: it leaves a significant ecological footprint, but at the same time, it possesses immense potential to catalyze positive environmental change. The concept of sustainable sport is no longer just an ecological objective; it is a social responsibility that synthesizes human health, economic development, and environmental protection. Sport, as a uniquely unifying force, can instill the necessity of responsible living on our planet into the consciousness of millions of people, which is critically important for preserving a healthy and sustainable environment for future generations.

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სპორტი და გარემო: ეკოლოგიური პასუხისმგებლობა და მდგრადი განვითარების პერსპექტივები

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აბსტრაქტი

წინამდებარე კვლევის მიზანია სისტემურად შეფასდეს თანამედროვე სპორტის ინდუსტრიის ორმხრივი როლი: მისი ნეგატიური ეკოლოგიური კვალი (ნახშირბადის ემისიები, ნარჩენები, წყლის მოხმარება) და მისი პოტენციალი მდგრადი განვითარების პრინციპების დანერგვისა და ადვოკატირების თვალსაზრისით, საერთაშორისო გამოცდილებისა და საქართველოს კონტექსტის გათვალისწინებით. კვლევა მოიცავს სპორტული ღონისძიებებისა და ინფრასტრუქტურის ეკოლოგიური ზემოქმედების გამოყოფას, მათ გავლენას სპორტსმენთა ჯანმრთელობაზე და ღონისძიებების ორგანიზებაზე, საერთაშორისო „მდგრადი სპორტის“ პოლიტიკის ანალიზს და წარმატებული ქეისების შემოწმებას. გარდა ამისა, მუშაობა იკვლევს სპორტის ინდუსტრიის პოტენციალს საზოგადოებრივი ცნობიერების ამაღლებისა და ეკოლოგიური პასუხისმგებლობის გაძლიერების პლატფორმად, ხოლო შემდგომში სტრატეგიულ რეკომენდაციებს სთავაზობს საქართველოს სპორტის სისტემისთვის მდგრადობისა და ეკოლოგიური სტანდარტების ეფექტურ დანერგვასთან დაკავშირებით.

საკვანძო სიტყვები: მდგრადი სპორტი, ეკოლოგიური კვალი, ნახშირბადის ემისიები, გლობალური დათბობა, ოლიმპიური ქარტია, UNEP.

References

1. Lominadze, G. (2021). *Ecological Education and Environmental Awareness in Sport*. Journal of Sport and Society, No. 5, pp. 34–42. *(In Georgian)*

2. World Health Organization Country Office in Georgia. (2023). *Environmental Pollution and Health in Georgia*. Tbilisi: WHO. *(In Georgian)*

3. Ministry of Environmental Protection and Agriculture of Georgia. (2024). *National Report on Environmental Policy*. Tbilisi. *(In Georgian)*

4. Dvalishvili, I. (2018). *Fundamentals of Ecological Management of Sporting Events*. Theory and Practice of Physical Culture, Vol. 12, pp. 57–65. *(In Georgian)*

5. World Health Organization (WHO). (2020). *Air Pollution and Health: A Global Assessment*. Geneva: WHO Press.

6. McCullough, B. P., Orr, M., & Kellison, T. (2020). *Sport Ecology: Conceptualizing an Emerging Subdiscipline within Sport Management*. Journal of Sport Management, 34(6), 509–520.

DOI: 10.56580/GEOMEDI83

7. International Olympic Committee (IOC). (2021). *Sustainability Strategy and Olympic Agenda 2020+5*. Lausanne: IOC Publications.

8. Collins, A., Jones, C., & Munday, M. (2021). *Assessing the environmental impacts of mega sporting events: The 2020 Tokyo Olympics*. Journal of Environmental Management, 290, 112581.

9. UNESCO. (2022). *Sport for Climate Action Framework*. Paris: UNESCO Publishing.

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Original Research Article

Water Polo in Georgia: Current State and Development Prospects

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Abstract

Preparaton is underway in Georgian water polo for 2028. By decision of the European Swimming Federation, the Water Polo Championship will be held in Tbilisi in two years. The best teams of the continent will gather in the country's capital. In this article we discuss the results of the Georgian water polo champion team "Apollo" in the Euro League round in Montpellier, France held in 2026 and show that our sportsmen can successfully compete against Europe's best teams. But despite the progress, Georgian water polo still faces challenges. The number of Olympic-size pools remains limited, and financial support is smaller compared with leading European countries such as Hungary, Serbia, Croatia, and Italy. Water polo has strategic importance for Georgian sports because it increases the country's visibility in aquatic disciplines beyond swimming. Participation in European and world championships strengthens Georgia's sporting reputation and creates opportunities for international cooperation. Compared with traditional water polo powers such as Hungary, Serbia, and Croatia, Georgia is still developing. However, its steady improvement during the last decade demonstrates significant potential for future success. In this context, it is obvious that more financial support is needed to create a stable and reliable basis for further development of water polo in Georgia. We also point out the need for more active use of scientific research methods to optimize the training process and improve the physical and technical preparation of athletes.

Keywords: Water polo, Water Polo Champions League – Euro 2026, Results of "Apollo" in the French tour, Georgian Aquatic Sports Federation.

Introduction

Water polo is one of the developing aquatic sports in Georgia. Although the country is more internationally recognized for sports such as rugby, wrestling, and judo, Georgian water polo has experienced significant progress during the last two decades.

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The establishment of professional clubs, improvements in youth development, and repeated participation in European and world competitions have helped Georgia become a competitive nation in international water polo.

The men's national team of Georgia has become increasingly competitive in European water polo. The team first appeared in the European Championship in 2014 and has continued to participate regularly in major tournaments. Georgia achieved one of its best results at the 2022 European Championship, finishing eighth. The country also participated in the 2022 World Championship, where it placed tenth.

The national team is managed by the Georgian Aquatic Sports Federation and includes many athletes who compete professionally in European leagues. The squad combines physical strength with tactical discipline, characteristics often associated with Georgian sports culture.

In 2019, the Georgian national water polo team received the title of "Best National Team of Georgia" after successful international performances and repeated qualification for the European Championship finals.

Last year, in 2025, at the meeting of the Georgian Water Polo Federation, a new president was elected - veteran water polo player and currently businessman D. Abdushelishvili. Before that, Mr. Dimitri had appeared before the public as the president of the water polo team "Apollo".

This year two Georgian teams are competing in the European Champions League: the Tbilisi teams "Dinamo" and "Apollo".

The Georgian water polo champion team, "Apollo," participated in the Euro Cup round in Montpellier, France, this year. In this article, we discuss the tournament results and demonstrate that Georgian sportsmen have made significant progress over the last 10 years, allowing them to compete successfully with the best European teams. We also analyze the current state of water polo in Georgia and provide recommendations on how to improve management, performance, and training within the sport.

Research objective

analysis of team results; analysis of the current state of water polo in Georgia; presentation of recommendations to the team staff.

Research methods

monitoring of the competitive activity of water polo players was carried out according to the methodology developed by us [1, 2]. This methodology enables the collection of data regarding various player and team parameters, specifically individual, group, and collective tactics for both defense and attack. Additionally, it allows for the retrieval of diverse information on technical-tactical maneuvers during play, tailored to the coach's specific objectives.

Results

Research methods are essential for the scientific development of water polo [1-9]. Physiological testing, biomechanical analysis, tactical observation, psychological assessment, and experimental studies all contribute to improving athlete performance and team success. Advances in technology continue to provide more accurate and detailed information about the sport.

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The integration of sports science into water polo allows coaches and athletes to train more efficiently, prevent injuries, optimize tactics, and better understand the demands of elite competition. As scientific methods continue to evolve, research will remain a fundamental part of the future development of water polo.

Using our established methodology [1, 2], we analyzed 'Apollo's' performance at the Euro Cup round in Montpellier, France.

The team roster included 15 water polo players aged 18–33. In Montpellier, the Georgian water polo players played 4 matches over 4 competition days. Opponents: Honved (Hungary), Primorje (Croatia), Bologna (Italy), Montpellier (France).

D. Giorgadze did not participate; he was replaced by Serbian legionnaire S. Vuksanovich. Moldovan Malishau missed one match due to injury; in the other three, he played 2–4 minutes. Second goalkeeper Kapanadze played in the penalty shootout

Apollo Playing in Defense

Georgian players used help defense (1:5), shifting to zone defense; pressing was rare. Goalkeeper Razmadze saved 3 penalties but needs more team support.

Central defenders Jakhaya and Rogach were excluded 8 and 6 times for rough play and conceded penalties twice each.

Apollo Playing in Attack

In 4 matches, the team scored 59 goals; 33 (56%) from play: 6 counterattacks; 13 flank-to-flank transfers; 10 positional play goals.

Only 2 goals from center forward; none from free play. Counterattack use: 34 times.

Table 1 shows the results of the “Apollo” team in matches with opponents. GK Stability – goalkeeper’s stability: the percentage of the goalkeeper’s wins; Shots on Goal – the number of shots on goal; GK Wins - the number of shots on goal blocked by the goalkeeper; Num. Adv. Realization – the number of numerical advantage realizations; Num. Disadv. – the number of failures to realize a numerical advantage; Active CA – active counter-attacks; Goal CA - counterattacks with goal scoring; Team Efficiency – the ratio of goals scored to the total number of shots.

Table 1. The results of the “Apollo” team in matches with opponents

N	Teams	GK Stabi-lity	Shots on Goal	GK Wins	Num. Adv. Realization	Num. Disadv.	Counter-attacks	Active CA	Goal CA	Team Efficiency
1	Apollo–Honved	32.1	28	9	3–7 (42.8%)	58.4%	7	3	–	44%
2	Apollo–Primorje	41	22	9	4–9 (44.4%)	33.4%	7	4	–	
3	Apollo–Bologna	30.4	23	7	5–9 (55.5%)	55.6%	7	2	1	
4	Apollo–Montpellier	41	22	9	7–14 (50%)	50%	13	4	5	

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	Apollo Average	35.7	95	34	19–39 (48.7%)	50%	34	13	6	40.4%

Table 2. The results of the opponents of the "Apollo" team

N	Teams	GK Stabi-lity	Shots on Goal	GK Wins	Num. Adv. Realization	Num. Disadv.	Counter-attacks	Active CA	Goal CA	Team Efficiency
1	Honved–Apollo	40%	30	12	5–12 (41.6%)	57.2%	7	2	2	50%
2	Primorje–Apollo	58%	31	18	6–9 (66.6%)	55.6%	7	1	1	43.3%
3	Bologna–Apollo	48.2	29	14	4–9 (44.4%)	44.6%	6	1	–	
4	Montpellier–Apollo	37.5	32	12	3–6 (50%)	50%	7	1	2	
	Opponents Average	45.9	122	56	18–36 (50%)	51.3%	27	5	5	41%

Table 2 shows the results of the opponents of the "Apollo" team.

Playing with Numerical Advantage

Average realization: 48.7%. Against Hungary 42.8%. Against France 50%, but it should have been higher. Team must prepare 3–4 ideal combinations and transform systems to 3:3 or 4:2.

Defense in Numerical Disadvantage

Average in 4 matches: 50%. Against Croatia: 33.4%. Georgian players compensated with goals from play; same vs France – 50%. The team must improve blocking, zone control and correct tactical positioning.

The analysis of the matches of the Georgian water polo team "Apollo" at the competition in France presented in this article shows that Georgian water polo players are quite capable of competing against the best European teams.

The Georgia men's national water polo team has improved a lot over the last decade, but it is still clearly a “second-tier” European side rather than a true continental powerhouse.

At club/national infrastructure level, Georgia is still behind the traditional water polo cultures:

- Hungary and Serbia have enormous domestic traditions and talent pipelines.
- Croatia and Spain have elite professional clubs and youth systems.
- Georgia’s domestic ecosystem is much smaller, although its European club ranking has improved to around 11th–14th range recently.

Conclusion

The management of sports development in Georgian water polo needs to be re-evaluated. The material and technical base

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must be developed, and new swimming complexes should be built. Today, water polo is an expensive sport - revitalizing sports schools will help us address this issue. Maximum attention must be paid to the preparation of reserves.

For the first time in 35 years, Georgian players showed stable play against Europe's best teams. Three matches ended in draws, and two were lost in penalty shootouts. Wins against Primorje and Montpellier in regular time. The team scored 59 goals (56 % from play). Average age 30 - generational change expected in 1–2 years. Although challenges related to infrastructure and funding remain, Georgia's achievements in European and world competitions indicate a promising future. More attention should be paid to statistical and analytical analysis of athletes' physical, technical, and tactical training. Furthermore, it is necessary to periodically monitor and evaluate athletes' key physiological parameters.

Continued investment in youth training, coaching, and international cooperation may allow Georgian water polo to become even more competitive on the global stage.

წყალბურთი საქართველოში: მიმდინარე მდგომარეობა და განვითარების პერსპექტივები

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აბსტრაქტი

საქართველოს წყალბურთში მიმდინარეობს მზადება 2028 წლისთვის. ევროპის ცურვის ფედერაციის გადაწყვეტილებით, ორ წელიწადში თბილისში ჩატარდება წყალბურთელთა ჩემპიონატი. კონტინენტის საუკეთესო გუნდები მოიყრიან თავს ქვეყნის დედაქალაქში. წინამდებარე სტატიაში განვიხილავთ საქართველოს წყალბურთის ჩემპიონი გუნდის - „აპოლოს“ შედეგებს 2026 წელს საფრანგეთის ქალაქ მონპელიეში გამართულ ევროთასის (Euro Cup) ტურში და ვაჩვენებთ, რომ ჩვენს სპორტსმენებს შეუძლიათ წარმატებით გაუწიონ კონკურენცია ევროპის საუკეთესო გუნდებს. მიუხედავად პროგრესისა, ქართული წყალბურთი კვლავ დგას გარკვეული გამოწვევების წინაშე. ოლიმპიური სტანდარტების აუზების რაოდენობა შეზღუდულია, ხოლო ფინანსური მხარდაჭერა ჩამოუვარდება ევროპის ისეთ წამყვან ქვეყნებს, როგორიცაა უნგრეთი, სერბეთი, ხორვატია და იტალია. წყალბურთს სტრატეგიული მნიშვნელობა აქვს ქართული სპორტისთვის, რადგან იგი ზრდის ქვეყნის ცნობადობას საწყალოსნო დისციპლინებში. ევროპისა და მსოფლიო ჩემპიონატებში მონაწილეობა აძლიერებს საქართველოს სპორტულ რეპუტაციას და ქმნის საერთაშორისო თანამშრომლობის შესაძლებლობებს. ტრადიციულ წყალბურთის სახელმწიფოებთან შედარებით (უნგრეთი, სერბეთი, ხორვატია),

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საქართველო ჯერ კიდევ განვითარების პროცესშია, თუმცა ბოლო ათწლეულის სტაბილური გაუმჯობესება, სამომავლო წარმატების დიდ პოტენციალზე მეტყველებს. ამ კონტექსტში აშკარაა, რომ მეტი ფინანსური მხარდაჭერაა საჭირო ქართული წყალბურთის შემდგომი განვითარებისთვის სტაბილური ბაზის შესაქმნელად. ჩვენ, ასევე, ხაზს ვუსვამთ სამეცნიერო კვლევის მეთოდების უფრო აქტიური გამოყენების აუცილებლობას საწვრთნელი პროცესის ოპტიმიზაციისა და სპორტსმენების ფიზიკური და ტექნიკური მომზადების გასაუმჯობესებლად.

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References

1. Karangozashvili D. (1990). Dissertation abstract. Tbilisi.
2. Karangozashvili D. (2022). Tactical activity of water polo players. Tbilisi.
3. Hochstein, S., Hohenstein, D., & Hohmann, A. (2022). Goal Shot Analysis in Elite Water Polo -World Cup Final 2018 in Berlin. Applied Sciences, 12(3), 1298. https://doi.org/10.3390/app12031298
4. Melchiorri, G., Triossi, T., Bianchi, D., Tancredi, V., & Viero, V. (2022). Physical Characteristics and Performance Tests in Male Water Polo: A Multiple Regression Analysis on Youth. International journal of environmental research and public health, 19(14), 8241. https://doi.org/10.3390/ijerph19148241
5. Botonis, P. G., Toubekis, A. G., & Platanou, T. I. (2019). Physiological and Tactical On-court Demands of Water Polo. Journal of strength and conditioning research, 33(11), 3188–3199. https://doi.org/10.1519/JSC.0000000000002680
6. De Siati, F., Laffaye, G., Gatta, G., Dello Iacono, A., Ardigò, L. P., & Padulo, J. (2016). Neuromuscular and technical abilities related to age in water-polo players. Journal of sports sciences, 34(15), 1466–1472. https://doi.org/10.1080/02640414.2015.1119298
7. Botonis, P. G., Toubekis, A. G., & Platanou, T. I. (2019). Training Loads, Wellness and Performance Before and During Tapering for a Water-Polo Tournament. Journal of human kinetics, 66, 131–141. https://doi.org/10.2478/hukin-2018-0053
8. Viero, V., Triossi, T., Bianchi, D., Campagna, A., & Melchiorri, G. (2020). Physical and performance variables for talent identification in water polo. The Journal of sports medicine and physical fitness, 60(10), 1309–1316. https://doi.org/10.23736/S0022-4707.20.10712-6
9. Perazzetti, A., Tessitore, A., Özkol, M. Z., Novoselac, N., & Dopsaj, M. (2025). Assessment of Youth Water Polo Players' Swimming Sprint Potential: A New Approach to Building an International Model. Journal of Functional Morphology and Kinesiology, 10(2), 200. https://doi.org/10.3390/jfmk10020200

Reasoned Opinion

Vaccination and medical education of athletes

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Abstract

It is important to mention that athletes represent a specific group of the population with definite health demands due to intensive physical activity, regular travel, and close contact in training and competitive environments. These factors increase their sensibility to infectious diseases, which can negatively impact both individual performance and team outcomes. It is widely known that the vaccination is a critical preventive strategy in safeguarding athletes' health; however, vaccination coverage in this group is often incomplete due to limited awareness and insufficient medical guidance. This paper shows the role of vaccination in athlete health management and strengthens the importance of targeted medical education regarding health issues, prevention and rehabilitation. The proposed research includes current recommendations for immunization in athletes, including routine vaccines and those indicated for travel or sport-specific risks. Additionally, the study examines barriers to vaccine uptake, such as lack of knowledge, fear of side effects, and misinformation and misinterpretation.

The importance of medical education is highlighted as a key intervention to improve vaccination rates among young athletes. The educational programs for athletes, their coaches, and sports health professionals can improve the understanding of vaccine safety, efficacy, and timing. The integration of the Integrating preventive medicine into sports training systems may reduce the incidence of infectious diseases, sport traumas and in the future can support the optimal athletic performance.

We have concluded that the encouraging vaccination strategies together with inclusive medical education is vital for helping improve athlete health, minimizing disease-related troubles, and ensuring continuous performance at any level, both amateur and professional.

Keywords: athletes, vaccination, immunization, medical education, sports medicine.

Introduction

Athletes globally, due to the specific demands of their profession, face health challenges frequently. Intensive physical activity, regular travel, and close contact

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contact during training and competition substantially increases their exposure to infectious diseases, especially it was viable during Covid-19 period. The above-mentioned adversely affects both individual performance and the overall success of sports teams. Vaccination remains as one of the most effective prevention strategies to defend athlete health, but the vaccination rates among athletes remain still incompatible. It is important to mention that the various factors contribute to this, including inadequate awareness, misunderstandings about vaccine safety, and insufficient medical guidance at all. This paper covers the critical role of vaccination in athlete health management and the importance of medical education in overcoming barriers to vaccine acceptance, especially in sport field.

Sport influences people's health, the formation of value systems and human behavior, and the functioning of the financial and economic system. Sport has both educational and health-improving, as well as an economic function [3].

According to Article 17 of the Law of Georgia “On Sports”, which concerns the participation of health care organizations and institutions in the development of sports, health care organizations and institutions, functions, duties and competencies are defined, among which it should be noted: b) Sub-clause: “They provide medical control to members of the sports section, provide medical services to the Georgian national and other teams on The basis of a contract.” e) Sub-clause: “Sports training and competitions can be held in an ecologically and hygienically clean environment.” [1].

As for preventive vaccinations, they are regulated by Article 78 of the Law of Georgia "On Health" and approved by the Ministry. The Ministry develops and approves the national calendar of preventive vaccinations and the state medical program necessary for its implementation [2].

According to Article 15 of Chapter III of the same law: Management, Organization and Financing of the Health Care System, the implementation of state policy in the field of health care is ensured by the Ministry of Internally Displaced Persons from the Occupied Territories, Health, Labour and Social Affairs of Georgia (hereinafter referred to as the Ministry), which develops and issues relevant legal acts on issues within its competence, unless otherwise established by the legislation of Georgia [2].

Vaccination as an Important Preventive Measure

Routine vaccinations are highly recommended for athletes. These vaccines help protect against common infections. Additionally, athletes who travel frequently for competitions or training may require sport-specific vaccinations or those recommended for travel-related risks. These include vaccines for meningitis, yellow fever, and typhoid, which are particularly important for athletes participating in events in regions with higher risks of these diseases [4].

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The COVID-19 pandemic highlighted the importance of vaccination in ensuring that athletes can continue to compete safely. Since then, vaccinations have become a routine part of health protocols for athletes, not only for disease prevention but also to ensure that teams and competitions remain safe from outbreaks [5].

Barriers to Vaccination in Athletes

Despite the evident health benefits, vaccination coverage among athletes remains incompatible due to low understanding of the importance to be vaccinated. One of the primary barriers to vaccine uptake is a lack of awareness about the importance and safety. Many athletes, coaches, and even medical staff may not fully understand which vaccines are necessary for their specific sports or the regions in which they compete [5].

This lack of awareness is often compounded by misinformation or misconceptions about vaccines. Some athletes are afraid of potential side effects, believing that vaccines might negatively impact their performance or health in the long term. Others may avoid vaccination due to the belief that it could interfere with their training or competition cycles, fearing that side effects such as fever or fatigue could hinder their performance [6].

Another important barrier is the insufficient assistance from healthcare professionals. In many cases, athletes and coaches receive limited counseling on the importance of immunization or the risks associated with neglecting vaccination. Furthermore, athletes may not be aware of the importance of getting vaccinated in relation to their specific training and competition schedules, leading to confusion about when and how to receive vaccinations without compromising performance [6].

The Role of Medical Education in Improving Vaccine Coverage

Medical education plays a substantial role in addressing barriers. One of the most effective ways to improve vaccine uptake is through targeted education programs designed for athletes, coaches, and sports healthcare professionals. By enhancing their understanding of vaccine safety, efficacy, and the optimal timing for vaccination relative to training and competition cycles, athletes are more likely to make informed decisions regarding vaccination [7].

It is essential for athletes to understand that vaccines are thoroughly tested for safety and that the benefits far outweigh the risks. Additionally, these programs can provide athletes with guidance on how to incorporate vaccination into their schedules without negatively affecting their performance.

Health professionals in sport and coaches play an important role in this educational process. By becoming advocates for vaccination and working closely with athletes, these individuals can help improve vaccine awareness and ensure that athletes are protected from preventable diseases. Sports medicine professionals, such as team

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physicians, play a particularly critical role in providing personalized vaccine recommendations and addressing athletes' concerns about potential side effects.

Integrating preventive medicine, including vaccination, into the broader structure of sports training programs is another effective strategy. By doing so, athletes are more likely to view vaccination as a regular part of their health regimen, akin to proper nutrition, exercise, and recovery protocols. This integration can reduce the incidence of infectious diseases and ultimately support an athlete's optimal performance [4].

Conclusion

The importance of vaccination in athlete health cannot be exaggerated. It is widely known that vaccines are essential in protecting athletes from infectious diseases. Once again, to improve vaccination coverage, it is necessary to address the barriers of misinformation, lack of awareness, and limited medical guidance. Medical education is a crucial intervention in this regard. By providing athletes, coaches, and sports healthcare professionals with precise, it is possible to improve vaccine uptake and ensure that athletes remain healthy and perform at their best at all levels, such as individual and as a team.

To accomplish above-mentioned, comprehensive educational programs, directed medical counseling, and the integration of preventive medicine into sports training systems are more essential. Improving vaccination coverage strategies, alongside with continued medical education, will eventually promote athlete health, decrease disease-related disorders, and ensure improved performance at both amateur and professional levels. These recommendations are for the athletes, their coaches and medical personnel in sport industry. Of course, furthermore investigations must be done in this regard as soon as possible.

სპორტსმენების ვაქცინაცია და სამედიცინო განათლება

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აბსტრაქტი

მნიშვნელოვანია აღინიშნოს, რომ სპორტსმენები წარმოადგენენ მოსახლეობის სპეციფიკურ ჯგუფს, რომელსაც აქვს ჯანმრთელობის გარკვეული მოთხოვნები ინტენსიური ფიზიკური აქტივობის, რეგულარული მოგზაურობის და ვარჯიშსა და შეჯიბრებებში მჭიდრო კონტაქტის გამო. ეს ფაქტორები ზრდის მათ მგრძნობელობას ინფექციური დაავადებების მიმართ, რამაც შეიძლება უარყოფითად იმოქმედოს როგორც ინდივიდუალურ შესრულებაზე, ასევე გუნდის შედეგებზე. ფართოდ არის ცნობილი, რომ ვაქცინაცია სპორტსმენების ჯანმრთელობის დაცვის კრიტიკული პრევენციული სტრატეგიაა; თუმცა, ამ ჯგუფში ვაქცინაციის დაფარვა ხშირად არასრულია შეზღუდული ცოდნა და არასაკმარისი სამედიცინო განათლების გამო.
ეს ნაშრომი აჩვენებს ვაქცინაციის როლს სპორტსმენების ჯანმრთელობის მართვაში და ამლიერებს მიზნობრივი სამედიცინო განათლების მნიშვნელობას ჯანმრთელობის საკითხებთან, პრევენციასა და რეაბილიტაციასთან დაკავშირებით. ჩატარებული კვლევა მოიცავს სპორტსმენებში იმუნიზაციის მიმდინარე რეკომენდაციებს, მათ შორის რუტინულ ვაქცინებს და იმ ვაქცინებს, რომლებიც აუცილებელია მოგზაურობის ან სპორტთან დაკავშირებული რისკებისთვის. გარდა ამისა, კვლევა მოიცავს ვაქცინის მიღების ბარიერებს, როგორიცაა ცოდნის ნაკლებობა, გვერდითი მოვლენების შიში, დეზინფორმაცია და არასწორი ინტერპრეტაცია.

სამედიცინო განათლების მნიშვნელობა ხაზგასმულია, როგორც მთავარი ინტერვენცია ახალგაზრდა სპორტსმენებში ვაქცინაციის მაჩვენებლების გასაუმჯობესებლად. სპორტსმენების, მათი მწვრთნელებისა და ჯანდაცვის სპეციალისტებისთვის საგანმანათლებლო პროგრამებს შეუძლიათ გააუმჯობესონ ვაქცინის უსაფრთხოების, ეფექტურობისა და დროის აღქმა. სპორტული აქტივობების სისტემებში პრევენციული მედიცინის ინტეგრირებამ შესაძლოა შეამციროს ინფექციური დაავადებების, სპორტული ტრავმების შემთხვევები და მომავალში ხელი შეუწყოს ოპტიმალურ სპორტულ შედეგებს.

ჩვენ შეგვიძლია დავასკვნათ, რომ ვაქცინაციის სტრატეგიების წახალისება ინკლუზიურ სამედიცინო განათლებასთან ერთად სასიცოცხლოდ მნიშვნელოვანია სპორტსმენების ჯანმრთელობის გაუმჯობესების, დაავადებასთან დაკავშირებული პრობლემების მინიმიზაციისა და უწყვეტი შესრულების უზრუნველყოფისთვის ნებისმიერ, როგორც სამოყვარულო, ასევე პროფესიონალურ დონეზე.

საკვანძო სიტყვები: სპორტსმენები, ვაქცინაცია, იმუნიზაცია, სამედიცინო განათლება, სპორტული მედიცინა.

References

1. Law of Georgia On Sports. Website, 28.7.2020 Law of Georgia No 2769 of 5 April 2023.
2. Law of Georgia On Health Care. 10.12.1997
3. State Sports Policy Document 2014-

2020, Resolution of the Government of Georgia of May 22, 2013 N 127, p.6,

4. World Health Organization (WHO) (2023). *Vaccines and Immunization for Athletes*. Retrieved from [WHO website link].

5. Shannon, S., & Campbell, L. (2021). Barriers to Vaccination Among Athletes: A Systematic Review. *Journal of Public Health, 43*(2), 105-118.

6. Miller, G., & Thompson, H. (2020). The Role of Education in Promoting Vaccine Uptake Among Professional Athletes. *Sports Health Review, 12*(1), 59-72.

7. Centers for Disease Control and Prevention (CDC). (2023). *Recommended Vaccines for Athletes: CDC Guidelines*. Retrieved from [CDC website link].

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Reasoned Opinion

Rehabilitation and Social Integration of Children with Physical and Cognitive Developmental Disabilities: International Experience and Modern Approaches

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Abstract

The rehabilitation and social integration of children with physical and cognitive developmental disabilities constitute a critical priority within contemporary public health, education, and social policy. Modern international frameworks are anchored in the biopsychosocial model, which conceptualizes disability not merely as an individual's functional deficit, but as the dynamic interaction between the individual, environmental factors, social attitudes, and systemic barriers. The objective of this study is to evaluate current international models of pediatric rehabilitation, analyze mechanisms of social integration, and identify evidence-based, effective interventions. The methodology relies on a comparative analysis of reports from international organizations, contemporary scientific literature, and diverse national practices. The findings indicate that early intervention, multidisciplinary rehabilitation, inclusive education, and technological innovations significantly enhance children's functional independence, social participation, and overall quality of life. Concurrently, social stigma, economic inequality, and disparate access to services persist as substantial challenges.

Keywords: Rehabilitation, Developmental Disabilities, Social Integration, Inclusive Education, Early Intervention, Biopsychosocial Model.

Introduction

Physical and cognitive developmental disabilities among pediatric populations represent one of the most pressing challenges in global healthcare and social policy. According to data from the World Health Organization (WHO), millions of children worldwide live with various developmental disorders, which fundamentally restricts their capacity to Fully engage in educational, social, and community processes [1].

The contemporary international paradigm is rooted in the biopsychosocial model, which views disability as the product of the interaction between an individual and their environment [6]. This approach departs substantially from the traditional medical model; it shifts the focus from diagnoses and purely functional deficits toward the child's social participation, environmental adaptation, and collective societal responsibility [2].

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Over the past decade, paramount importance has been placed on the development of early intervention, multidisciplinary rehabilitation, inclusive education, and family-centered services [3, 4]. Concurrently, modern technological innovations—including virtual reality (VR), telerehabilitation, and assistive technologies—have fundamentally transformed clinical practice and enhanced service efficacy [4].

Despite documented progress, many countries still face profound challenges, including inequitable access to services, social stigma, economic barriers, and under-developed inclusive environments, all of which impede the comprehensive social integration of children [2, 6].

Research Objective

The purpose of this study is to conduct a comprehensive analysis of contemporary international models for the rehabilitation and social integration of children with physical and cognitive developmental disabilities. It aims to evaluate their efficacy and, based on evidence-based practices, identify interventions that optimize functional independence, social participation, and quality of life.

The study places specific emphasis on:

- The critical significance of early intervention;
- The efficacy of multidisciplinary rehabilitation;
- The role of inclusive education;
- The application of technological innovations;
- The importance of family- and community-centered services.

Relevance of the Study

The relevance of this search is underscored by the rising global prevalence of pediatric developmental disabilities and the increasing urgency of issues surrounding social integration [1]. Within the modern scientific community, substantial attention is directed toward enhancing a child's functioning, social participation, and quality of life, moving beyond isolated medical rehabilitation [4].

It is particularly critical to examine the factors that obstruct comprehensive integration, including:

- Discrimination and social stigma;
- Under-developed inclusive education systems;
- Limited or inequitable access to rehabilitation services;
- Economic and regional disparities [2, 6].

Furthermore, the study's relevance is amplified by the ongoing transformation of international policy away from traditional medical frameworks toward rights-based, inclusive approaches [2].

Research Novelty

The scientific novelty of this paper lies in its interdisciplinary and holistic examination of pediatric rehabilitation and social integration.

The novel contributions of this study include:

- A systemic and comparative analysis of contemporary international experiences;
- An evaluation of rehabilitation mechanisms framed within the biopsychosocial model;
- An analysis of the efficacy of recent technological innovations;
- Highlighting the critical importance of family-centered and community-based services;

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- An assessment of the correlation between inclusive education and multidisciplinary rehabilitation.

Literature Review

The Biopsychosocial Approach

Contemporary scientific literature demonstrates that the functioning of children with developmental disabilities is profoundly shaped not only by health conditions but also by environmental and social factors. The *International Classification of Functioning, Disability and Health (ICF)*, developed by the World Health Organization, serves as the primary theoretical foundation for modern rehabilitation practices [6].

Early Intervention

Empirical studies confirm that early diagnosis and intervention significantly improve a child's cognitive, motor, and social development [5]. Family-centered interventions that actively engage parents have proven uniquely effective during these critical neurodevelopmental stages [3].

Multidisciplinary Rehabilitation

Modern approaches rely heavily on multidisciplinary collaboration, integrating physiotherapy, occupational therapy, speech and language therapy, neuropsychological interventions, and psychosocial support [4].

Inclusive Education

Inclusive education is recognized as a primary mechanism for social integration [2]. Research indicates that children integrated into inclusive environments demonstrate superior social adaptation and emotional well-being.

Methodology

This study utilizes a qualitative research design, incorporating:

- An analysis of global reports from international organizations;
- A systemic review of peer-reviewed
scientific literature;
- A comparative analysis of cross-national practices.

A thematic analysis method was employed to identify international best practices and prominent systemic challenges.

Results

The findings of this study demonstrate that:

- Early intervention significantly mitigates the long-term impact of functional limitations [3, 5];
- Multidisciplinary rehabilitation substantially enhances functional independence [4];
- Inclusive education fosters robust social integration [2];
- Technological innovations optimize the efficacy of therapeutic processes [4];
- Family-centered models increase children's active social participation [3].

Conversely, social stigma, economic hardships, and restricted access to specialized services remain formidable barriers globally [1, 6].

Discussion

The gathered evidence confirms that pediatric rehabilitation must be rooted in a holistic and interdisciplinary framework that seamlessly unifies medical, psychological, educational, and social components [4, 6].

International experience indicates that successful systems are built upon early childhood intervention, multidisciplinary teamwork, inclusive schooling, and

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community-based services [1, 3]. Within this framework, deinstitutionalization policies are paramount, as they directly facilitate the development of children into fully-fledged, valued members of society [2].

Conclusion

Early intervention, multidisciplinary rehabilitation, and inclusive education form the cornerstone of effective rehabilitation and social integration for children with developmental disabilities.

While modern technological innovations significantly enhance the efficacy of therapeutic processes, it remains imperative to dismantle social barriers and improve service accessibility. The biopsychosocial model has established itself as the modern international standard, offering the most comprehensive framework for assessing and supporting child functioning.

Recommendations

- Implement systemic institutionalization of the biopsychosocial model across sectors;
- Expand the reach and capacity of early childhood intervention programs;
- Advance the infrastructure for multidisciplinary rehabilitation teams;
- Strengthen and resource the inclusive education system;
- Increase the accessibility and affordability of assistive technologies;
- Enhance financial and psychosocial support frameworks for families;
- Further develop community-based services and advance deinstitutionalization policies.

ფიზიკური და კოგნიტური განვითარების დარღვევების მქონე ბავშვთა რეაბილიტაცია და სოციალური ინტეგრაცია: საერთაშორისო გამოცდილება და თანამედროვე მიდგომები

ლელა აფციაური

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აბსტრაქტი

ფიზიკური და კოგნიტური განვითარების დარღვევების მქონე ბავშვთა რეაბილიტაცია და სოციალური ინტეგრაცია თანამედროვე საზოგადოებრივი ჯანმრთელობის, განათლებისა და სოციალური პოლიტიკის ერთ-ერთ უმნიშვნელოვანეს მიმართულებას წარმოადგენს. თანამედროვე საერთაშორისო მიდგომები ეფუძნება ბიო-ფსიქო-სოციალურ მოდელს, რომლის მიხედვითაც შეზღუდულობა განიხილება არა მხოლოდ ინდივიდის ფუნქციური დეფიციტის, არამედ გარემოს, სოციალური დამოკიდებულებებისა და სისტემური ბარიერების ურთიერთქმედების შედეგად. წინამდებარე კვლევის მიზანია ბავშვთა რეაბილიტაციის თანამედროვე საერთაშორისო მოდელების შეფასება, სოციალური ინტეგრაციის მექანიზმების ანალიზი და მტკიცებულებებზე დაფუძნებული

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ეფექტური ინტერვენციების იდენტიფიცირება. კვლევა ეფუძნება საერთაშორისო ორგანიზაციების ანგარიშების, თანამედროვე სამეცნიერო ლიტერატურისა და სხვადასხვა ქვეყნის პრაქტიკის შედარებით ანალიზს. კვლევის შედეგები მიუთითებს, რომ ადრეული ინტერვენცია, მულტიდისციპლინური რეაბილიტაცია, ინკლუზიური განათლება და ტექნოლოგიური ინოვაციები მნიშვნელოვნად აუმჯობესებს ბავშვთა ფუნქციურ დამოუკიდებლობას, სოციალურ მონაწილეობასა და ცხოვრების ხარისხს. ამასთანავე, სოციალური სტიგმა, ეკონომიკური უთანასწორობა და სერვისებზე შეზღუდული ხელმისაწვდომობა კვლავ მნიშვნელოვან გამოწვევად რჩება.

საკვანძო სიტყვები: რეაბილიტაცია, განვითარების დარღვევები, სოციალური ინტეგრაცია, ინკლუზიური განათლება, ადრეული ინტერვენცია, ბიო-ფსიქო-სოციალური მოდელი.

References

1. World Health Organization. (2023). *Global report on children with developmental disabilities*. Geneva: WHO.

2. UNICEF. (2022). *Inclusion of children with disabilities*. New York: UNICEF.

3. Novak, I., et al. (2020). Early intervention for children with developmental disabilities. *Pediatrics*, 145(1), 1–12.

4. Camden, C., et al. (2019). Rehabilitation for children: Evidence-based approaches. *Developmental Medicine & Child Neurology*, 61(8), 890–898.

5. Shonkoff, J. P. (2021). *The Science of Early Childhood Development*. Harvard University Press.

6. World Health Organization & World Bank. (2021). *World Report on Disability*. Geneva: WHO.

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Original Research Article

Outpatient Care Utilization in Georgia: Determinants and Health System Efficiency Perspectives

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Abstract

Outpatient healthcare utilization is widely used as an indicator of how effectively a healthcare system responds to the needs of the population. It reflects not only access to medical services, but also the overall organization of healthcare delivery and the balance between outpatient and hospital-based care. In Georgia, the use of outpatient services has increased considerably during recent years and reached approximately 15.8 million visits in 2024. At the same time, inpatient infrastructure has remained relatively unchanged. The present study examines several factors that may influence outpatient healthcare utilization in Georgia using official national statistical data. The analysis focuses on physician and nursing workforce availability, hospital bed capacity, healthcare expenditure per capita, demographic aging, and urbanization. The findings show that physician availability and healthcare expenditure are positively associated with outpatient service use. In addition, population aging appears to increase demand for outpatient care, which is consistent with the growing healthcare needs of older individuals. By contrast, hospital bed availability demonstrates a negative relationship with outpatient utilization, possibly reflecting a gradual shift from inpatient care toward outpatient services. Overall, the results indicate that although outpatient healthcare services continue to expand in Georgia, certain structural and organizational challenges remain within the healthcare system. The study highlights the importance of strengthening primary healthcare and improving the distribution and use of healthcare resources.

Keywords: Outpatient care, healthcare utilization, health system efficiency, Georgia, resource allocation.

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Introduction

Over the last few decades, many healthcare systems have increasingly shifted their attention from hospital-centered treatment toward outpatient and primary healthcare services. One of the main reasons for this transition is the growing pressure on healthcare systems caused by rising costs, demographic aging, and increasing demand for accessible medical care [9]. Outpatient services are often considered more flexible and cost-effective, particularly for preventive care and long-term disease management.

Georgia has experienced similar changes in healthcare utilization patterns. During the past decade, the number of outpatient visits has steadily increased and reached approximately 15.8 million in 2024. In comparison, inpatient infrastructure has shown relatively little change over the same period. According to national statistical data, the country currently has around 239 hospitals and nearly 15 000 hospital beds. The healthcare workforce includes approximately 24 000 physicians and 21 000 nurses.

Even though these healthcare resources exist, the use of outpatient services continues to increase. This may mean that some problems still remain in the organization of the healthcare system and the distribution of resources. For this reason, it is important to study what affects outpatient healthcare use and what changes may improve the healthcare system.

Aim and Objectives

The aim of this study is to examine the main factors affecting outpatienthealthcare utilization in Georgia and to understand how these factors influence the healthcare system using national statistical data. The study focuses on healthcare resources, healthcare spending, and demographic changes related to outpatient service use.

The objectives of the study are:

- To examine trends in outpatient healthcare utilization;
- To identify major factors associated with outpatient service use;
- To assess the role of healthcare workforce availability in healthcare utilization;
- To evaluate the relationship between healthcare expenditure and access to outpatient care;
- To examine the interaction between inpatient capacity and outpatient demand;
- To analyze the impact of population aging on healthcare utilization patterns.

Materials

The study is based on official statistical information from the National Statistics Office of Georgia. The data consist of healthcare and demographic indicators [1], [2].

The main variables included in the analysis were [7], [8], [9], [10]:

- Outpatient visits per capita (as a dependent variable);
- Physician density (physicians per 1 000 population as an independent variable);
- Nursing staff density (nurses per 1 000 population as an independent variable);

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- Hospital bed availability (beds per 1 000 population as an independent variable);
- Healthcare expenditure per capita (as an independent variable);
- Proportion of population aged 65+ (as an independent variable);
- Urbanization rate (percent urban population as an independent variable).

These indicators were selected because they show the availability of healthcare resources. They also reflect population characteristics. Such variables may affect the use of healthcare services.

Data and Descriptive Analysis

The major indicators presented in Table 1 show the current condition and capacity of the healthcare system in Georgia.

The data suggest that outpatient and primary healthcare services are used more actively than before. Many patients now receive medical consultation and treatment outside hospitals. These reflect ongoing changes in healthcare service delivery.

At the same time, the number of hospitals and hospital beds remains relatively limited compared to the growing demand for healthcare services.

Georgia still has a large medical workforce. It includes around 24 000 doctors and 21 000 nurses. However, balancing healthcare demand with available resources continues to be an important challenge for the healthcare system.

Table 1. Main Healthcare Indicators in Georgia, 2024 [1], [2].

Statistical Indicator	Numerical Value
Number of Outpatient visits	15 805 939
Number of Hospitals	239
Number of Hospital beds	14 964
Number of Physicians	24 139
Number of Nurses	21 308
Number of Population (approximately)	3.7 million

Note: The data of healthcare statistics for 2025 will be available on July 29, 2026.

The charts included in the study demonstrate changes in outpatient healthcare utilization and hospital infrastructure over time. Outpatient visits show a steady upward trend. This means growing demand for ambulatory healthcare services (Chart 1. [1]). Meanwhile, hospital bed capacity fluctuated during the observed period, with a decline in earlier years followed by partial recovery after 2016 (Chart 2. [1]).

Chart 1. Number of Outpatient facilities and outpatient visits, thousand

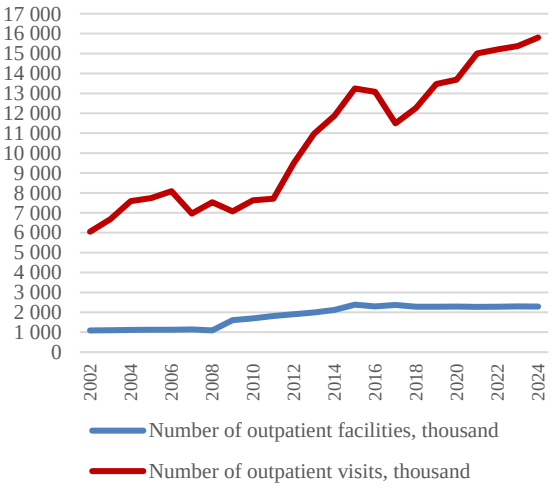

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Chart 2. Number of hospital beds, thousand

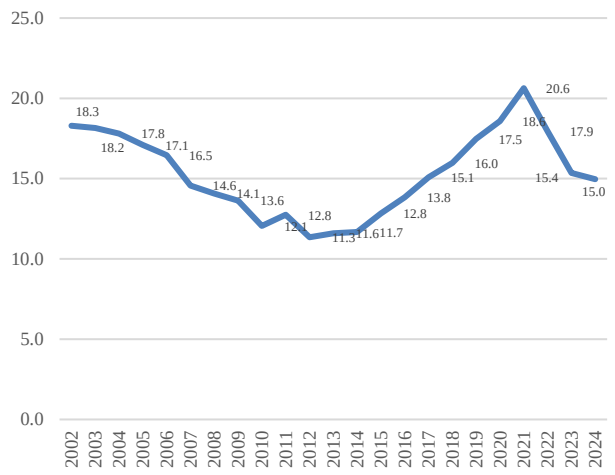

Table 2. Principal Healthcare Indicators Per Capita {1},[2}.

Name of the Indicator	Numerical Value
Doctors per 1000 population	6.5
Nurses per 1000 population	5.7
Number of Hospital beds per 1 000 population	4.0
Outpatient visits per capita	4.27

Table 2 further illustrates healthcare resource availability relative to population size. Georgia has approximately 6.5 doctors and 5.7 nurses per 1 000 population, indicating comparatively strong physician availability. However, hospital bed availability remains moderate at 4 beds per 1 000 population, which supports the view that the healthcare system is becoming increasingly outpatient-oriented.

The average of 4.27 outpatient visits per capita also indicates relatively active utilization of healthcare services. This may reflect improved access to healthcare and greater use of preventive and diagnostic services by the population. Nevertheless, the difference between outpatient demand and inpatient capacity could create additional pressure on hospitals during periods of increased healthcare needs.

Methods

This study applies a multivariate linear regression model [3], [4], [5], [6] to examine the determinants of outpatient healthcare utilization in Georgia. The analysis focuses on the relationship between outpatient service use and several demographics, structural, and economic factors that may influence healthcare demand and accessibility.

The empirical model is specified as follows:

$$Y=\beta0+\beta1Physicians+\beta2Nurses+\beta3Beds+\beta4Expenditure+\beta5Aging+\beta6Urbanization+\varepsilon$$

In this equation Y is the resultant variable. It represents outpatient healthcare utilization per capita. β0 is the intercept term. β_1–β_6 are the estimated coefficients of the explanatory variables. ε denotes the error term.

The dependent variable in the analysis is outpatient utilization per capita. Independent variables include six factors: physician density, nursing density, hospital bed availability, healthcare expenditure per

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capita, population aging rate and urbanization rate. These variables were selected because of their theoretical relevance in explaining healthcare utilization patterns.

Standard statistical procedures were used to estimate the regression coefficients and evaluate statistical significance. Statistical significance was assessed at the 5% level ($p < 0.05$).

Results

The regression analysis identified several factors associated with outpatient healthcare utilization in Georgia. The estimated model demonstrated relatively strong explanatory power, with an R^2 value of 0.71 and an adjusted R^2 of 0.68. This suggests that the selected variables explain a substantial proportion of variation in outpatient healthcare utilization.

The overall model was statistically significant ($F = 18.92$, $p < 0.001$). The table below represents the coefficient of determination, F statistics and the level of significance.

Table 3. Regression Statistics

Statistical Indicator	Value
R^2	0.71
Adjusted R^2	0.68
F-statistic	18.92
p-value	< 0.001

Among the included predictors, physician density showed the strongest positive association with outpatient utilization ($\beta = 0.42$, $p < 0.01$). This finding suggests that greater physician availability may improve access to medical services and contribute to more frequent use of outpatient care.

Healthcare expenditure per capita also demonstrated a positive and statistically significant relationship with outpatient utilization ($\beta = 0.35$, $p < 0.05$). Higher healthcare spending may contribute to better infrastructure, improved service quality, and wider healthcare accessibility.

The proportion of the elderly population was another significant factor ($\beta = 0.28$, $p < 0.05$). Older populations generally require more frequent medical consultations and long-term management of chronic conditions, which naturally increases demand for outpatient healthcare services.

Hospital bed availability, however, showed a negative relationship with outpatient utilization ($\beta = -0.25$, $p < 0.05$). One possible explanation is that healthcare systems relying more heavily on inpatient care may place comparatively less emphasis on outpatient services. At the same time, this relationship may reflect ongoing structural changes in the Georgian healthcare system, where outpatient care is gradually becoming more important.

Unlike several other variables, nursing workforce density and urbanization rate were not statistically significant within the model. Their influence on outpatient utilization may therefore be indirect or less pronounced in the context of this analysis.

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Overall, the findings indicate that outpatient healthcare utilization in Georgia is influenced mainly by physician availability, healthcare expenditure, and demographic aging.

Table 4. Overall Multivariate Regression Results on Determinants of Outpatient Healthcare Utilization

Name of Predictor	β Coefficients	Std. Error	t	p-value	Statistical Interpretation
Physician density	0.42	0.12	3.50	<0.01	Positive, significant
Nursing density	0.10	0.08	1.25	0.22	Not significant
Hospital bed availability	-0.25	0.09	-2.78	0.01	Negative, significant
Healthcare expenditure per capita	0.35	0.15	2.33	0.02	Positive, significant
Population 65 and above (%)	0.28	0.11	2.55	0.01	Positive, significant
Urbanization level (%)	0.08	0.07	1.14	0.26	Not significant

Conclusion

The findings of this study suggest that outpatient healthcare utilization in Georgia is shaped mainly by physician availability, healthcare expenditure, and demographic changes such as population aging. These factors appear to play an important role in determining the level of demand for outpatient healthcare services. The negative relationship between hospital bed availability and outpatient utilization may indicate a gradual transition from inpatient-centered healthcare delivery toward greater reliance on outpatient care. At the same time, the findings point to possible inefficiencies in healthcare resource distribution between inpatient and outpatient sectors.

Overall, the study highlights the importance of strengthening primary healthcare services, improving healthcare workforce distribution, and supporting more efficient allocation of healthcare resources. Such measures may contribute to better healthcare accessibility and improved long-term sustainability of the healthcare system in Georgia.

Policy Implications

The findings of this study highlight several important implications for healthcare policy in Georgia. Strengthening primary healthcare services should remain a priority, as better access to primary care may support earlier diagnosis and reduce unnecessary hospitalizations.

The results also suggest that increasing physician availability in outpatient settings

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could improve access to medical services and reduce pressure on inpatient care. In addition, more effective involvement of nurses in chronic disease management and patient follow-up may improve continuity and efficiency of care.

The negative relationship between hospital bed availability and outpatient utilization indicates the need for better coordination between inpatient and outpatient sectors. Finally, population aging emphasizes the importance of expanding preventive care and health promotion programs to address growing long-term demand for outpatient healthcare services.

ამბულატორიული მომსახურების გამოყენება საქართველოში: განმსაზღვრელი ფაქტორები და ჯანდაცვის სისტემის ეფექტიანობის პერსპექტივები

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აბსტრაქტი

ამბულატორიული მომსახურების გამოყენება ჯანდაცვის სისტემის მუშაობის შეფასების ერთ-ერთ მნიშვნელოვან მაჩვენებლად ითვლება, რადგან, ის აჩვენებს, თუ რამდენად ხელმისაწვდომია მოსახლეობისთვის სამედიცინო მომსახურება და როგორ ფუნქციონირებს ჯანდაცვის სისტემა მთლიანობაში. გარდა ამისა, ის გვაძლევს წარმოდგენას იმაზე, თუ როგორი ბალანსია ამბულატორიულ და სტაციონარულ მომსახურებას შორის. საქართველოში, ბოლო წლებში, ამბულატორიულ სერვისებზე მიმართვიანობა მნიშვნელოვნად გაიზარდა და 2024 წელს ვიზიტების რაოდენობამ, დაახლოებით, 15.8 მილიონს მიაღწია. ამავე დროს, სტაციონარული ინფრასტრუქტურა თითქმის უცვლელი დარჩა. ჩვენი კვლევა ეფუძნება ოფიციალურ სტატისტიკურ მონაცემებს და მიზნად ისახავს იმ ფაქტორების შესწავლას, რომლებიც გავლენას ახდენს ამბულატორიული მომსახურების გამოყენებაზე საქართველოში. მნიშვნელოვან მიზეზობრივ ცვლადებად განხილულია ექიმებისა და ექთნების რაოდენობა, საავადმყოფო საწოლების რაოდენობა, ჯანდაცვაზე გაწეული ხარჯები, მოსახლეობის დაბერება და ურბანიზაციის დონე. კვლევის შედეგების მიხედვით, ექიმების ხელმისაწვდომობის ზრდა ამბულატორიული მომსახურების უფრო აქტიურად გამოყენებაზე მიუთითებს. მსგავსი კავშირი გამოვლინდა ჯანდაცვის ხარჯების შემთხვევაშიც. დაფინანსების ზრდასთან ერთად, იზრდება სამედიცინო მომსახურებაზე ხელმისაწვდომობაც. ასევე, გამოიკვეთა, რომ მოსახლეობის დაბერება ზრდის ამბულატორიულ მომსახურებაზე მოთხოვნას, რადგან, ასაკის მატებასთან ერთად, ადამიანები უფრო ხშირად საჭიროებენ სამედიცინო მეთვალყურეობასა და

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მკურნალობას. ამასთან ერთად, კვლევამ აჩვენა, რომ საავადმყოფო საწოლების რაოდენობასა და ამბულატორიული მომსახურების გამოყენებას შორის უარყოფითი კავშირი არსებობს. ეს, შესაძლოა, მიუთითებდეს იმაზე, რომ ჯანდაცვის სისტემა თანდათან გადადის ამბულატორიულ მომსახურებაზე და მცირდება სტაციონარული მკურნალობის მნიშვნელობა. საერთო ჯამში, კვლევის შედეგები აჩვენებს, რომ საქართველოში ამბულატორიული მომსახურების განვითარებასთან ერთად, კვლავ რჩება გარკვეული პრობლემები რესურსების განაწილებისა და ჯანდაცვის სისტემის ორგანიზების მიმართულებით. ამიტომ მნიშვნელოვანია პირველადი ჯანდაცვის გაძლიერება და არსებული რესურსების უფრო ეფექტიანად გამოყენება.

საკვანძო სიტყვები: ამბულატორიული მომსახურება, ჯანდაცვის გამოყენება, ჯანდაცვის სისტემის ეფექტიანობა, საქართველო, რესურსების განაწილება

References

1. National Statistics Office of Georgia. Healthcare Indicators. https://www.geostat.ge/en/modules/categories/54/healthcare

2. National Statistics Office of Georgia. Indicators of vital statistics, Healthcare expenditures, https://www.geostat.ge/en

3. Gujarati DN, Porter DC. Basic Econometrics. 6th ed. New York: McGraw-Hill Education; 2021.

4. Wooldridge JM. Introductory Econometrics: A Modern Approach. 7th ed. Boston: Cengage Learning; 2021.

5. Arkes J. Regression Analysis: A Practical Introduction. 3rd ed. London: Routledge; 2025.

6. Starfield B. Primary Care: Balancing Health Needs, Services, and Technology. Rev ed. New York: Oxford University Press; 1998.

7. Grossman M. On the Concept of Health Capital and the Demand for Health. Journal of Political Economy. 1972;80(2):223–255.

8. Arrow KJ. Uncertainty and the Welfare Economics of Medical Care. American Economic Review. 1963;53(5):941–973.

9. World Health Organization. Primary Health Care, 2025, https://www.who.int/news-room/fact-sheets/detail/primary-health-care

10. World Health Organization. Country Data: Georgia. https://data.who.int/countries/268

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Original Research Article

Biomechanical Analysis of the Relationship Between Anthropometric Characteristics and Performance Results in Elite Track and Field Athletes

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Abstract

In athletics, sports performance may depend on the following biomechanical parameters of the athlete: muscle strength, body mass, moment of inertia, height, stride length, stride frequency and the length of an athlete's legs and arms. Each track and field discipline has its own requirements for these parameters, allowing for deviations from statistically calculated mean values. These deviations are due to the biomechanical characteristics of the specific discipline. In this article, we conduct a biomechanical analysis of deviations from mean values in the height, weight, and BMI indices of elite track and field athletes. We believe that when selecting and training athletes, coaches should consider their physical parameters as a whole, taking into account the biomechanical characteristics of the specific discipline.

Keywords: Sports biomechanics, biomechanical analysis, BMI index, athletics.

Introduction

It is well known that the Olympic champions, finalists and participants are well differentiated on age, height and weight (adjusted for height) in each of the eight running events [1]. Sprinters have a more massive body shape, shorter lower legs in relation to the length of the thigh, broader shoulders and narrower hips, greater musculature and cellular mass [2, 3]. Long-distance athletes are characterized by the highest ectomorphy and lowest muscle mass and body fat percentages to optimize oxygen utilization and reduce mass [4]. Some authors suggest that a mass distribution with smaller leg mass and greater trunk mass may be advantageous for achieving better running performance in endurance runners [5]. Middle-distance runners are the slimmest, and have a narrow trunk and little subcutaneous fat [2]. Throwers have predominantly mesomorphic somatotype and exhibit the largest body dimensions with significantly higher muscle mass and higher body fat percentages [4]. Jumpers tend to be more ectomorphic with leaner physiques, featuring substantially lower muscle mass [4].

The analysis of correlations between some body composition indicators and athletic performance is also recommended during

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the preparation of young athletes [6, 7]. Coaches and sports scientists can use the data obtained to better control training, as well as for talent identification and athlete selection.

In recent works, we discussed the average values of height, weight, and BMI index of elite track and field athletes and explained their biomechanical essence [8, 9]. It became clear that in sports disciplines such as the men's 100, 200, and 400-meter sprints, 800-meter run, high jump, long jump, triple jump, javelin throw, and combined events, the aforementioned parameters for most athletes are very close to the statistically calculated mean values. However, exceptions also exist where an athlete's height, weight, or BMI differs significantly from the mean. In this paper, we investigate the biomechanical essence of such exceptions.

Research Objectives

The main objective of this study is to determine how the performance of an elite track and field athlete depends on the athlete's height and weight in a specific athletic discipline from the biomechanical point of view, and what causes the existing deviations in these parameters.

Materials and Methods

In this paper, we used data from the world's best male track and field athletes across 10 athletic disciplines, which are published on the internet [10]. We conducted a statistical analysis of this data, calculated the average values of the athletes' height, weight, and BMI index for all disciplines, and compiled a table of their deviations from the mean value, based on which a qualitative biomechanical analysis of these deviations was subsequently performed.

Results

The average values of the height, weight, and BMI index of elite athletes across 10 athletic disciplines are shown in Table 1. Table 2 presents the metrics of these same parameters for world champions. Table 3 includes the data of those athletes whose height differs from the average value by 5 or more centimetres.

Table 1. Statistically calculated average values of height, weight, and BMI index of world-ranked male track and field athletes.

Discipline	Number of Athletes	Average Height (m)	Average Weight (kg)	BMI (kg/m²)
100 m Run	39	1.8	79.08	24.29
200 m Run	10	1.84	77.8	23.11
400 m Run	10	1.87	78	22.4
800 m Run	10	1.81	64.5	19.8
400 m Hurdles	20	1.82	65.76	19.88
High Jump	35	1.93	76.57	20.6
Long Jump	21	1.84	78.9	23.43
Triple Jump	10	1.86	79.6	22.98
Javelin Throw	11	1.9	97.18	26.84
Decathlon	61	1.9	88.34	24.56

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Table 2. Values of height, weight, and BMI index of world record holders across 10 track and field disciplines.

Discipline	World Record	Athlete's Name	Height (m)	Weight (kg)	BMI (kg/m²)
100 m Run	9.58 s	Usain Bolt	1.95	94	24.72
200 m Run	19.19 s	Usain Bolt	1.95	94	24.72
400 m Run	43.29 s	Michael Johnson	1.85	79	23.08
800 m Run	1:40.9 min	David Rudisha	1.9	71	19.67
400 m Hurdles	46.78 s	Kevin Young	1.94	82	21.79
High Jump	2.45 m	Javier Sotomayor	1.93	80	21.48
Long Jump	8.95 m	Mike Powell	1.88	79	22.35
Triple Jump	18.29 m	Jonathan Edwards	1.82	72	21.74
Javelin Throw	98.48 m	Jan Železný	1.86	88	25.44
Decathlon	9039 pts.	Ashton Eaton	1.85	84	24.54

Table 3. Deviations of height, weight, and BMI index of world-ranked male track and field athletes from the statistically calculated average values.

#	Sport Discipline and Athlete's Full Name	Result	Height (m)	Weight (kg)	BMI (kg/m²)
	100 m Run				
1	Usain Bolt	9.58 s	1.95	94	24.72
2	Asafa Powell	9.72 s	1.9	88	24.38
3	Nesta Carter	9.78 s	1.73	78	26.06
4	Olusoji Fasuba	9.85 s	1.65	70	25.71
5	Mike Rodgers	9.85 s	1.7	76	26.3
6	Francis Obikwelu	9.86 s	1.95	74	19.46
7	Michael Frater	9.88 s	1.7	67	23.18
8	Travis Padgett	9.89 s	1.73	82	27.4
	200 m Run				
1	Usain Bolt	19.19 s	1.95	94	24.72
2	Walter Dix	19.53 s	1.75	86	28.08
3	Xavier Carter	19.63 s	1.91	77	21.11
4	Wallace Spearmon	19.65 s	1.91	79	21.66
	400 m Run				
1	Harry Reynolds	43.29 s	1.93	84	22.55
2	Lee Evans	43.86 s	1.8	78	24.07
	800 m Run				
1	David Rudisha	01:40.9 min	1.9	71	19.67
2	Joaquim Cruz	01:41.3 min	1.87	74	21.16
3	Mohammed Aman	01:42.4 min	1.73	55	18.38
	400 m Hurdles				

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1	Kevin Young	46.78 s	1.94	82	21.79
2	Amadou Dia Ba	47.23 s	1.9	72	19.94
3	Bershawn Jackson	47.3 s	1.73	72	24.06
4	Hadi Soua'an Al-Somaily	47.53 s	1.72	72	24.34
5	Fabrizio Mori	47.54 s	1.68	68	24.09
6	Winthrop Graham	47.6 s	1.72	72	24.34
	High Jump				
1	Carlo Thränhardt	2.42 m	1.99	85	21.46
2	Patrik Sjöberg	2.41 m	2	84	21
3	Hollis Conway	2.40 m	1.83	68	20.3
4	Stefan Holm	2.40 m	1.81	69	21.06
5	Linus Thörnblad	2.38 m	1.8	76	23.46
6	Dietmar Mögenburg	2.39 m	2.01	78	19.31
7	Gennadiy Avdeyenko	2.38 m	2	82	20.5
	Long Jump				
1	Bob Beamon	8.9 m	1.89	75	21.99
2	Robert Emmiyan	8.86 m	1.78	69	21.78
3	Irving Saladino	8.73 m	1.76	70	22.6
4	Iván Pedroso	8.71 m	1.76	66	21.31
5	James Beckford	8.62 m	1.78	78	24.62
6	Yago Lamela	8.56 m	1.77	79	25.22
7	Aleksandr Menkov	8.56 m	1.78	74	23.36
8	Savante Stringfellow	8.52 m	1.91	84	23.03
	Triple Jump				
1	Kenny Harrison	18.09 m	1.78	75	23.67
2	James Beckford	17.92 m	1.78	78	24.62
3	Jadel Gregório	17.9 m	2.02	104	25.49
	Combined Events (Decathlon)				
1	Ashton Eaton	9039 pts.	1.85	84	24.56
2	Jürgen Hingsen	8832 pts.	2	102	25.5
3	Bryan Clay	8832 pts.	1.8	84	25.93
4	Dmitriy Karpov	8725 pts.	1.98	98	25
5	Leonel Suárez	8654 pts.	1.8	78	24.07
6	Dean Macey	8603 pts.	1.97	92	23.71
7	Aleksandr Pogorelov	8528 pts.	2.01	94	23.27
8	Christian Schenk	8500 pts.	2.01	93	23.02

In athletics, sports performance may depend on the following biomechanical parameters of the athlete:

- Muscle strength;
- Body mass;
- Moment of inertia;
- Height;
- Stride length;
- Stride frequency;
- Length of legs and/or arms.

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Muscle strength is important in all sports, but at the same time, we must consider the fact that muscle mass increases total body mass. This, in turn, requires more energy from the athlete and can cause fatigue in athletic disciplines where the athlete has to perform prolonged, intense movements.
Body mass is necessary when the athlete must perform a short-term action related to moving other physical objects (javelin throw, shot put, etc.).

The moment of inertia depends on the distribution of the athlete's mass in space. The further the centers of gravity of individual body parts are from the athlete's overall body center of gravity, the more energy it requires for the athlete to actuate and move these parts. Therefore, performing a movement by a tall athlete with long legs or arms requires more energy than performing a similar movement by a short athlete.

Height is important in many athletic events. Therefore, in all ten disciplines discussed, the average height of the athletes exceeds 1.80 m. Height is particularly important in disciplines such as the high jump, javelin throw, and combined events (decathlon).

Stride frequency indicates how often the athlete's foot touches the ground per minute. Stride length, on the other hand, determines the distance the athlete covers in a single stride. Speed is a function of frequency and stride length. These parameters are interdependent, and their optimal ratio yields maximum speed. An increase in speed is achieved by increasing either stride length or frequency.

Long arms can prove beneficial in athletic disciplines where athletes perform throws, strikes, and puts. Long legs, on the other hand, are useful in running and when performing jumps.
Based on a detailed analysis of the accumulated data, we can explain the biomechanics of the aforementioned athletic disciplines:

100 m: The height of athletes in this discipline ranges from 1.65 to 1.95 m. This is due to the fact that a short athlete can achieve a good result through quickness—meaning a higher stride frequency—while a tall athlete has longer strides but will have to expend more energy to overcome inertia. In this discipline, the athlete must find the optimal balance between stride length and frequency.

200 m: The height of athletes in this discipline ranges from 1.75 to 1.95 m. In this sport, more emphasis is placed on stride length and less emphasis on muscle strength; therefore, 200-meter sprinters are taller and leaner than 100-meter sprinters.

400 m: The height of athletes here ranges from 1.80 to 1.93 m. As the distance increases, energy expenditure increases. Therefore, 400-meter runners put more emphasis on stride length and less emphasis on muscle strength. On average, they are taller than 200-meter runners and have a lower BMI.

800 m: The height of athletes here ranges from 1.73 to 1.90 m. They are shorter and lighter than 400-meter runners because, due to the quite long distance, the focus is on the economical expenditure of resources. In this discipline, the athlete must find the optimal balance between stride length, stride frequency, and energy expenditure. Athletes in this discipline have the lowest BMI index (19.80 kg/m^2) among the 10 disciplines.

400 m Hurdles: In this sports discipline, athletes have low average values for mass

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and BMI - 65.76 kg and 19.88 kg/m^2. The height of the athletes ranges from 1.68 m to 1.94 m. These figures are very similar to the corresponding metrics of 800-meter runners, but 400-meter hurdlers have a wider range of heights. This means that both very short and very tall athletes have their own advantages in this discipline.

High Jump: It is well known that high jumpers are usually very tall (height ranges from 1.80 to 2.01 m, with an average height value of 1.93 m). However, there are exceptions (for example, Hollis Conway and Stefan Holm with personal bests of 2.40 m, and Linus Thörnblad—his result is 2.38 m). Despite their relatively short stature (1.83 m, 1.81 m, and 1.80 m, respectively), these athletes achieved phenomenal results due to their sports technique and relatively small moment of inertia. Carlo Thränhardt, Patrik Sjöberg, Dietmar Mögenburg, and Gennadiy Avdeyenko are very tall (1.99 m, 2.00 m, 2.01 m, and 2.00 m, respectively) and have relatively large moments of inertia. In this discipline, an athlete's great height significantly improves jump performance and partially counteracts the negative effect of increased moment of inertia.

Long Jump: The world record in this sport belongs to Mike Powell, the second-best result to Bob Beamon, and the third to Robert Emmiyan, whose heights are 1.88 m, 1.89 m, and 1.78 m, respectively; Table 3 contains even more athletes whose heights are significantly below the average value (1.84 m). It is well known that a long jumper must also be a good sprinter and possess good jumping technique. A tall athlete can achieve a good result due to their height, which increases speed during the runway approach because of increased stride length, while a short athlete may turn out to be faster due to a relatively smaller moment of inertia.

Triple Jump: Due to its specific nature, the triple jump has a lot in common with the long jump. Therefore, the biomechanical parameters of the representatives of these two disciplines are close to each other. Triple jumpers are slightly taller, but their BMIs are slightly lower. This is because they expend more energy while performing three jumps than long jumpers do, and they must place a greater emphasis on height and weight reduction. Exceptions are Kenny Harrison and James Beckford, who are relatively short (1.78 m), and Jadel Gregório, who is very tall (2.02 m) and has a heavy weight (104 kg). The first two must focus on muscle strength and speed, while the third must utilize his height and body power.

Javelin Throw: In Table 3, this discipline has no exceptions because a javelin thrower must be physically strong, and possess sufficient mass and height. It is also desirable to have long arms and legs.

Combined Events (Decathlon): Combined events include the 100 meters, 400 meters, 1500 meters, 110 meters hurdles, long jump, high jump, pole vault, discus throw, javelin throw, and shot put. Only tall and strong athletes can achieve success in all of these sports. However, they are lighter on average than javelin throwers, which is due to the specific nature of their sport, which includes disciplines where a lighter weight provides more benefit. Height ranges from 1.80 to 2.01 m. This means that relatively short athletes focus on muscle strength and a reduced moment of inertia, while tall athletes focus on height and muscle power.

Conclusion

In this paper, using the data of world-ranked athletes across 10 track and field events, we studied the deviations of their height,

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weight, and BMI from the mean value. It was established that in all ten events, the aforementioned indicators for the majority of athletes do not differ significantly from the mean value: for example, the deviation of height from the average value is less than 5 cm. However, it was also established that in almost all disciplines except the javelin throw, there are significant deviations: for example, in the 100-meter sprint, the height of athletes ranges from 1.65 to 1.95 m, and weights range from 68 to 94 kg.

This means that in these disciplines, tall and relatively short athletes have their respective advantages and disadvantages. For instance, tall athletes have a greater stride length, which is very important in sprinting, but at the same time, they have a larger moment of inertia, which reduces the quickness of movements and requires more muscular energy. In contrast, short athletes have a shorter stride length but are faster. Regarding weight, it should be noted that in the case of athletes of the same height, a heavier athlete may have more energy and power, but will also have an increased moment of inertia. Therefore, it is crucial for an athlete to effectively utilize their physical parameters, such as height and weight, and find the optimal balance between power and speed.

ელიტური მძლეოსნობის სპორტსმენების ანთროპომეტრიულ მახასიათებლებსა და შესრულების შედეგებს შორის ურთიერთკავშირის ბიომექანიკური ანალიზი

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აბსტრაქტი

მძლეოსნობაში სპორტული მაჩვენებლები შეიძლება დამოკიდებული იყოს შემდეგ ბიომექანიკურ პარამეტრებზე: კუნთების ძალა, სხეულის მასა, ინერციის მომენტი, სიმაღლე, ნაბიჯის სიგრძე, ნაბიჯების სიხშირე და სპორტსმენის ფეხებისა და ხელების სიგრძე. თითოეულ მძლეოსნობის დისციპლინას აქვს საკუთარი მოთხოვნები ამ პარამეტრებისთვის, რაც გულისხმობს გადახრებს სტატისტიკურად გამოთვლილი საშუალო მნიშვნელობებიდან. ეს გადახრები განპირობებულია კონკრეტული დისციპლინის ბიომექანიკური მახასიათებლებით. ამ სტატიაში ჩვენ ვატარებთ ელიტური მძლეოსნების სიმაღლის, წონისა და სხეულის მასის ინდექსის საშუალო მნიშვნელობებიდან გადახრების ბიომექანიკურ ანალიზს. ჩვენ ვთვლით, რომ სპორტსმენების შერჩევისა და ვარჯიშის დროს მწვრთნელებმა უნდა განიხილონ მათი ფიზიკური პარამეტრები მთლიანობაში, კონკრეტული დისციპლინის ბიომექანიკური მახასიათებლების გათვალისწინებით.

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საკვანძო სიტყვები: სპორტის ბიომექანიკა, ბიომექანიკური ანალიზი, BMI ინდექსი, მძლეოსნობა.

References

1. Khosla T. (1978). Standards on age, height and weight in Olympic running events for men. British journal of sports medicine, 12(2), 97–101. https://doi.org/10.1136/bjsm.12.2.97

2. Stachoń, A., Pietraszewska, J. & Burdukiewicz, A. (2023). Anthropometric profiles and body composition of male runners at different distances. Sci Rep 13, 18222. https://doi.org/10.1038/s41598-023-45064-9

3. Barbieri, D., Zaccagni, L., Babić, V., Rakovac, M., Mišigoj-Duraković, M., & Gualdi-Russo, E. (2017). Body composition and size in sprint athletes. The Journal of sports medicine and physical fitness, 57(9), 1142–1146. https://doi.org/10.23736/S0022-4707.17.06925-0

4. Herrera-Amante, Carlos Abraham, Carvajal-Veitía, Wiliam, Ramos-García, César Octavio, Garcia-Carrillo, Exal, Cortés-Roco, Guillermo, Olivares-Arancibia, Jorge, Aguilera-Martínez, Nicole, & Yáñez-Sepúlveda, Rodrigo. (2025). Anthropometric Characteristics, Somatotype and Body Composition: Differences between Cuban and Mexican Olympic and Non-Olympic Track and Field Athletes. International Journal of Morphology, 43(3), 816-822. https://dx.doi.org/10.4067/S0717-95022025000300816

5. Ueno, H., Suga, T., Takao, K., Terada, M., Nagano, A., & Isaka, T. (2021). Relationship Between Body Segment Mass and Running Performance in Well-Trained Endurance Runners. Journ al of Applied Biomechanics, 37(6), 531–537. https://doi.org/10.1123/jab.2020-0239

6. Aikawa, Y., Murata, M. & Omi, N. (2020). Relationship of height, body mass, muscle mass, fat mass, and the percentage of fat with athletic performance in male Japanese college sprinters, distance athletes, jumpers, throwers, and decathletes. J. Phys. Fit. Sports Med. 9, 7–14.

7. Sánchez Muñoz, C., Muros, J. J., López Belmonte, Ó., & Zabala, M. (2020). Anthropometric Characteristics, Body Composition and Somatotype of Elite Male Young Runners. International journal of environmental research and public health, 17(2), 674. https://doi.org/10.3390/ijerph17020674

8. Egoyan, A., Shakhverdieva, S., Tyo, E., Gobirakhashvili, A., Moistsrapishvili, K. (2023). The relationship between the performance of elite track and field athletes

and their height, weight and BMI. Proceedings of the III International Scientific Conference "Health and Sport", Tbilisi, 27-28 April, 2023, 59-63. https://doi.org/10.5281/zenodo.7978995

9. Egoyan, A.E., Gobirakhashvili, A.D., Moistsrapishvili, K.M. (2023). Biomechanical analysis of the dependence of the high jump result on the height and weight of an athlete. Proceedings of the III international scientific and practical conference "Nation's health and improvement of physical and sports education", Kharkiv National Technical University, Department of Physical Education, 79-83.

10. Wikipedia. Official world championship track and field events. (Retrieved on December 10, 2024). https://en.wikipedia.org/wiki/Sport_of_athletics.

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Review

Sociocultural and religious aspects of the ancient Olympic Games

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Abstract

This article explores the phenomenon of the Ancient Greek Olympic Games as a pivotal mechanism in the formation of cultural and religious identity within the ancient world. The study analyzes the role of the Games in facilitating peace among city-states (*poleis*), the evolution of athletic disciplines, and the influence of social hierarchy on participant selection criteria. Particular emphasis is placed on the political significance of the "Sacred Truce" (*ekecheiria*) and the multifaceted factors that ensured the continuity of this tradition for nearly twelve centuries. By examining the intersection of athletics, religion, and diplomacy, the paper underscores the Games' enduring impact on Panhellenic unity and the foundations of Western sportsmanship.

Keywords: Olympia, Cult of Zeus, Panhellenic identity, Sacred Truce, Ancient Agonistics.

Relevance of the Research

The study of the Ancient Greek Olympic Games maintains exceptional relevance in modern humanities and social sciences. It provides a comprehensive framework to understand the intricate interplay between physical education, religious worldview, and social organization in ancient society.

The Olympic Games represent a foundational historical precedent upon which sport emerged as a social institution, subsequently shaping its ideological and organizational structures, including the core principles of the modern Olympic movement.

Research Objective

The objective of this study is a systematic Analysis of the historical development, functional purpose, and ideological foundations of the Olympic Games. The paper aims to decipher the internal structure of the Olympic phenomenon, thereby establishing a theoretical foundation for further research in sports history and the philosophy of Olympism.

Research Methodology

This study utilizes historical-comparative, cultuological, and sociological analysis. The source base comprises texts by classical authors, alongside modern studies in historiography and the sociology of sport.

Introduction

In the history of Ancient Greek civilization, the Olympic Games were far more than a mere sporting event.

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They constituted a multifaceted sociocultural phenomenon and a complex institutional system that integrated religious rituals, mythological beliefs, political relations, and the ideal of human physical and spiritual perfection.

The Games were dedicated to the supreme deity, Zeus, and their staging was regarded as a sacred duty. Through this practice, the Hellenes expressed their devotion to the gods and conceptualized the place of humanity within a harmonious cosmic order.

Main Body

The ancient Olympic Games stand as one of the oldest and most significant cultural-religious institutions in human history. Most scholars identify 776 BC as the official beginning of the ancient Olympic Games, the year in which the name of the first victorious athlete—Koroibos of Elis—was recorded.

The Games were held in Olympia, at the foot of Mount Kronos in the valley of the Alfeios River on the Peloponnese peninsula. The heart of Olympia was the *Altis*, a sacred grove hosting a vast complex of religious and athletic structures: the palaestra, gymnasium, stadium, hippodrome, baths, and residential and auxiliary infrastructure.

Olympia was also home to the grand Temple of Zeus, which housed the colossal statue of Zeus sculpted by Phidias—celebrated as one of the Seven Wonders of the Ancient World.

The competitions were accompanied by ritual sacrifices, festive processions, and prayers. Of particular importance was the solemn oath taken by the athletes before Zeus, which bound their behavior to strict ethical and religious standards.

One of the most vital institutional achievements of the Olympic Games was the "Sacred Truce" (*ekecheiria*). This truce mandated a temporary cessation of hostilities and guaranteed safe passage for all those traveling to Olympia. This practice served as a legal projection of a religious norm, ensuring both the Panhellenic character and the physical safety of the Games.

The ancient Olympic Games were staged on the same grounds once every four years for a span of 1,170 years. This four-year cycle became known as an "Olympiad" and eventually evolved into a calendar system; time was tracked by Olympiads rather than by individual years.

The Games were fundamentally rooted in the principle of *agon* (competition). Initially, the entire event lasted only a single day and consisted of a single event: the *stade* (a short footrace of one stadium length). For nearly half a century (spanning the first 13 Games), this single race remained the sole competition of the Greek festival. In the 14th Olympic Games (724 BC), the *diaulos* (a double-stadium race) was introduced to the program, and from the 15th Games onward, long-distance running (*dolichos*) was added, ranging successively from 8 to 10, 12, and 14 stades.

As the number of athletic disciplines and participants grew, the duration of the Games was extended to five days. The program expanded to include complex disciplines such as the pentathlon, boxing, pankration, and chariot racing.

The criteria for participation in the Olympiad were strictly regulated: only free Greek men were permitted to compete. Women were forbidden from competing or even entering the stadium, with the sole

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exception of the priestess of the goddess Demeter. However, separate athletic competitions for women, known as the "Heraean Games," were held in honor of the goddess Hera.

In the ancient Olympiads, there were no second or third places—there was only a single winner. The victor, known as an *Olympionique*, was accorded the highest honors in society. The immediate prize was a branch of a sacred wild olive tree, which had to be cut with a golden knife by a boy under the age of twelve whose parents were both living and of unblemished character. The branch was cut from the tree believed to have been planted by Heracles himself. This wreath symbolically represented supreme honor and glory.

However, the true, material rewards awaited the victor back in his home city-state (*polis*). The *Olympionique* was hailed as a hero; statues were erected in his honor, he was exempted from taxes, and he enjoyed special privileges for the rest of his life. The names of these illustrious athletes and their achievements were meticulously recorded and preserved in gymnasiums and temples.

The youth drew great inspiration from the examples of these heroes, some of whom were eventually elevated to receive divine honors. Historical sources tell of Leonidas of Rhodes, who achieved twelve victories across four consecutive Olympiads between 164 and 152 BC. Remarkably, this record stood unbroken for 2,160 years, until American swimmer Michael Phelps won his 13th individual gold medal at the 2008 Beijing Olympic Games.

Beginning with the 84th Games in 444 BC, competitions in art and rhetoric became an integral part of the Olympic Games. The Greeks did not rigidly separate artistic mastery from athletic prowess. This integration demonstrates that Greek culture viewed physical and intellectual perfection as a unified ideal. The greatest minds of the era—including Socrates, Plato, Aristotle, Pythagoras, and Herodotus—gathered in Olympia. It was during these 84th Games that Herodotus read portions of his *Histories* to the gathered crowds, earning the laurel crown of victory.

Interestingly, the Greek ideal of *kalokagathia*—the harmonious unity of physical beauty and moral/spiritual virtue—bridged any divide between athletes and intellectuals. For instance, history records that Pythagoras won the title of *Olympionique* in boxing, while Plato was an accomplished and successful wrestler.

The ancient Olympic Games were celebrated without interruption for nearly twelve centuries (1,170 years). From 776 BC to 394 AD, they were held 293 times, a record of institutional longevity that is virtually unprecedented in human cultural history. There is likely no other human endeavor that boasts such a long and magnificent continuity.

Nevertheless, like all great historical traditions, the ancient Olympic Games eventually reached their end. In 393 AD, Roman Emperor Theodosius I, as part of his policy to establish Christianity as the state religion, banned the Olympic Games, viewing them as pagan rituals. Sometime later, by decree of Theodosius II, the religious buildings of Olympia were systematically destroyed, and subsequent natural disasters buried the stadium and remaining infrastructure beneath layers of silt and earth.

Today, the ancient Olympic Games remain one of the most brilliant heritages of global civilization, having laid the

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foundational concepts of modern sport, peace, and international unity.

Conclusion

The ancient Olympic Games were a unique sociocultural and religious institution that defined the identity and value system of the Hellenic world. By harmonizing religious ritual with athletic *agon*, they fostered Panhellenic unity, served vital socio-political functions, and established a value system anchored in honor, justice, and personal excellence.

The exceptional longevity of the Games over many centuries was made possible by the organic unity of religious belief, social practice, and cultural self-expression.

Thus, the Olympic Games can be understood as one of the primary pillars of ancient Greek civilization, one that exerted a profound influence on the subsequent development of Western culture and continues to maintain its symbolic significance within the modern Olympic movement.

ანტიკური ოლიმპიური თამაშების სოციოკულტურული და რელიგიური ასპექტები

ჯემალ ძაგანია

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აბსტრაქტი

წინამდებარე სტატია იკვლევს ძველბერძნული ოლიმპიური თამაშების ფენომენს, როგორც ანტიკური სამყაროს კულტურული და რელიგიური იდენტობის ფორმირების ერთ-ერთ უმნიშვნელოვანეს მექანიზმს. ნაშრომში გაანალიზებულია თამაშების როლი პოლისებს შორის მშვიდობის დამყარების პროცესში, სპორტული დისციპლინების ევოლუცია და სოციალური იერარქიის გავლენა მონაწილეთა შერჩევის კრიტერიუმებზე. კვლევა განსაკუთრებულ ყურადღებას ამახვილებს „წმინდა ზავის“ (*ekecheiria*) პოლიტიკურ მნიშვნელობასა და იმ ფაქტორებზე, რომლებმაც განაპირობეს ამ ტრადიციის თორმეტსაუკუნოვანი უწყვეტობა.

საკვანძო სიტყვები: ოლიმპია, ზევსის კულტი, პანელინური იდენტობა, წმინდა ზავი, ანტიკური აგონისტიკა.

References

1. Berishvili, E. (2019). *Olympic Dilogy*. Georgian National Olympic Committee, Tbilisi. (In Georgian)

2. Dzagania, G. (2004). *History of Physical Education and Sport*. Tbilisi. (In Georgian)

DOI: 10.56580/GEOMEDI82

3. Dzagania, G. (2004). *Olympic Games* (Textbook). Tbilisi. (In Georgian)

4. Dzagania, G. (2018). *Everything About the Olympic Games* (Monograph). Tbilisi. (In Georgian)

5. Stolbov, V. V., Finogenova, L. A., & Melnikova, N. Y. (2000). *History of Physical Culture and Sport* (Textbook). Moscow: FiS. (In Russian)

6. Kun, L. (1982). *General History of Physical Culture and Sport*. Moscow: Raduga. (In Russian)

7. Platonov, V. P., & Guskov, S. N. (1994, 1997). *Olympic Sport* (Textbook, Vols. 1 & 2). Kyiv: Olympic Literature. (In Russian)

8. Golden, M. (1998). *Sport and Society in Ancient Greece*. Cambridge University Press.

9. Miller, S. G. (2004). *Ancient Greek Athletics*. Yale University Press.

10. Pausanias. (1918). *Description of Greece* (W. H. S. Jones, Trans.). Harvard University Press.

11. Reid, H. L. (2011). *Athletics and Philosophy in the Ancient World: Contests of Virtue*. Routledge.

12. Spathari, E. (2000). *The Olympic Spirit*. Adam Editions

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უნივერსიტეტ გეომედის მულტიპროფილური საუნივერსიტეტო კლინიკა

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