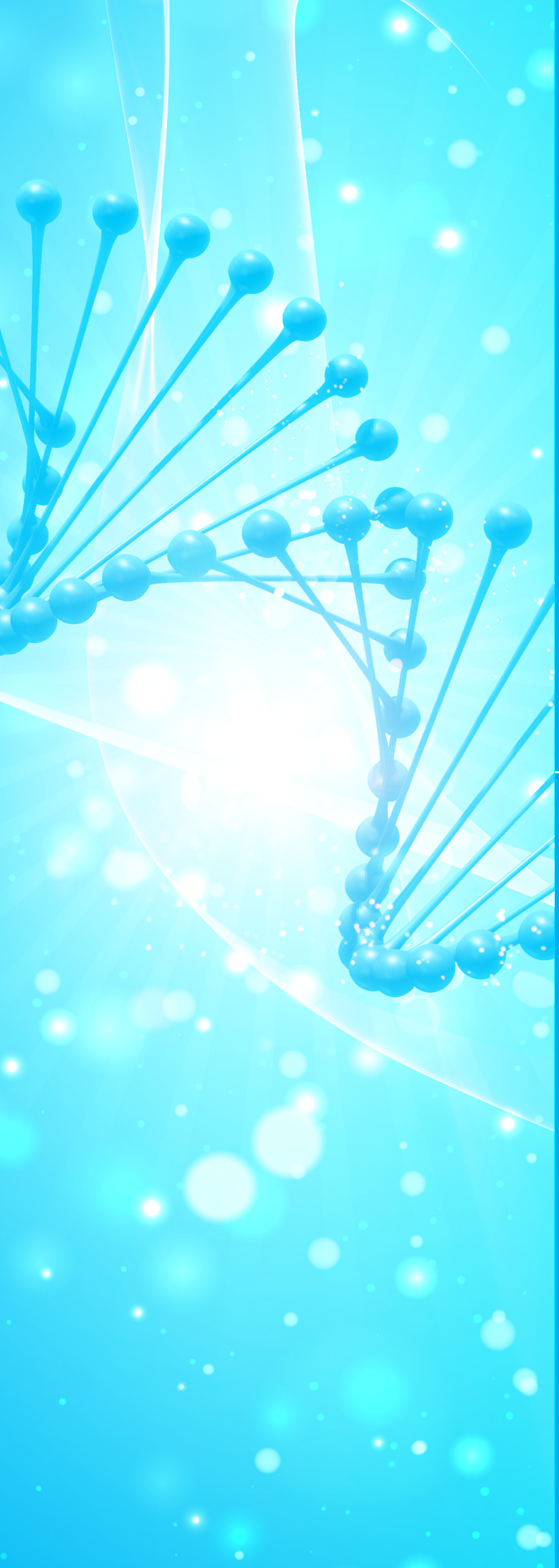

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SADRŽAJ

ORIGINALNI RAD

PREGLEDNI RAD

CONTENTS

ORIGINAL ARTICLE

REVIEW ARTICLE

ORIGINALNI RAD

UDK BROJ: 615.211.015.4
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INTERAKCIJE PROKAINA SA KLJUČNIM PROTEINIMA U RAZVIĆU SRCA ZEBRICA: *IN SILICO* ANALIZA

Nikola Mitović[1], Milica Milošević[2], Maša Ristić[3], Ljubica Dimitrijević[4], Sanjin Kovačević[1], Jelena Nešović Ostojić[1], Marija S. Stanković[1]

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SAŽETAK

Uvod/Cilj: Prokain je lokalni anestetik iz aminoestarske grupe koji blokira natrijumove voltažno-zavisne kanale. S obzirom na to da može proći kroz placentu u jonizovanom obliku, postavlja se pitanje njegovog uticaja na embrionalni razvoj. Zebrice, koje imaju značajan stepen homologije sa ljudskim genomom, omogućavaju proučavanje razvoja kardiovaskularnog sistema sa pouzdanom ekstrapolacijom na čoveka. Ispitivanje uticaja prokaina na ključne proteine u razvoju srca zebrica pomoću molekularnog dokinga.
Metode: Prvo je izvršen skrining interakcije prokaina i celog ljudskog proteoma koristeći *FINDSITE*^{comb} softver. Na osnovu značajnih interakcija sa visokim stepenom preciznosti analize, selektovano je 113 proteina. Pomoću *ZFIN* baze je određen stepen homologije između selektovanih ljudskih proteina sa zebričinim, tkivna-specifičnost i vremena ekspresije. Devet proteina su ispunili sve kriterijume: *kcnh6a, kcnh7, kcnh5a, kcnh2a, psen2, rbfa* i *zfpl1* i dalje su ispitivani molekularnim dokingom u AutoDock Vina programu.
Rezultati: Većina proteina se eksprimira visokom stopom tokom blastule. Doking rezultati su pokazali da *scn1laa* protein i prokain imaju najnižu vrednost Gibsove slobodne energije (-6 kCal/mol), dok je za *zfp11* protein vrednost bila najviša (-4,4 kCal/mol). Vezivanje prokaina na ispitivane proteine pokazalo je slične aminokiselinske sekvence unutar iste familije proteina.
Zaključak: Prokain ostvaruje interakcije sa proteinima uključenim u razvoj srca zebrica u *in silico* uslovima. Dalje analize na živim embrionima su potrebne kako bi se dopunili ovi rezultati.

Ključne reči: prokain, razvoj srca, zebrice, molekularni doking.

Uvod

Prokain predstavlja kratkodelujući lokalni anestetik iz aminoestarske grupe koji se primenjuje u stomatologiji i veterini (1). Mehanizam dejstva ostvaruje putem blokade natrijumovih voltažno-zavisnih kanala. Nakon resorpcije, metaboliše se u plazmi pod dejstvom pseudoholinesteraze koja ga hidrolizuje u para-amino benzoičnu kiselinu koja se putem bubrega izlučuje urinom. Vreme poluživota iznosi svega 7,7 minuta (2). Iako je najizraženije dejstvo prokaina na blokadu natrijumovih kanala u manjoj meri deluje antagonistički i na N-metil-D-aspartat, nikotinske i serotoninske receptore (3).

Prokain u svom jonizovanom obliku može proći kroz placentu, pa se opravdano postavlja pitanje o njegovom eventualnom uticaju na razviće ploda (4). Podaci na ovu temu su deficitarni, pa tako današnje preporuke savetuju da se primenjuje u slučaju stomatoloških ili nekih drugih intervencija samo ukoliko benefiti preovlađuju potencijalne rizike. Zbog svog mehanizma dejstva, efekti prokaina bi pogotovu trebali biti ispitani na razvojne strukture u kojima su jonski kanali visoko eksprimirani, kao što su to npr. srčane ćelije.

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ORIGINAL ARTICLE

INTERACTION OF PROCAINE WITH KEY PROTEINS FOR HEART DEVELOPMENT IN ZEBRAFISH: *IN SILICO* ANALYSIS

Nikola Mitović[1], Milica Milošević[2], Maša Ristić[3], Ljubica Dimitrijević[4], Sanjin Kovačević[1], Jelena Nešović Ostojić[1], Marija S. Stanković[1]

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SUMMARY

Introduction/Aim: Procaine is a local anesthetic from the amino ester group that blocks voltage-gated sodium channels. Since it can cross the placenta in its ionized form, its potential impact on embryonic development is of concern. Zebrafish, which have a significant degree of homology with the human genome, allow for the study of cardiovascular system development with reliable extrapolation to humans. Investigation of the effects of procaine on key proteins involved in zebrafish heart development using molecular docking.
Methods: First, a screening of the interaction between procaine and the entire human proteome was performed using FINDSITE^{comb} software. Based on significant interactions with a high degree of analysis precision, 113 proteins were selected. Using the ZFIN database, the degree of homology between the selected human proteins and zebrafish proteins, tissue specificity, and expression timing were determined. Nine proteins met all the criteria: kcnh6a, kcnh7, kcnh5a, kcnh2a, psen2, rbfa, and zfpl1, and were further investigated through molecular docking in the AutoDock Vina program.
Results: Most of the proteins were highly expressed during the blastula stage. Docking results showed that the scn1laa protein and procaine had the lowest Gibbs free energy value (-6 kCal/mol), while the zfp11 protein had the highest value (-4.4 kCal/mol). Procaine binding to the tested proteins revealed similar amino acid sequences within the same protein family.
Conclusion: Procaine interacts with proteins involved in zebrafish heart development under *in silico* conditions. Further analyses on live embryos are needed to complement these findings.

Keywords: procaine, heart development, zebrafish, molecular docking

Introduction

Procaine is a short-acting local anesthetic from the amino ester group that is used in dentistry and veterinary medicine (1). The mechanism of action is achieved by blocking voltage-gated sodium channels. After resorption, it is metabolized in the plasma by the enzyme pseudocholinesterase through hydrolysis into para-amino benzoic acid, which is then excreted by the kidneys via urine. The half-life is only 7.7 minutes (2). Although the most pronounced effect of procaine is on the blockade of sodium channels, it also acts, to a lesser extent, antagonistically on N-methyl-D-aspartate, nicotinic and serotonin receptors (3).

Procaine in its ionized form can pass through the placenta, so the question of its possible influence on the development of the fetus is justified (4). Data on this topic is lacking, and therefore, current recommendations advise that it should be applied in case of dental or some other interventions, only when benefits outweigh potential risks. Due to its mechanism of action, the effects of procaine on developmental structures, in which ion channels are highly expressed, such as heart cells, should be investigated.

Zebrice (lat. *Danio rerio*) su slatkovodne ribe čije potomstvo se pokazalo kao dobar model za ispitivanje razvića i razvojnih abnormalnosti. Zbog relativno kratkog perioda embriogeneze (4 dana) eksperimenti traju kratko, ekonomične su za održavanje, a transparentnost embriona omogućava lako praćenje velikog broja morfometrijskih i funkcionalnih parametara (5). Visok stepen homologije sa ljudskim genomom, promene u morfologiji i funkcionalnosti kardiovaskularnog sistema mogu biti proučavane na zebricama sa pouzdanom ekstrapolacijom na čoveka. Srce embriona je smešteno na prominentnoj poziciji, na ventralnoj strani, omogućavajući dobru vizuelizaciju razvića i analize srčane funkcije (6).

Proces razvića srca je regulisan brojnim mehanizmima u kojima su posrednici različiti proteini (7). Stoga, efekat štetnih noksi može interferirati sa navedenim regulatornim mehanizmima i dovoditi do različitih fenotipskih abnormalnosti. Interakcije noksi i proteina možemo ispitivati molekularnim dokingom kojim se utvrđuje orijentacija, afinitet i interakcija liganda na mestu vezivanja u proteinu (8).

Imajući u vidu sve navedeno, cilj našeg rada bio je ispitivanje interakcija prokaina sa ključnim proteinima u razviću srca zebrica uz pomoć bioinformatičke – doking analize.

Metode

Preliminarni skrining proteoma

Kako bi se utvrdile moguće interakcije između prokaina i proteina domaćina, izvršen je skrining kompletnog ljudskog proteoma korišćenjem *FINDSITE*^{comb} softvera. Ovaj softver analizira strukturu unetog molekula koristeći podatke iz različitih baza kao što su *PDB*, *chEMBL* i *DrugBank*, i poredi potencijalne strukturne sličnosti između unetog molekula i proteina iz ovih baza. Rezultati su prikazani u tabelarnom formatu i obuhvataju mTC vrednost (Tanimoto koeficijent – mera sličnosti između dva elementa), preciznost analize, naziv proteina iz *RefSeq* baze i opis proteina (9).

Za dalja istraživanja odabrani su proteini sa preciznošću analize većom od 70%, što je obuhvatilo ukupno 113 proteina (9). Ove analize su se odnosile na ljudske proteine. Zbog toga je uz pomoć *ZFIN* baze podataka utvrđen stepen homologije između ljudskih proteina i njihovih odgovarajućih kod zebrica, njihova tkivna specifičnost i ekspresije

Tabela 1. Podaci o ispitivanim proteinima preuzeti iz ZFIN baze podataka

Oznaka proteina	Naziv proteina	Lokalizacija	Funkcija
kcnh6a	Voltažno-zavisni kalijumov kanal, familija H, član 6a	Transmembranski protein	Srčana kontrakcija. Koristi se za proučavanje sindroma dugog QT i sindroma kratkog QT intervala. Eksprimiran i u probavnom traktu, mišićima, imunskim ćelijama.
kcnh7	Voltažno-zavisni kalijumov kanal, familija H, član 7	Transmembranski protein	Uloga u depolarizaciji i repolarizaciji ćelije. Konstitutivno eksprimiran u većini ćelija.
kcnh5a	Voltažno-zavisni kalijumov kanal, familija H, član 5a	Transmembranski protein	Učestvuje u transmembranskom transportu, održavanju membranskog potencijala
kcnh2a	Voltažno-zavisni kalijumov kanal, familija H, član 2a	Transmembranski protein	Učestvuje u patofiziologiji dugog QT sindroma i kratkog QT sindroma. Eksprimira se u srcu, mišićima, imunskom sistemu.
psen2	Presenilin 2	Endoplazmatski retikulum i Goldžijev aparat	Učestvuje u razvoju dilatativne kardiomiopatije.
rbfa	Ribozom vezujući faktor A	Mitohondrije	Učestvuje u obradi RNK molekula
zfpl1	Protein sličan cinkovim prstima 1	Goldžijev aparat i transmembranski protein	Učestvuje u vezivanju metalnih jona. Zadužen za razvoj srca, retroperiotoneuma i jetre.
scn8aa	Voltažno zavisni Na kanal, tip VIII	Transmembranski protein	Učestvuje u aksonskom transportu, eksprimira se u CNS-u, srcu, trigeminalnom ganglionu.
scnl1a	Voltažno zavisni Na kanal, tip I, alfa	Transmembranski protein	Učestvuje u aksonskom transportu, eksprimira se u CNS-u, srcu, nervnoj cevi.

Zebrafish (lat. *Danio rerio*) are freshwater fish whose offspring was shown to be a good model for the examination of growth and developmental abnormalities. Due to the relatively short period of embryogenesis (4 days), the experiments last a short time, they can be maintained at low cost, while the transparency of the embryo enables easy monitoring of a large number of morphometric and functional parameters (5). A high degree of homology with the human genome, changes in the morphology and functionality of the cardiovascular system can be studied in zebrafish with the reliable extrapolation to humans. The heart of the embryo is located in a prominent position, on the ventral side, thus allowing the good visualization of development and the analysis of cardiac function (6).

The process of heart development is regulated by numerous mechanisms in which various proteins are mediators (7). Therefore, the effect of noxious stimuli can interfere with the above mentioned regulatory mechanisms and lead to different phenotypic abnormalities. The interactions between noxious stimuli and proteins can be examined with the help of molecular docking, which determines the orientation, affinity and interaction of ligands at the binding site in the protein (8).

Having in mind all the above mentioned, the aim of our study was to examine the interaction between procaine and key proteins in the development of zebrafish with the help of bioinformatics – docking analysis.

Methods

Preliminary screening of the proteome

In order to determine possible interactions between procaine and host proteins, the complete human proteome was screened using FINDSITEcomb software. This software analyzes the structure of the input molecule using data from various databases such as PDB, chEMBL and DrugBank, and compares potential structural similarities between the input molecule and proteins from these databases. The results are presented in the form of tables and they include the mTC value (the Tanimoto coefficient – a measure of similarity between two elements), the precision of analysis, the name of the protein from RefSeq database and the description of the protein (9).

The proteins with the accuracy of analysis higher than 70% were selected for further research,

Table 1. Data on the examined proteins obtained from the ZFIN database

Protein label	Full name of the protein	Localization	Function
kcnh6a	Potassium Voltage-Gated Channel Subfamily H Member 6a	Transmembrane protein	Cardiac contraction. Used for studying long QT syndrome and short QT interval syndrome. Also expressed in the digestive tract, muscles, immune cells.
kcnh7	Potassium Voltage-Gated Channel Subfamily H Member 7)	Transmembrane protein	Role in cell depolarization and repolarization. Constitutively expressed in most cells.
kcnh5a	Potassium Voltage-Gated Channel Subfamily H Member 5a	Transmembrane protein	Participates in transmembrane transport and maintenance of membrane potential.
kcnh2a	Potassium Voltage-Gated Channel Subfamily H Member 2a	Transmembrane protein	Involved in the pathophysiology of long QT syndrome and short QT syndrome. Expressed in the heart, muscles, and immune system.
psen2	Presenilin 2	Endoplasmic reticulum and Golgi apparatus	Involved in the development of dilated cardiomyopathy.
rbfa	Ribosome Binding Factor A	Mitochondria	Participates in RNA molecule processing.
zfpl1	Zinc Finger Protein-Like 1	Golgi apparatus and transmembrane protein	Involved in binding metal ions. Responsible for the development of the heart, retroperitoneum, and liver.
scn8aa	Sodium Voltage-Gated Channel Alpha Subunit 8a	Transmembrane protein	Participates in axonal transport, expressed in the CNS, heart, and trigeminal ganglion.
scnl1a	Sodium Channel, Non-Voltage-Gated 1 Alpha Subunit	Transmembrane protein	Participates in axonal transport, expressed in the CNS, heart, and neural tube.

tokom embriogeneze (10). Na kraju, ustanovili smo da 9 proteina ispunjava sve kriterijume (homologi proteini koji su eksprimirani tokom embriogeneze u srcu zebrica), te su oni dalje analizirani. Nazivi, funkcije i lokalizacija ovih proteina preuzeti su iz *ZFIN* baze i prikazani su u Tabeli 1.

Priprema za molekularni doking

Strukture proteina (receptora) dobijene kristalografijom su preuzete sa *PDB* ili *AlphaFold* sajta. 3D struktura prokain-hidrohlorida (liganda) je preuzeta sa *PubChem*-a (11).

Molekularni doking

Molekularni doking je metoda koja se koristi za predviđanje toga kako će se ligand orijentisati i interagovati na mestu vezivanja unutar proteina (receptora). U ovom istraživanju primenili smo *AutoDock Vina* softver za predviđanje ovih interakcija, što je tehnika koja se široko koristi u procesu otkrivanja novih lekova (12).

Prilikom rada u ovom programu, prvo se unose strukture proteina u *PDB* formatu i liganda u *SDF* formatu, a zatim se, prema potrebi, vrše modifikacije. U našim analizama uklonili smo molekule vode iz proteina, jer one često nemaju značajnu ulogu u procesu vezivanja, čime smo olakšali računanje. Takođe, dodali smo polarne atome vodonika i naelektrisanja receptorima kako bismo povećali broj potencijalnih veznih mesta pre početka procesa dokinga. Proces je podešen tako da su sve veze liganda rotirajuće, dok su veze receptora fiksirane (12).

Nakon pokretanja dokinga, program simulira interakcije između različitih funkcionalnih grupa receptora i liganda. Na kraju, program prikazuje deset najrelevantnijih interakcija, uz vrednosti Gibsove slobodne energije i srednjeg kvadratnog odstupanja pozicija atoma (RMSD). Niže, negativne vrednosti Gibsove slobodne energije ukazuju na veću verovatnoću spontane reakcije, odnosno jače vezivanje između receptora i liganda, dok *RMSD* vrednosti omogućavaju procenu tačnosti dobijenih rezultata dokinga (12).

Rezultati

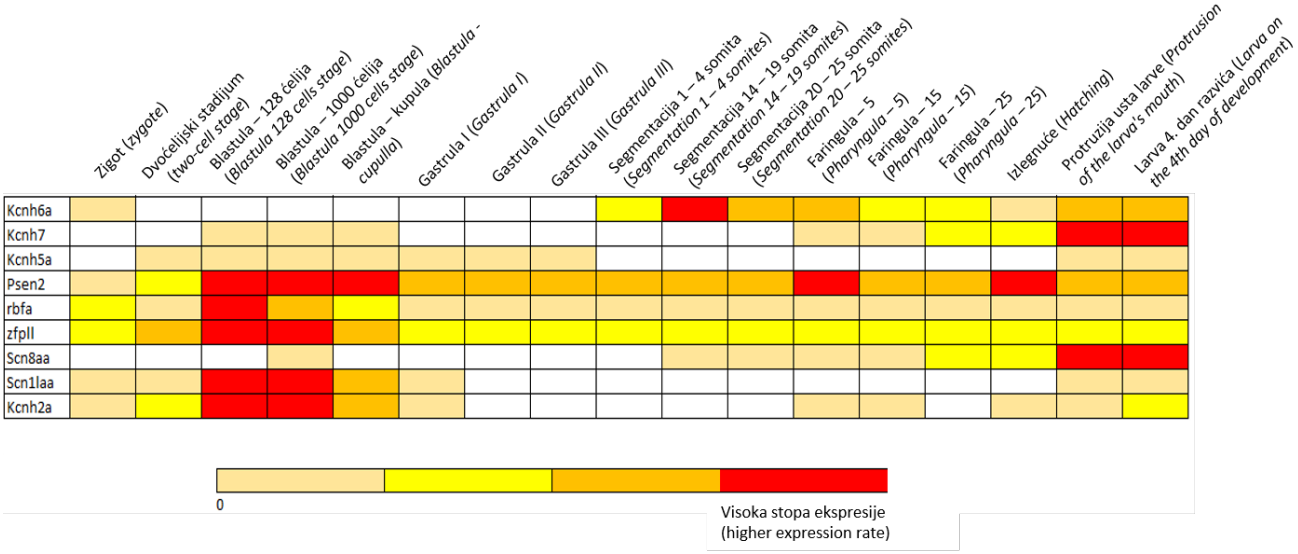
Stepen ekspresije ispitivanih proteina

Koristeći podatke preuzete sa *ZFIN* baze, kreirane su termalne mape koje prikazuju vreme i intenzitet ekspresije analiziranih proteina. Na X-osi mape nalazi se podela na 17 segmenata, pri čemu svaki segment predstavlja određenu fazu razvoja u kojoj se dešavaju specifične promene. Na Y-osi su prikazani ispitivani proteini. Ove mape omogućavaju praćenje dinamičkih promena u ekspresiji proteina tokom različitih faza embrionalnog razvoja, pružajući uvid u potencijalnu ulogu svakog proteina u tim ključnim periodima.

Prema dobijenim podacima, većina proteina (5 od 9) se eksprimira visokom stopom tokom perioda blastule (128 ćelija i 1000 ćelija) (Grafikon 1).

Molekularni doking

Molekularni doking je odrađen uz pomoć *AutoDock Vina* programa, gde su za poređenja uzete



Grafikon 1. Termalna mapa sa prikazom nivoa ekspresije ispitivanih proteina kroz različite periode embriogeneze

and 113 proteins were included (9). These analyses were related to human proteins. Therefore, the degree of homology between human proteins and the corresponding ones in zebrafish was determined with the help of the ZFIN database, as well as their tissue specificity and expression during embryogenesis (10). In the end, we found that 9 proteins met all the criteria (homologous proteins that are expressed during embryogenesis in the heart of zebrafish), and therefore, they were further analyzed. Names, functions and localization of these proteins were taken from the ZFIN database and are shown in Table 1.

Preparation for molecular docking

The structures of proteins (receptors), which were obtained by crystallography, were downloaded from PDB or AlphaFold website. 3D structure of procaine-hydrochloride (ligand) was downloaded from PubChem (11).

Molecular docking

Molecular docking is a method used to predict how a ligand will be oriented and how it will interact at the binding site in the protein (receptor). In this study, we applied the AutoDock Vina software for predicting these interactions, which is a technique that is widely used in the process of discovering new drugs (12).

While working in this program, the structures of proteins in PDB format and ligands in SDF format are entered first, and then, if necessary, modifications are made. In our analyses, we removed water molecules from proteins, because they often do not have a significant role in the binding process, thus simplifying the calculations. Also, we added polar hydrogen atoms and electric charges to receptors in order to increase the number of potential binding sites before the docking process starts. The process is set so that all ligand bonds are rotatable, while receptor bonds are fixed (12).

After docking has been started, the program simulates the interactions between different functional groups of the receptor and ligand. Finally, the program, displays the ten most relevant interactions, along with the values of Gibbs free energy and the root mean square deviation of atomic positions (RMSD). Lower, negative values of Gibbs free energy indicate a higher probability of spontaneous reaction, that is, a stronger binding between the receptor and ligand, while the RMSD values enable the assessment of the accuracy of obtained results of docking (12).

Results

The degree of expression of examined proteins

Using data downloaded from the ZFIN database, thermal maps, which show the time and intensity of expression of analyzed proteins, were created. There is a division into 17 segments on the X-axis of the map, where each segment represents a certain stage of development, in which specific changes occur. The examined proteins are shown

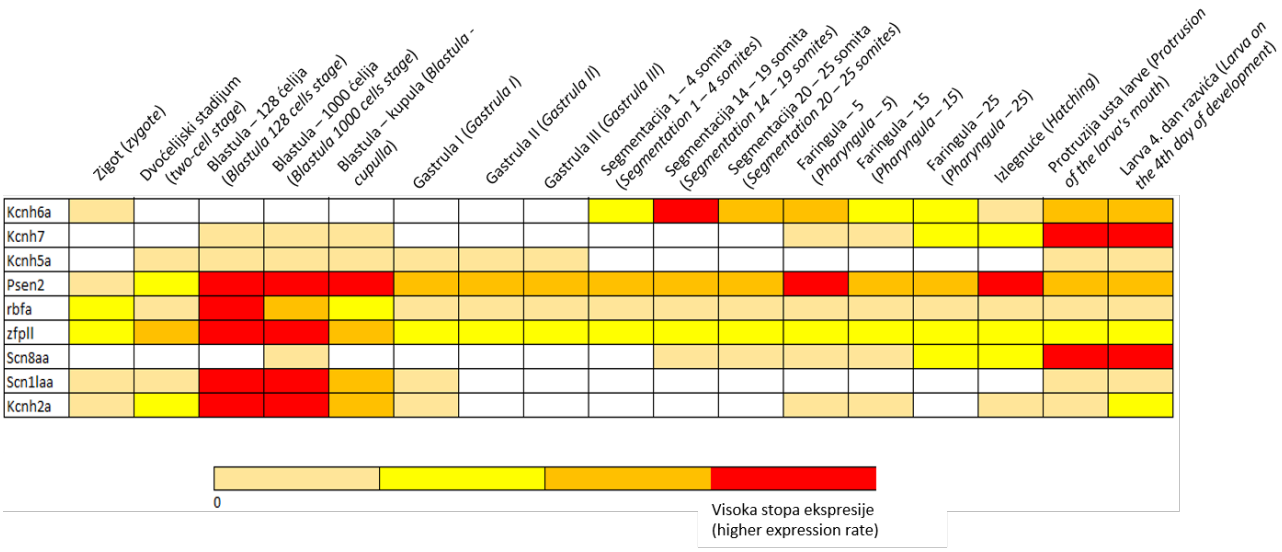


Figure 1. Heat map showing the expression levels of the examined proteins through different stages of embryogenesis

Grafikon 2. Vrednosti Gibsove slobodne energije u interakcijama izmedju prokaina i ispitivanih proteina. Prikazane vrednosti za svaki protein imale su RMSD niže od 3 (visoka preciznost dokinga), što je činilo po 2 interakcije po proteinu.

interakcije gde su vrednosti *RMSD*-a bile niže od 3 (za veće vrednosti se smatra da je preciznost analize mala).

Interakcija *scn1laa* proteina i prokaina je imala najnižu vrednost Gibsove slobodne energije i iznosila je - 6 kCal/mol. Za protein *zfp11* je vrednost Gibsove slobodne energije bila najmanja i iznosila je - 4,4 kCal/mol. Vrednosti energija ostalih interakcija su date u grafiku 2.

Pored vrednosti energija, ispitivali smo i vezna mesta prokaina na ispitivanim proteinima i pokazali da postoji određeni stepen sličnosti u vezivanju između proteina koji pripadaju familiji natrijumovih (*scn8aa*, *scn1la*) i kalijumovih (*kcnh6a*, *kcnh7*) voltažno-zavisnih kanala (Tabela 2). U slučaju natrijumovih kanala najčešće vezno mesto je sadržalo aminokiselinsku sekvencu koja ima u sebi leucin (LEU) i asparagin (ASN), dok u slučaju kalijumovi kanala je bila sekvenca koja sadrži histidin (HIS) i ileucin (ILE).

Diskusija

Prokain je kratkodelujući estarski lokalni anestetik koji se, uglavnom, danas primenjuje u stomatologiji i veterini (1). Prokain za sada nije ispitan u kontekstu embriotoksičnosti, ali je dozvoljen za primenu kod trudnica pre izvođenja dentalnih intervencija u posebnim indikacijama (2, 13). Efekti prokaina se ostvaruju blokadom voltažno zavisnih natrijumovih kanala, i posledič-

Tabela 2. Aminokiselinske sekvence i njihova redna mesta u ispitivanim proteinima sa kojima je prokain ostvario veze

Oznaka proteina	Aminokiselinska sekvenca za koju se prokain vezuje
kcnh6a	Ile523, Ile511, His1131
kcnh7	Ser36, His365, Leu364
kcnh5a	Tyr210, Trp292, Arg367
kcnh2a	Asn467, Phe468, Ile464
psen2	Trp208, Leu204, Phe184
rbfa	Arg294, Hist162, Asp267
zfpl1	Phe86, Trp82, Asn85
scn8aa	Asn904, Arg965, Lue1009
scnl1a	Phe1472, Asn885, Leu990

Skraćenice: Ile - ileucin, His – histidin, Ser – serin, Leu – leucin, Tyr – tirozin, Trp – triptofan, Arg – arginin, Asn – asparagin, Phe – fenil-alanin.

Figure 2. Gibbs free energy values in interactions between procaine and the examined proteins. The displayed values for each protein had RMSD below 3 (high docking precision), resulting in 2 interactions per protein.

on the Y-axis. These maps enable the monitoring of dynamic changes in the expression of proteins during different stages of embryonic development, providing insight into the potential role of each protein in those key periods.

According to the obtained data, most of the proteins (5 out of 9) are expressed at a high rate during the blastula period (128 cells and 1000 cells) (Figure 1).

Molecular Docking

Molecular docking was performed with the help of AutoDock Vina program, where comparisons were made using interactions, where RMSD values were lower than 3 (for higher values, the accuracy of the analysis was considered low).

The interaction between scn11aa protein and procaine had the lowest value of Gibbs free energy and it amounted to -6 kCal/mol. For the protein zfp11, the Gibbs free energy value was the lowest and it amounted to -4.4 kCal/mol. The energy values of other interactions are presented in Figure 2.

In addition to energy values, we also examined the binding sites of procaine on examined proteins and we showed that there was a certain degree of similarity in binding between proteins that belong to the family of sodium (scn8aa, scn1la) and potassium (kcnh6a, kcnh7) voltage-gated channels (Table 2). In the case of sodium channels, the most

Table 2. Amino acid sequences and their positions in the examined proteins with which procaine formed interactions

Protein label	Amino acid sequence to which procaine binds
kcnh6a	Ile523, Ile511, His1131
kcnh7	Ser36, His365, Leu364
kcnh5a	Tyr210, Trp292, Arg367
kcnh2a	Asn467, Phe468, Ile464
psen2	Trp208, Leu204, Phe184
rbfa	Arg294, Hist162, Asp267
zfpl1	Phe86, Trp82, Asn85
scn8aa	Asn904, Arg965, Lue1009
scnl1a	Phe1472, Asn885, Leu990

Abbreviations: Ile – Isoleucine, His – Histidine, Ser – Serine, Leu – Leucine, Tyr – Tyrosine, Trp – Tryptophan, Arg – Arginine, Asn – Asparagine, Phe – Phenylalanine.

no sprečavanjem prenosa signala (2). Poznavajući efekte postavlja se opravdano pitanje uticaja ovog anestetika na razviće struktura koji obiluju jonskim kanalima, kao što je srce. Pored klasičnih *in vivo* modela za ispitivanje toksičnosti danas se sve više koriste i kompjuterske analize i simulacije – *in silico* analize (14).

Razviće je dinamičan proces u kome dolazi do velikog broja promena koje su orkestrirane regulisanim stopama ekspresije različitih proteina (15). U našem radu smo pokazali da je većina proteina eksprimirana u visokoj stopi u periodu blastule, 2 h i 15 min nakon oplođenja, što nam može ukazati na kritičnu tačku u razviću gde bi prokain mogao ostvariti toksične efekte. Ekstrapolirajuću ove podatke na čoveka, ukazujemo na činjenicu da je ovo vrlo rani period kada obično žena ni ne sumnja da je trudna. Tarner i autori su sproveli studiju na 60.000 trudnica tokom 6 godina sa primenom prokaina tokom dentalnih intervencija i nisu pokazali da dolazi do značajnog porasta u komplikacijama na plodu (16). Međutim, u ovom radu su trudnice bile izlagane prokainu u odmakloj trudnoći i dobijeni rezultati mogu da se objasne ili gore navedenom kritičnom tačkom ili razlikom u metabolisanju prokaina kod čoveka i zebrica.

Na osnovu rezultata molekularnog dokinga utvrdili smo da prokain, u srcu zebrica, najviše ostvaruje efekte na kalijumove i natrijumove voltažno-zavisne kanale što je u skladu sa njegovim primarnim efektom (2). Pored ovih, ističu se još 3 proteina: presenilin 2, ribozom vezujući faktor A i protein sličan cinkovim prstima 1, koji su bitni za razviće srca ali ne posreduju u transportu navedenih jona. Njihove funkcije su vezane za različite procese, poput energetskog metabolizma, sinteze proteina, obrade primarnog tranksripta itd. (17–20). Uzimajući u obzir rezultate radova u kojima su animalnim modelima isključivani geni koji kodiraju ispitivane proteine može se očekivati ispad i u strukturi (nepravilno organizovana srčana mišićna vlakna i fibroza) i u funkciji srčanog mišića (bradikardija i produžen QT interval) (21,22).

Na kraju smo ispitivali vezna mesta prokaina na proteinima. Slične aminokiselinske sekvence su utvrđene među proteinima koji pripadaju istim familijama što ukazuje na blisko filogenetsko poreklo (23). Hov i autori su sekvencirali genom zebrica i pokazali homologiju u 70% gena u odnosu na čovekov genom (24). Filogenetski starije strukture poput jonskih kanala, pokazuju visok stepen homologije među vrstama pa je značaj naših dobijenih rezultata utoliko veći jer možemo pretpostaviti da će iste interakcije biti ostvarene i na nivou čovekovih (homologih) proteina (25).

Zaključak

Prokain u in silico uslovima ostvaruje značajne interakcije sa proteinima koji učestvuju u razvoju srca kod zebrica. Posebno je uočeno da je većina ovih proteina visoko eksprimirana u fazi blastule, što potencijalno označava ključnu tačku u razvoju u kojoj bi prokain mogao ispoljiti najtoksičnije efekte. Ekstrapolacija ovih rezultata na čoveka ukazuje da je ovo rani stadijum trudnoće, kada još uvek nisu prisutni znaci koji upućuju na graviditet što može biti značajan aspekt u kontekstu budućih primena prokaina. Dobijene rezultate ne treba koristiti samostalno već u sprezi sa rezultatima na živim embrionima koje treba dopuniti u nekim budućim istraživanjima.

Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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common binding site contained the amino acid sequence including leucine (LEU) and asparagine (ASN), while in the case of potassium channels, it was a sequence containing histidine (HIS) and isoleucine (ILE).

Discussion

Procaine is a short-acting local anesthetic, which is today mainly used in dentistry and veterinary medicine (1). Procaine has not been examined so far in the context of embryotoxicity, but it has been allowed for use in pregnant women before dental interventions in special indications (2,13). The effects of procaine are achieved by blocking voltage-gated sodium channels, and consequently by preventing transmission of signals (2). Knowing the effects, the legitimate question is raised about the impact of this anesthetic on the development of structures rich in ion channels, such as the heart. In addition to classic *in vivo* models for toxicity testing, today computer analyses and simulations – *in silico* analyses are increasingly used (14).

Development is a dynamic process, in which a large number of changes occur that are orchestrated by the regulated expression rates of various proteins (15). In our study, we have shown that most proteins are expressed at a high rate in the blastula period, 2h and 15 minutes after fertilization, which may indicate a critical point in development, where procaine could have toxic effects. By extrapolating these data to humans, we have pointed to the fact that this is the very early period when usually a woman does not even suspect that she is pregnant. Turner et al. conducted a study that included 60,000 pregnant women during 6 years, when procaine was administered during dental interventions and they did not show a significant increase in fetal complications (16). However, in this study, pregnant women were exposed to procaine in late pregnancy, while the obtained results can be explained either by the above mentioned critical point or by the difference in metabolizing procaine in humans and zebrafish.

Based on the results of molecular docking, we determined that procaine, in the heart of zebrafish, had most effects on potassium and sodium voltage-gated channels, which is in accordance with its primary effect (2). In addition to these, three more proteins stand out: presenilin2, ribosome-binding factor A and zinc finger-like proteins, which are important for the development of the heart but do not mediate in the transport of the mentioned ions. Their functions are connected with various processes, such as energy metabolism, synthesis of proteins, processing of primary transcript etc. (17-20). Taking into consideration the results of studies, in which protein-encoding genes were excluded in animal models, disorders related to the structure can be expected (irregularly arranged cardiac muscle fibers and fibrosis), as well as defects related to the function of the cardiac muscle (bradycardia and prolonged QT interval) (21,22).

Finally, we examined the binding sites of procaine on proteins. Similar amino acid sequences have been found among proteins belonging to the same families, which points to the close phylogenetic origin (23). Hov et al. sequenced the genome of zebrafish and showed homology in 70% of genes in comparison to the human genome (24). Phylogenetically older structures such as ion channels show a high degree of homology between species, so the importance of our obtained results is greater because we can assume that the same interactions will be realized at the level of human (homologous) proteins (25).

Conclusion

Procaine under *in silico* conditions achieves significant interactions with proteins that are involved in heart development in zebrafish. It was observed that most of these proteins were highly expressed at the blastula stage, which potentially marks the key point in development where procaine could exert its most toxic effects. The extrapolation of these results to humans indicates that this is the early stage of pregnancy, when signs of pregnancy are not present, which may be an important aspect in the context of future applications of procaine. The obtained results should not be used independently, but together with the results obtained on live embryos, which should be supplemented in some future research.

Competing interests

The authors declared no competing interests.

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UTICAJ 2,4-DIAMINOBUTERNE KISELINE NA PROTEINE KOJI UČESTVUJU U RAZVIĆU MORFOMETRIJSKI MERLJIVIH PARAMETARA OKA KOD ZEBRICE: *IN SILICO* ANALIZA

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SAŽETAK

Uvod: 2,4- diaminobuterna kiselina (2,4-DABA), ekscitatorna amino-kiselina sa dokazanim neurotoksičnim efektom se nalazi u vodenim ekosistemima, sa potencijalom za akumulaciju u biljnim i u životinjskim organizmima. S obzirom da je dokazan njen neurotoksični, hepatotoksični i potencijalno kancerogeni efekat postavlja se pitanje moguće embriotoksičnosti. Zahvaljujući velikoj homologiji sa ljudskim genomom, dinamika i morfologija razvića se može proučavati na zebricama (lat. *Danio rerio*), koje predstavljaju dobar model sistem za ispitivanje razvića i razvojnih abnormalnosti.
Cilj: Ispitivanje uticaja 2,4-DABA-e na proteine ključne u razviću oka zebrica pomoću molekularnog dokinga.
Metode: Inicijalno je urađen skrining celokupnog genoma korišćenjem *FINDSITE*^{comb} softvera, preciznom analizom je selektovano 1119 proteina iz baze kojima smo utvrđivali stepen homologije, tkivno specifičnu ekspresiju i vreme ekspresije. Šest proteina koji su ispunili tražene kriterijume, analizirani su u *AutoDock Vina* programu molekularnim dokingom.
Rezultati: Interakcija fzd8a proteina i 2,4-DABA-e ispoljila je najnižu vrednost Gibsove slobodne energije od - 4,6 kCal/mol, dok je najviša od - 3,4 kCal/mol zabeležena u interakciji sa proteinom *pbx4*. Takođe, uočena je sličnost aminokiselinske sekvence u proteinima za koje se vezivala 2,4-DABA, koja se ogledala u aminokiselinama koje u svom sastavu imaju –SH grupu.
Zaključak: Sprovedenim istraživanjem pokazano je da 2,4-DABA može ostvarivati svoje efekte na razvoj oka, tokom celog perioda. Rezultate *in silico* analiza ne treba posmatrati izolovano, već kao početni korak i smernice za istraživanja u in vivo uslovima. Stoga naša studija treba biti dopunjena rezultatima ispitivanja na živim embrionima.

Ključne reči: bioinformatika, razviće oka, 2,4-DABA, zebrice

Uvod

2,4- diaminobuterna kiselina (2,4-DABA) je ekscitatorna amino-kiselina sa dokazanim neurotoksičnim efektom (1). Predstavlja metabolički produkt cijanobakterija (2), a nalazi se i u brojnim ekosistemima kako slatkovodnim, tako i morskim, ali i u uzorcima aerosola i tla u njihovoj blizini (3).

Pored toga primećeno je da ima potencijal akumulacije u živim organizmima, kao što su alge, ribe, krabe, ali i u nekim biljnim organizmima, kao i u organizmima sisara (2). Nalazi se i u otpadnim vodama, a potencijalno i u vodama za piće gde ostvaruje interakciju sa sporednim produktima dezinfekcije vode (3).

Svoj dokazani neurotoksični efekat 2,4-DABA ostvaruje delujući kao nelinearni i nekompetitivni inhibitor transaminaze gama aminobuterne kiseline (GABA), te tako povećava koncentraciju GABA-e. Pored toga dovodi do osmotske lize ćelije, ostvaruje hepatotoksični efekat, a istražuje se potencijalni kancerogeni efekat u nastanku glioma, fibrosarkoma, karcinoma jetre itd. (4).

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ORIGINAL ARTICLE

THE IMPACT OF 2,4-DIAMINOBUTYRIC ACID ON PROTEINS INVOLVED IN THE DEVELOPMENT OF MORPHOMETRICALLY MEASURABLE EYE PARAMETERS IN ZEBRAFISH: AN IN SILICO ANALYSIS

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SUMMARY

Introduction: 2,4-Diaminobutyric acid (2,4-DABA) is an excitatory amino acid with neurotoxic, hepatotoxic, and potentially carcinogenic effects, found in aquatic ecosystems with a tendency to accumulate in plants and animals. Due to its potential impact on development, its embryotoxicity is being studied. Zebrafish (Danio rerio), with high homology to the human genome, serve as an excellent model for studying development and developmental abnormalities.
Objective: To investigate the effect of 2,4-DABA on proteins crucial for zebrafish eye development using molecular docking.
Methods: Proteome screening was conducted using the FINDSITEcomb software, selecting 1119 proteins based on homology, tissue specificity, and expression timing. Six proteins that met the criteria were analyzed using molecular docking in the AutoDock Vina program.
Results: The interaction of the fzd8a protein with 2,4-DABA showed the lowest Gibbs free energy value of -4.6 kCal/mol, while the interaction with the pbx4 protein had the highest value of -3.4 kCal/mol. A similarity was observed in the amino acid sequence of proteins that bind to 2,4-DABA, particularly in those containing an –SH group.
Conclusion: 2,4-DABA may affect eye structure development in zebrafish by interacting with proteins throughout the entire development period. The results of *in silico* analyses provide a basis for further in vivo research, which should be conducted on live embryos to confirm these findings.

Key words: bioinformatics, eye development, 2,4-DABA, zebrafish

Introduction

2,4-Diaminobutyric acid (2,4-DABA) is an excitatory amino acid with a proven neurotoxic effect (1). It is a metabolic product of cyanobacteria (2), and it is found in numerous ecosystems, both freshwater and marine, as well as in the samples of aerosols and soil in their vicinity (3).

In addition, it has been noticed that it has the potential of accumulation in live organisms, such as algae, fish, crabs, as well as in some plants and mammalian organisms (2). It has also been found in waste water, and potentially in drinking water, where it interacts with by-products of water disinfection (3).

2,4-DABA achieves its proven neurotoxic effect by acting as a non-linear and non-competitive inhibitor of GABA (gamma-aminobutyric acid) transaminase activity, thus increasing the concentration of GABA. In addition, it leads to osmotic lysis, achieves the hepatotoxic effect, while its carcinogenic effect is being investigated in the development of glioma, fibrosarcoma, liver cancer, etc. (4).

2,4-DABA ima i pokazani antitumorski efekat, jer dovodi do osmotske lize ćelije nakon ulaska aktivnim transportom pomoću transportera za aminokiselinu alanin (5).

Zebrice (lat. *Danio rerio*) su slatkovodne ribe, dužine 2–4 cm, koje predstavljaju dobar model sistem za ispitivanje razvića i razvojnih abnormalnosti (6). Neke od najznačajnijih karakteristika zebrica kao model sistem za ispitivanje razvića su: veličina, jednostavnost genetičkog manipulisanja, visoka feritlnost, lakoća i ekonomičnost za održavanje, brzo i transparentno razviće (7).

Zahvaljujući velikoj homologiji sa ljudskim genomom, dinamika i morfologija razvića koji se proučavaju na ovim ribama mogu se preneti i na razviće ljudskog embriona (8). Oko embriona nalazi se na prominentnoj poziciji, te je pogodno pratiti njegovo razviće kroz nekoliko morfometrijskih parametara. Parametri koji se mogu pratiti su dijametri oka, dijametri sočiva, njegova površina, oblik i drugo. S obzirom da strukture oka potiču kombinovano od mezoderma i nervne kreste (9) postavlja se pitanje uticaja 2,4-DABA-e ne samo na razvoj struktura oka već i na ostale nervne strukture.

In silico analiza potencijalnih interakcija različitih molekula predstavlja brz način provere mehanizma dejstva određene toksične supstance i spoznavanje patofizioloških procesa koji su posledica istog (10,11).

S obzirom na široku rasprostranjenost 2,4-DABA-e, njenu neurotoksičnost i kancerogenost, ali i neistraženost mehanizma njegovog delovanja, cilj našeg rada je bio ispitivanje interakcije ovog toksina sa proteinima bitnim u razviću oka, mehanizama kojim ova amino-kiselina deluje, kao i mogućih posledica koje će iz njenog dejstva proisteći.

Metode

Preliminarni skrining proteoma

U cilju utvrđivanja mogućih interakcija 2,4-DABA-e i proteina domaćina, odrađen je skrining celog proteoma čoveka, koristeći *FINDISTE*^{comb} softver. Ovaj softver funkcioniše po principu analize unesene hemijske strukture molekula uključujući informacije iz različitih baza podataka (*PDB*, *chEMBL*, *DrugBank*) i upoređujući potencijalne sličnosti u strukturnim domenima između unetog molekula i svih dostupnih proteina. Rezultati se prikazuju tabelarno sa sledećim podacima: mTC vrednost (Tanimoto koeficijent – skor koji ukazuje na meru sličnosti između 2 elementa), preciznost odrađene analize, naziv proteina u *RefSeq* bazi i opis proteina (12).

Za dalje analize su korišćeni rezultati čija je preciznost analize bila preko 70%, što je činilo ukupno 1119 proteina.

Navedene analize su, kao što je gore navedeno, važile za proteine ljudskog organizma. Stoga, koristeći *ZFIN* bazu podataka, utvrdili smo stepen homologije između intereagujućih proteina sa ljudskim i ispitali stopu i tkivnu specifičnost njihove ekspresije kroz period embriogeneze u zebrica (13). Finalno smo utvrdili da sve kriterijume (homologi proteini koji se eksprimiraju tokom embriogeneze u oku zebrica) ispunjava 6 proteina iz naše baze koje smo dalje analizirali. Nazivi, funkcija i lokalizacija ispitivanih proteina su preuzeti sa ZFIN-a i prikazani su u tabeli 1.

Priprema za molekularni doking

Strukture proteina (receptora) dobijene kristalografijom su preuzete sa *PDB* ili AlphaFold sajta. 3D struktura prokain-hidrohlorida (liganda) je preuzeta sa *PubChem*-a (14).

Molekularni doking

Molekularni doking je tehnika koja predviđa orijentaciju, afinitet i interakciju liganda na mestu vezivanja u receptoru (protein). U našem radu smo koristili *AutoDock Vina* program koji se primenjuje za predviđanje navedenih interakcija, što je našlo široku primenu u otkrivanju novih lekova.

Nakon otvaranja programa, strukture proteina (u *PDB* formatu) i liganda (u *SDF* formatu) se ubacuju i modifikuju prema potrebi. Za naše analize smo kod ispitivanih molekula uklonili molekule vode. U većini slučajeva, molekuli vode nemaju značajnu ulogu u vezivanju pa se zbog toga brišu kako bi se olakšala izračunavanja. Pored ovoga, polarni atomi vodonika i naelektrisanja su dodati molekulima receptora pre inicijalizacije procesa u cilju „otvaranja“ što više veznih mesta. Molekularni doking je odrađen pod okolnostima da su sve veze liganda rotirajuće, dok su veze receptora podešene da nemaju ovu mogućnost (15).

Pokretanjem dokinga program započinje simulacije interakcija između različitih funkcionalnih grupa receptora i liganda. Na kraju se prikazuje 10 najreprezentativnijih interakcija sa vrednostima Gibsove slobodne energije i srednjeg kvadratnog

2,4-DABA has been shown to have an antitumor effect, because it leads to osmotic lysis after entering by active transport with the help of aminoacid transporter alanine (5).

Zebrafish (Danio rerio) are freshwater fish, 2-4 cm long, which represent a good model system for the examination of development and developmental abnormalities (6). Some of the most important characteristics of zebrafish that serve as a model system for the examination of development are: size, simplicity of genetic manipulation, high fertility, simple and inexpensive maintenance, fast and transparent development (7).

Thanks to the high homology with the human genome, the dynamics and morphology of development, which are studied in these fish, can also be transferred to the development of the human embryo (8). The eye of the embryo is in a prominent position, and it is convenient to monitor its development through several morphometric parameters. The parameters that can be monitored are the following: the diameters of the eye, the diameters of the lenses, its surface, shape, etc. Considering that eye structures are derived from the mesoderm and neural crest (9), the question of the impact of 2,4-DABA is raised, including both the impact on the development of eye structures and on other neural structures.

In silico analysis of potential interactions between different molecules represents a quick way to check the mechanism of action of certain toxic substances and to realize consequential pathophysiological processes (10,11).

Considering the widespread distribution of 2,4-DABA, its neurotoxicity and carcinogenicity, as well as the unexplored mechanism of its action, the aim of our study was to examine the interaction between this toxin and proteins that are important for eye development, the mechanism by which this amino acid acts, as well as the possible consequences of its action.

Methods

Preliminary screening of the proteome

In order to determine possible interactions between 2,4-DABA and host proteins, screening of the entire human proteome was performed using the FINDSITE^{comb} software. This software works on the principle of analysis of the input chemical molecule structure, including information from different databases (PDB, chEMBL, DrugBank), and comparison of potential similarities in structural domains between the input molecule and all available proteins. The results are presented in tables with the following data: mTC value (the Tanimoto coefficient – score that indicates the measure of similarity between 2 elements), the accuracy of analysis, the name of the protein in the RefSeq database and description of the protein (12).

The results, whose accuracy was over 70%, were used for further analysis, and it included the total of 1119 proteins.

The mentioned analyses were, as stated above, valid for the proteins of the human organism. Therefore, using the ZFIN database, we determined the degree of homology between the proteins interacting with the human ones, and examined the rate and tissue specificity of their expression throughout the period of embryogenesis in zebrafish (13). Finally, we determined that 6 proteins from our database met all the criteria (homologous proteins that are expressed during embryogenesis in the eye of zebrafish), and we further analyzed them. The names, function and localization of the examined proteins were obtained from the ZFIN database and they are shown in Table 1.

Preparation for molecular docking

Protein (receptor) structures, which were obtained by crystallography, were downloaded from the PDB or AlphaFold websites. The 3D structure of procaine-hydrochloride (ligand) was downloaded from PubChem (14).

Molecular docking

Molecular docking is a technique that predicts the orientation, affinity and interaction of ligands at the binding site in a receptor (protein). In our study, we used the AutoDock Vina program, which is used for predicting the mentioned interactions, which has found wide application in discovering new drugs. After opening the program, the structures of proteins (in PDB format) and ligands (in SDF format) are entered and modified as needed. We removed water molecules from the examined molecules in our analyses. In most cases, water molecules do not have a significant role in binding, and therefore, they are removed in order to facilitate calculations. In addition, polar hydrogen atoms and electric charges are

Tabela 1. Podaci o ispitivanim proteinima preuzeti iz ZFIN baze podataka

Oznaka proteina	Pun naziv proteina	Lokalizacija	Funkcija
Lgsn	Lengsin	Transmembranski protein Citoplazma	Učestvuje u morfogenezi sočiva i eksprimira se u njemu
rnf216	Prstenasti protein 216	Citoplazma	Učestvuje u razvoju oka i malog mozga
fzd8a	Uvijeni receptor 8a	Transmembranski protein	Učestvuje u građi oka, u neurogenezi, ekspimira se u nervnoj kresti, CNS-u i digestivnom traktu
cyp1b1	Citohrom P450, familija 1, subfamilija B, polipeptid 1	Mitohondrije, endoplazmatski retikulum	Učestvuje u patogenezi glaukoma.
Lepr	Leptinski receptor	Transmembranski protein	Učestvuje u razvoju čulnih organa Eksprimira se u CNS-u i notohordi
pbx4	Pre-B-ćelijska leukemija transkripcioni faktor 4	Jedro	Učestvuje u razvoju neurona

U tabeli su prikazane oznake, pun naziv, lokalizacija i funkcija proteina koje su ispunile kriterijume (homologi proteini koji se eksprimiraju tokom embriogeneze u oku zebrica); podaci preuzeti iz ZFIN baze podataka.

odstupanja atomskih pozicija (SKOAP). Negativnije vrednosti Gibsove slobodne energije ukazuju na veću šansu spontane reakcije odnosno jače vezivanje između receptora i liganda, dok vrednosti SKOAP-a nam služe za evaluaciju preciznosti odrađenog dokinga (15).

Rezultati

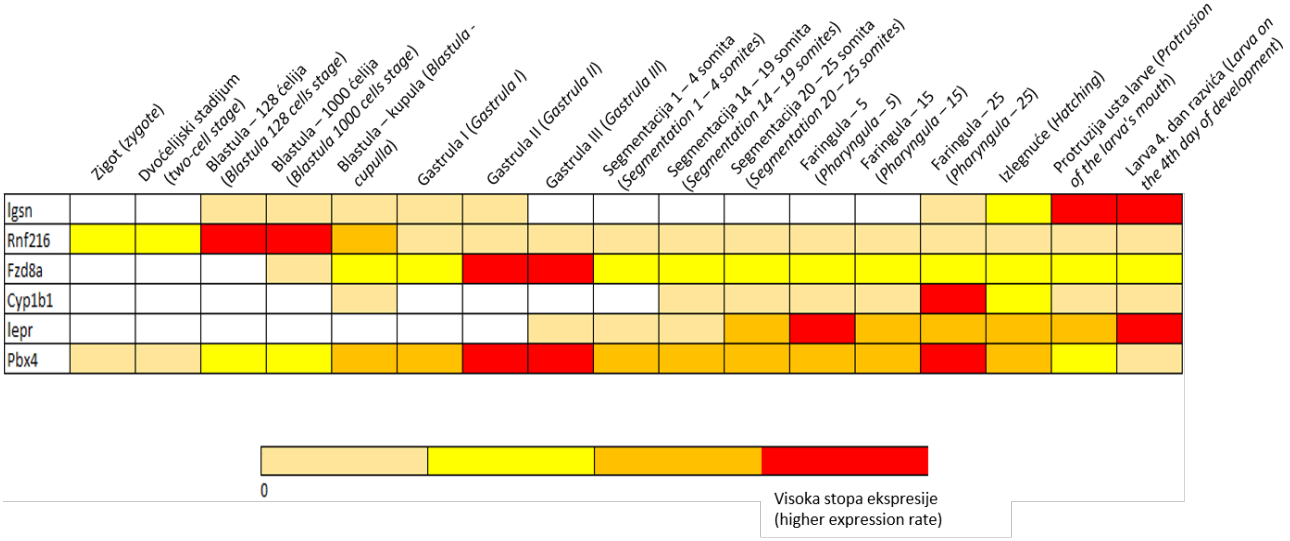
Stepen ekspresije ispitivanih proteina

Na osnovu podataka preuzetih sa *ZFIN*-a, napravljene su toplotne karte koje pokazuju vreme i stepen ekspresije ispitivanih proteina. X-osa karte je podeljena na 17 delova od kojih svaki predstavlja deo razvića u kome se dešavaju neke karakteristične promene. Na Y-osi se nalaze ispitivani proteini (Grafikon 1).

Prema dobijenim rezultatima utvđeno je da postoji difuzna raspoređenost u stopi eksprimiranja ispitivanih proteina. S tim u vezi možemo zaključiti da bi usled kontinuirane ekspozicije tokom perioda embriogeneze 2,4-DABA svoje efekte ostvarivala celom dužinom ovog perioda.

Molekularni doking

Molekularnim dokingom su za poređenja uzete interakcije gde su vrednosti SKOAP-a bile niže od 3 (za veće vrednosti se smatra da je preciznost analize mala).



Grafikon 1. Termalna mapa sa prikazom nivoa ekspresije ispitivanih proteina kroz različite periode embriogeneze (Skala pokazuje stepen ekspresije ispitivanih proteina kroz različite periode embriogeneze.)

Table 1. Data on the examined proteins obtained from the ZFIN database

Protein label	Full protein name	Localization	Function
Lgsn	Lengsin	Transmembrane protein Cytoplasm	Involved in lens morphogenesis and is expressed in it
rnf216	Ring finger protein 216	Cytoplasm	Involved in develepmont of eye and cerebellum
fzd8a	Frizzled receptor 8a	Transmembrane protein	Involved in eye structure, neurogenesis, and is expressed in the neural crest, CNS, and digestive tract
cyp1b1	Cytochrome P450, family 1, subfamily B, polypeptide 1	Mitochondria, endoplasmic reticulum	Involved in eye development, expressed in immature eye structures Involved in the pathogenesis of glaucoma
Lepr	Leptin receptor	Transmembrane protein	Involved in the development of sensory organs Expressed in the CNS and notochord
pbx4	Pre-B-cell leukemia transcription factor 4	Nucleus	Involved in neuron development

The table presents the labels, full names, localization, and functions of the proteins that met the criteria (homologous proteins expressed during zebrafish eye embryogenesis); data obtained from the ZFIN database.

assigned to the molecules of receptors before the initialization of the process aimed at "opening" as many binding sites as possible. Molecular docking was performed under the condition that all bonds of ligands are rotatable, while receptor bonds are set not to have this possibility (15).

By starting docking, the program starts simulations of interactions between different functional groups of receptors and ligands. Finally, the ten most representative interactions are shown with the values of Gibbs free energy and the root mean square deviation (RMSD) of atomic positions. The negative values of Gibbs free energy indicate a greater chance of a spontaneous reaction, that is, stronger binding between the receptor and the ligand, while the RSMD values are used to evaluate the accuracy of conducted docking (15).

Results

The degree of expression of examined proteins

Based on the data obtained from the ZFIN database, heat maps were created and they show the time and level of expression of examined proteins. The X-axis of the map is divided into 17 parts, and each of them represents one stage

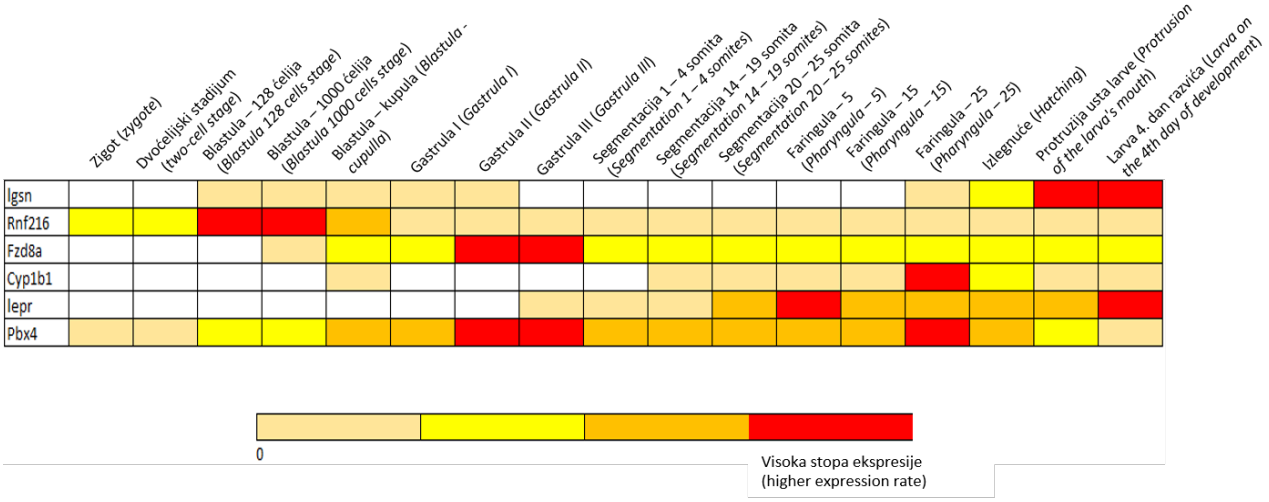
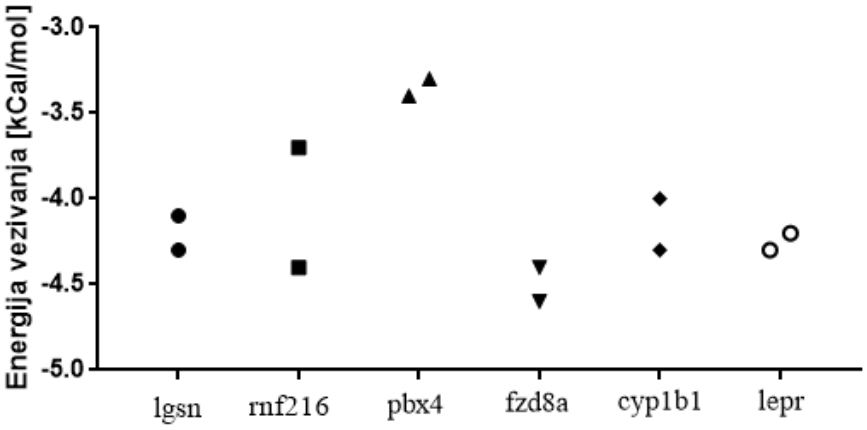


Figure 1. Heat map showing the expression levels of the examined proteins through different stages of embryogenesis (The scale shows the level of expression of the examined proteins through different stages of embryogenesis.)



Grafikon 2. Vrednosti Gibsove slobodne energije u interakcijama izmedju 2,4-DABA-e i ispitivanih proteina. Prikazane vrednosti za svaki protein imale su SKOAP niže od 3 (visoka preciznost dokinga), što je činilo po 2 interakcije po proteinu.

Interakcija *fzd8a* proteina i 2,4-DABA-e je imala najvišu vrednost Gibsove slobodne energije i iznosila je - 4,6 kCal/mol. Za protein *pbx4* je vrednost Gibsove slobodne energije bila najniža i iznosila je - 3,4 kCal/mol. Vrednosti energija ostalih interakcija su date u grafikonu 2.

Pored vrednosti energija, ispitivali smo i vezna mesta 2,4-DABA-e na ispitivanim proteinima. Iako međusobno različite funkcije proteina, sekvence za koje se vezivala 2,4-DABA su bile slične, odnosno, sadržale su aminokiseline koje u svom sastavu imaju –SH grupu (metionin, cistein) (Tabela 2).

Diskusija

2,4-DABA je neproteinska aminokiselina, koja ima dokazani neurotoksični, hepatotoksični efekat, dovodi do citolize ćelija, a ispituje se i njen kancerogeni efekat. Iako do sada slabo ispitana postavlja se pitanje mogućnosti uticaja pomenute aminokiseline na razvoj određenih tkiva ploda (16). Pored toga utvrđeno je da zbog difuzne raspoređenosti u stopi eksprimiranja ispitivanih proteina 2,4-diaminobuterne kiselina svoj efekat ostvaruje tokom čitave embriogeneze. To znači da ne postoji jedna kritična tačka u kojoj 2,4-DABA ostvaruje svoj efekat, već je njena toksičnost izražena tokom čitavog perioda, što povećava njen uticaj.

Pored standardnih animalnih modela danas se sve više koriste i kompjuterske simulacije (17) za ispitivanja mehanizama toksičnosti različitih supstanci. U izradi našeg rada koristili smo *AutoDock Vina*-u za ispitivanje uticaja 2,4-DABA-e na proteine uključene u razviće oka. Doking je metod koji omogućuje spoznaju orjentacije molekula koji su povezani u stabilni kompleks. Poznavanje orjentacije nam pokazuje afinitet vezivanja molekula koji grade kompleks. S obzirom da asocijacije između molekula imaju ulogu u prenosu signala, njihova orjentacija

Tabela 2. Aminokiselinske sekvence i njihova redna mesta u ispitivanim proteinima sa kojima je 2,4-DABA ostvarila veze

Oznaka proteina	Aminokiselina za koju se vezuje
Lgsn	Metionin135, cistein142, tirozin141
rnf216	Prolin611, arginin604, serin609
fzd8a	Serin268, metionin1,tirozin253
cyp1b1	Fenilalanin99, serin445, tirozin97
Lepr	Prolin389, Aspraginska kiselina370, valin392
Pbx4	Prolin389, Aspraginska kiselina370, valin392

Tabela sadrži oznake šest ispitivanih proteina, kao i aminokiselinske sekvence (sa rednim mestima) koje ostvaruju interrakciju sa 2,4 DABA-om.

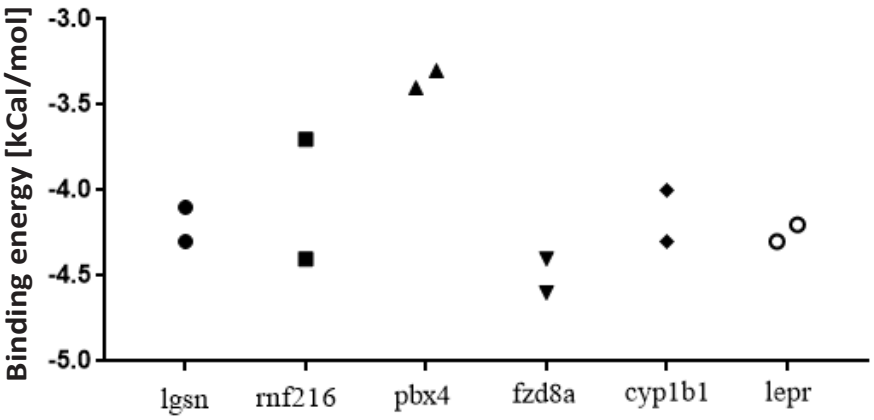


Figure 2. Gibbs free energy values in interactions between 2,4-DABA and the examined proteins. The displayed values for each protein had RMSD below 3 (high docking precision), resulting in 2 interactions per protein.

of development in which some characteristic changes occur. The examined proteins are on the Y-axis (Figure 1).

According to the obtained results, a diffuse distribution in the rate of expression of examined proteins was found. In this regard, it can be concluded that due to the continuous exposure during the period of embryogenesis, 2,4-DABA would show its effects throughout this period.

Molecular docking

Interactions, where RMSD values were lower than 3 (the precision of the analysis is considered low for higher values), were taken for comparison in molecular docking.

The interaction between fzd8a protein and 2,4-DABA had the highest Gibbs free energy value and it amounted to -4.6 kCal/mol. For protein pbx4, the Gibbs free energy value was the lowest and it amounted to -3.4 kCal/mol. The energy values of other interactions are presented in Figure 2.

In addition to energy values, we also examined the binding sites of 2,4-DABA on the examined proteins. Although the functions of proteins are different, the sequences to which 2,4-DABA bound were similar, that is, they included amino acids that contained an –SH group (methionine, cysteine) (Table 2).

Discussion

2,4-DABA is a non-protein amino acid, which has a proven neurotoxic, hepatotoxic effect, leads to cytolysis of cells, and its carcinogenic effect is also being investigated. Although it has been poorly investigated so far, the question relating to the possibility of impact of the above mentioned amino acid on the development of certain tissues of the fetus is raised (16).

Table 2. Amino acid sequences and their positions in the examined proteins with which 2,4-DABA formed interactions

Protein label	Amino acid to which procaine binds
Lgsn	Methionine 135, Cysteine 142, Tyrosine 141
rnf216	Proline 611, Arginine 604, Serine 609
fzd8a	Serine 268, Methionine 1, Tyrosine 253
cyp1b1	Phenylalanine 99, Serine 445, Tyrosine 97
Lepr	Proline 389, Aspartic acid 370, Valine 392
Pbx4	Glycine 117, Serine 116, Arginine 204

The table contains the labels of six examined proteins, as well as the amino acid sequences (with positions) that interact with 2,4-DABA.

može imati ulogu u tipu signala koji će se proizvesti, tako da možemo reći da je doking koristan za predviđanje jačine i tipa proizvedenog siganala (18).

Kod zebrica sa uklonjenim *fzd8a* genom (19) koji je našom doking analizom utvrđen da ima najjači afinitet vezivanja za 2,4-DABA-u, utvrđeno je da postoje brojne promene u odnosu na one sa funkcionalnim genom i njegovim proteinskim produktima. Međutim on ne deluje izolovano već u sadejstvu sa drugim proteinima iz ove familije (*fzd3*, *fzd9*, *fzd10*). Promene se pre svega odnose na razvoj nervnih struktura, kao što je dorzalni deo nervne cevi, ali i struktura oka pre svega pigmentnih ćelija-melanocita, a takođe je utvrđena nemogućnost migracije ćelija iz nervne kreste, što je u embriogenezi ključno za pravilno topografsko mapiranje.

U radu *Ferraiulo* i saradnika (20) pokazano je da 2,4-DABA ostvaruje dozno-zavisnu toksičnost. Na osnovu rezultata ovog rada utvrđen je uticaj na vijabilnost, kako embriona tako i odraslih jedinki, ali i na njihovu sposobnost plivanja, tj. na njihovu motoričku aktivnost. S obzirom na to možemo reći da ova aminokiselina nesumnjivo ima neurotoksični efekat na embrione. U našem radu potvrđene su interakcije ove aminokiselina i proteina ključnih za razvoj struktura oka embriona. Promene koje su uočene u pomenutom radu, pogotovo one koje se tiču motornih aktivnosti, mogle bi se objasniti uticajem 2,4- DABA, s obzirom na činjenicu da su strukture oka i strukture centralnog nervnog sistema istog embrionalnog porekla.

Purdie i saradnici su u svom radu (21) istraživali uticaj β-N-metilamino-L-alanin (BMAA) na razviće zebrica. Ova aminokiselina ima sličnu strukturu i dejstvo kao 2,4-DABA i generalno u prirodi najčešće sinergistički deluju. Ovo istraživanje potvrdilo je dozno-zavisne efekte na razvoj različitih struktura. Između ostalog nesumnjiv je uticaj na razvoj nervnih ćelija ključnih za inervaciju mišićnih strukuta, što se ispoljilo poremećajima u mišićnim aktivnostima u vidu klonusa sličnim konvulzijama. Navedeni rezultati mogli bi se objasniti interakcijama proteina koje smo ispitivali, a koji imaju bitnu ulogu u razvoju nervnih struktura i mišića.

Zaključak

Na osnovu dobijenih rezultata pokazano je da 2,4-DABA može ostvarivati svoje efekte tokom celog perioda razvića oka, ostvarujući značajne interakcije sa proteinima koji učestvuju u razviću oka. Rezultati *in silico* analiza se ne treba posmatrati izolovano, već kao početni korak i smernice za istraživanja u in vivo uslovima. Stoga i naša studija treba biti dopunjena rezultatima ispitivanja na živim embrionima.

Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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In addition, it was found that due to the diffuse distribution in the rate of expression of examined proteins, 2,4-diaminobutyric acid achieves its effect during the entire embryogenesis. This means that there is no single critical point at which 2,4-DABA achieves its effect, but that its toxicity is pronounced over the entire period, which increases its impact.

In addition to standard animal models, computer simulations (17) are increasingly used today for the examination of the mechanisms of toxicity of various substances. In our study, we used AutoDock Vina to examine the impact of 2,4-DABA on proteins involved in eye development. Docking is a method that enables the realization of the orientation of molecules that are connected in a stable complex. Knowledge of the orientation shows us the binding affinity of molecules that make up the complex. Considering the fact that associations between molecules have a role in signal transmission, their orientation can have a role in the type of signal that will be produced, and therefore, it can be said that docking is useful for predicting the strength and type of produced signals (18).

In zebrafish with the removed fzd8 gene (19), which was determined to have the strongest binding affinity for 2,4-DABA in our docking analysis, it was found that there are numerous changes compared to those with a functional gene and its protein products. However, it does not act in isolation, but in cooperation with other proteins from this family (fzd3, fzd9, fzd10). These changes primarily relate to the development of neural structures, such as the dorsal part of the neural tube, and eye structures, first of all, pigment cells - melanocytes, and the impossibility of cell migration from the neural crest, which is crucial in embryogenesis for proper topographic mapping, was also established.

In a study by Ferraiulo et al. (20), it has been shown that 2,4-DABA achieves dose-dependent toxicity. Based on the results of this study, the impact on the viability of embryos and adults was found, as well as on their ability to swim, that is, their motor activity. In regard to this, we can say that this amino acid undoubtedly has a neurotoxic effect on embryos. The interactions between these amino acids and proteins key for the development of embryonic eye structures were confirmed in our study. The changes, which were observed in the above mentioned study, especially those concerning motor activities, could be explained by the influence of 2,4-DABA, considering the fact that eye structures and the structures of the central nervous system are of the same embryonic origin.

Purdie et al. (21) investigated the influence of ß-N-methylamino-L-alanine (BMAA) on the development of zebrafish in their study. This amino acid has a similar structure and effect as 2,4-DABA and they generally act synergistically in nature. This study confirmed dose-dependent effects on the development of different structures. In addition, there is an undoubted influence on the development of nerve cells key for the innervations of muscle structures, which is manifested as disorders in muscle activities in the form of convulsions similar to clonic seizures. The mentioned results could be explained by the interactions of examined proteins, which have an important role in the development of neural structures and muscles.

Conclusion

Based on the obtained results, it was shown that 2,4-DABA can achieve its effects throughout the entire period of eye development, thus achieving significant interactions with proteins that participate in eye development. The results of *in silico* analysis should not be considered in isolation, but as a starting point and guidelines for *in vivo* research. Therefore, our study should be supplemented with the results of research conducted on live embryos.

Competing interests

The author declared no competing interests.

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PONAŠANJE I STAVOVI STUDENTKINJA MEDICINE PO PITANJU MENSTRUALNIH PROIZVODA

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SAŽETAK

Uvod/Cilj: Prema podacima Svetske banke, menstrualno siromaštvo pogađa oko 500 miliona žena širom sveta. Neadekvatni sanitarni uslovi i nedostupnost menstrualnih proizvoda, kao i njihovo neadekvatno korišćenje, mogu dovesti do brojnih posledica ozbiljnih poremećaja zdravlja žene. Cilj ovog istraživanja je bio da se ispitaju ponašanje i stavovi studentkinja medicine po pitanju menstrualnih proizvoda.
Metode: Studija preseka je sprovedena na Medicinskom fakultetu Univerziteta u Beogradu, u periodu 16-29.05.2024. godine. Uzorak je činilo 277 studentkinja medicine. Podaci su prikupljeni upitnikom. U statističkoj analizi podataka korišćen je χ^2 test.
Rezultati: Probleme sa nabavkom menstrualnih proizvoda tokom poslednjih 12 meseci je imalo 5,1% studentkinja. Statistički značajno češće ovaj problem su imale starije nego na mlađe studentkinje, dok statistički značajna razlika nije uočena između studentkinja sa stalnim mestom boravka u gradu i studentkinja sa stalnim mestom boravka na selu, kao ni između studentkinja I-III i IV-V godine studija. U takvim situacijama, 1,4% studentkinja je koristilo zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir i dr.), 1,8% je pozajmljivalo menstrualne proizvode od prijatelja, rođaka, itd., 1,1% je koristilo menstrualne proizvode duže vreme nego što to uobičajeno rade i 4,7% je kupovalo jeftinije menstrualne proizvode. Većina studentkinja (97,8%) je iskazala želju da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji.
Zaključak: Neophodno je uložiti napore na prevazilaženju problema nabavke menstrualnih proizvoda među studentkinjama starijih godina MFUB uvođenjem besplatnih menstrualnih proizvoda. Ovi rezultati pružaju polaznu osnovu za dalja istraživanja u ovoj oblasti sa ciljem sagledavanja faktora koji doprinose nedostupnisti menstrualnih proizvoda.

Ključne reči: Menstruacija, menstrualno zdravlje, menstrualni zdravstveni menadžment, menstrualno siromaštvo

Uvod

Prema definiciji Svetske zdravstvene organizacije menstruacija predstavlja fiziološki proces mesečnog izlučivanja krvi i tkiva sluzokože materice, kada trudnoća nije moguća (1). Menarha predstavlja početak reproduktivnog života devojčica, najčešće se dešava u periodu 10-13 godine života (1). S obzirom da žene u periodu od menarhe do menopauze menstruiraju, jako je važno vršiti promociju poboljšanja menstrualnog zdravlja žena i devojčica, sa ciljem da se omogući dostojanstvo, rodna ravnopravnost i reproduktivno zdravlje žena (2). Menstrualni zdravstveni menadžment (engl. *Menstrual health managemen*t - MHM) podrazumeva poboljšanje pristupa menstrualnim proizvodima neophodnim za održavanje higijene tokom menstruacije (higijenski ulošci, tamponi, menstrualne čašice) od adekvatnog materijala, zadovoljavajućeg kvaliteta i količine (2). Takođe, podrazumeva i prisustvo adekvatnih sanitarnih uslova (čista voda i sapun) za održavanje lične higijene i mesta koja

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BEHAVIOR AND ATTITUDES OF FEMALE MEDICAL STUDENTS REGARDING MENSTRUAL PRODUCTS

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SUMMARY

Introduction/Aim: According to the data of the World Bank, period poverty affects about 500 million women worldwide. Inadequate sanitary conditions and the unavailability of menstrual products, as well as their inadequate use, can lead to serious disorders of women's health. The aim of this study was to analyze the behavior and attitudes of female medical students regarding menstrual products.
Methods: TThe cross-sectional study was conducted at the Faculty of Medicine of the University of Belgrade, in the period 16-29 May 2024. year. The sample consisted of 277 medical students. Data were collected using a questionnaire. The χ^2 test was used for the statistical analysis of data.
Results: 5.1% of female students had problems with obtaining menstrual products during the last 12 months. Statistically significantly more often this problem was experienced by older than younger female students, while a statistically significant difference was not observed between female students with a permanent place of residence in the city and female students with a permanent place of residence in the countryside, as well as between female students of I-III and IV-V years of study. In such situations, 1.4% of female students used a substitute for a given menstrual product (eg cloth, toilet paper, etc.), 1.8% borrowed menstrual products from friends, relatives, etc., 1.1% used menstrual products for longer than they usually do and 4.7% bought cheaper menstrual products. The majority of female students (97.8%) expressed their wish for all school girls and female students in Serbia to have free products necessary for maintaining hygiene during menstruation.
Conclusion: It is necessary to continuously examine the behavior and attitudes of female students regarding menstrual products and the factors associated with them, both at the Faculty of Medicine of the University of Belgrade and at all other faculties, and use the results obtained as a basis for the creation and implementation of activities aimed at preserving and improving the health and quality of life of female students.

Key words: Period, Menstruation, Menstrual health, Menstrual Health Management, Period poverty

Introduction

According to the definition of the World Health Organization, menstruation is a physiological process of monthly discharge of blood and tissue from the mucous membrane of the uterus, when pregnancy is not possible (1). Menarche represents the beginning of girls' reproductive life, and it most often occurs between the ages 10 and 13 (1). Considering the fact that women menstruate from menarche to menopause, it is very important to promote the improvement of menstrual health of women and girls, which is aimed at enabling dignity, gender equality and women's reproductive health (2). Menstrual health management (MHM) implies providing access to menstrual products necessary for maintaining hygiene during menstruation (sanitary pads, tampons, menstrual cups), made of adequate materials, with satisfactory quality and quantity (2). It also implies the presence of adequate sanitary conditions (clean water and soap) for maintaining personal hygiene and places

omogućavaju korišćenje i menjanje menstrualnih proizvoda, kao i njihovo adekvatno odlaganje (3).

Menstrualno siromaštvo (engl. *Period poverty*) predstavlja nedostupnost finansijskih resursa za poboljšanje upravljanja MHM, što uključuje i nedostatak edukacije o pomenutom procesu (4). Prema podacima Svetske banke, menstrualno siromaštvo pogađa oko 500 miliona žena širom sveta. Neadekvatni sanitarni uslovi i nedostupnost menstrualnih proizvoda, kao i njihovo neadekvatno korišćenje mogu dovesti do ozbiljnih poremećaja zdravlja žene, kao što su infekcije, toksični šok sindrom i druge bolesti reproduktivnih organa (1).

Studije su pokazale da strah i osećaj poniženja koje devojčice osećaju zbog krvarenja i neprijatnog mirisa dovode do apsentizma i imaju negativan uticaj na edukaciju (1). Primećeno je da mnoge devojčice nemaju adekvatne zalihe menstrualnih proizvoda neophodnih za održavanje higijene, čak ni donjeg veša, što ih prisiljava na korišćenje zamena za uobičajene menstrualne proizvode, kao što su krpe, maramice ili toalet papir, tokom menstruacije (3). U cilju borbe protiv menstrualnog siromaštva pokrenute su mnoge globalne inicijative da menstrualni proizvodi budu besplatni na javnim mestima, kao što su škole. Takođe, inicijativa je da se pomenuti proizvodi oslobode poreza u prodavnicama (4). Smatra se da MHM zavisi od socio-ekonomskog statusa, edukacije, pa čak i od verskih ubeđenja i tradicije. Zato je sve veći fokus nevladinih organizacija, kao što je Dečji fond Ujedinjenih nacija (engl. *United Nations Children's Fund* - UNICEF) i drugih međunarodnih organizacija, na upravljanje MHM, sa ciljem da istaknu važnost ovog problema za devojčice školskog uzrasta, što zahteva dalja istraživanja u ovoj oblasti (3).

Cilj ovog istraživanja je bio da se ispitaju ponašanje i stavovi studentkinja medicine po pitanju menstrualnih proizvoda.

Metode

Istraživanje je sprovedeno u vidu studije preseka među studentkinjama Medicinskog fakulteta Univerziteta u Beogradu u periodu 16-29.05.2024. godine. Podaci su od ispitanica prikupljeni anonimnim upitnicima. Popunjavanje upitnika je organizovano na početku ili na kraju vežbi na kojima su prisustvovali u okviru redovne nastave. Svi student izabrane grupe uključeni su u istraživanje. Grupe studenata birane su metodom slučajnog izbora. Popunjavanje upitnika trajalo je 30-35 minuta.

Studijom je obuhvaćeno 426 studenata (muškaraca i žena), a isključeno 13, jer nisu dali podatke o uzrastu. Neophodna veličina uzorka za sprovođenje ovog istraživanje je 333 studenta Medicinskog fakulteta u Beogradu. Izračunata je korišćenjem Epi Info 7 (verzija 7.2.4.0). Podaci koji su korišćeni za određivanje neophodne veličine uzorka su: veličina populacije 2471 student medicine koji je prvi put upisan 2023/2024. godine, očekivana učestalost korišćenja kondoma pri svakom vaginalnom seksualnom odnosu studenata medicne 25,4% (5), verovatnoća greške tip I 5% i veličina efekta 1. Zbog mogućnosti odbijanja ispitanika da učestvuju u istraživanju ili da predaju prazne ili nekompletno popunjene upitnike, neophodnu veličinu uzorka smo povećali za 20% i iznosila je 400. U ovom radu, analizirano je korišćenje menstrualnih proizvoda zbog čega su uključene samo studentkinje, kojih je bilo 277.

Podaci su prikupljeni upitnikom, koji je pripremljen u skladu sa upitnikom Evropskog istraživanja zdravlja - drugi talas (engl. *European Health Interview Survey* - EHIS wave 2), prema definisanim međunarodno prihvaćenim indikatorima. Upitnik se sastojao iz sedam delova. Prvi deo upitnika odnosio se na demografske karakteristike ispitanika (pol, uzrast, godinu studija, prosek u prethodnom periodu studiranja, stalno mesto stanovanja, tj. mesto stanovanja van školske godine, s kim osoba živi, obrazovanje oca i majke, zaposlenost oca i majke), drugi na životne navike (fizička aktivnost, dužina spavanja, vrsta ishrane, učestalost izlaženja u provod, pušenje, konzumiranje alkohola i drugih psihoaktivnih supstanci), treći na emotivne veze (broj emotivnih veza, dužina trajanja emotivne veze, koje karakteristike treba da ima idealni partner, stavovi o partneru sa kojim bi bili u emotivnoj vezi – vera, rasa, etnička pripadnost, iz druge zemlje, zadovoljstvo sobom, itd.), četvrti na seksualno ponašanje (uzrast pri prvom seksualnom odnosu, upotreba kondoma, broj seksualnih partnera, polno prenosiva bolest, izabrani lekar, edukacija, gde bi želeli da postoji savetovalište za reproduktivno i seksualno zdravlje), peti na korišćenje kontracepcije (metode kontracepcije i učestalost korišćenja), šesti na menstrualne proizvode (da li je postojao problem sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci, šta urade u slučaju da nemaju dovoljno novca da kupe menstrualni proizvod neophodan

that allow for the menstrual products to be used and replaced, as well as their adequate disposal (3).

Period poverty means the unavailability of financial resources for the adequate management of menstrual health, which includes the lack of education about the mentioned process (4). According to the data of the World Bank, period poverty affects about 500 million women worldwide. Inadequate sanitary conditions and the unavailability of menstrual products, as well as their inadequate use can lead to serious health disorders in women, such as infections, toxic shock syndrome and other diseases of reproductive organs (1).

Studies have shown that girls' fear and humiliating feeling caused by bleeding and unpleasant odor lead to absenteeism and have a negative impact on education (1). It has been observed that many girls do not have adequate supplies of menstrual products necessary for maintaining hygiene, even underwear, which forces them to use substitutes for menstrual products, such as cloths, tissues or toilet paper, during menstruation (3). In order to struggle against period poverty, many global initiatives have been launched to make menstrual products free in public places, such as schools. Also, the initiative is taken to make the above mentioned products tax-exempt in stores (4). It is believed that MHM depends on socio-economic status, education and even religious beliefs and traditions. Therefore, non-governmental organizations, such as the United Nations children's fund (UNICEF) and other international organizations are increasingly focusing on the MHM management, with the aim of emphasizing the importance of this problem for school-age girls, which requires further research in this field (3).

The aim of this study was to analyze the behavior and attitudes of female medical students regarding menstrual products.

Methods

The study was conducted as a cross-sectional study and it included female students of the Faculty of Medicine in Belgrade in the period 16th to 29th May, 2024. The data were collected from respondents with the help of questionnaires. The questionnaires were filled out by female students at the beginning or at the end of exercises, which they attended within regular classes. All students of the selected group are included in the research. Groups of students were chosen by the method of random selection. Filling out the questionnaire lasted 30-35 minutes.

The study included 426 students, while 13 were excluded because they did not fill out the information about their age. The necessary sample size for conducting this study included 333 students of the Faculty of Medicine in Belgrade. It was calculated using Epi Info 7 (version 7.2.4.0). The following data were used to determine the necessary sample size: population size of 2471 medical students who were enrolled for the first time in 2023/2024, the expected frequency of condom use during each vaginal sexual intercourse of medical students 25.4% (5), the probability of making a type I error is 5% and the effect size is 1. We increased the necessary sample size by 20%, and it amounted to 400 due to the possibility that respondents could refuse to take part in the study or submit blank or incomplete surveys. In this study, the use of menstrual products was analyzed, and therefore only female students were included, that is, 277 of them.

The data were collected using the questionnaire, which was prepared in accordance with the European Health Interview Survey – wave 2 (EHIS), based on defined, internationally accepted indicators. The questionnaire consisted of seven parts. The first part of the questionnaire related to the demographic characteristics of respondents (gender, age, place of residence, year of study, average in the previous period of studies, with whom the person lives, education of father and mother, employment of father and mother), the second part related to habits (physical activity, length of sleep, type of diet, frequency of going out, smoking, alcohol consumption and use of other psychoactive substances – PAS), the third related to emotional relationships (number of emotional relationships, duration of emotional relationship, what characteristics should an ideal partner have, attitudes about a partner with whom they would be in an emotional relationship – religion, race, ethnicity, from another country, self-satisfaction, etc.), the fourth related to sexual behavior (age at first sexual intercourse, use of condoms, number of sexual partners, sexually transmitted disease, chosen doctor, education, where they would like to have a counseling center for reproductive and sexual health), the fifth to the

za održavanje higijene tokom menstruacije, da li bi želele da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji), a sedmi na seksualno uznemiravanje (koliko često dobijaju seksualne poruke, da li ih one uznemiravaju, da li znaju ko im je slao seksualne poruke, da li ih je neko naterao na seksualni odnos bez njihove saglasnosti itd.). U ovom istraživanju analizirani su samo podaci koji se odnose na demografske karakteristike ispitanika i menstrualne proizvode.

U statističkoj analizi podataka korišćene su metode deskriptivne statistike (srednja vrednost, standardna devijacija, medijana, minimum i maksimum). Za poređenje dve grupe ispitanika korišćen je χ^2 test. Razlika je označena kao signifikantna ukoliko je $p < 0,05$. Program SPSS 23.0 (SPSS Inc., Chicago, IL, USA) je korišćen za statističku obradu podataka.

Rezultati

Istraživanje je obuhvatilo 277 studentkinja Medicinskog fakulteta Univerziteta u Beogradu (I-V godine studija). Opseg starosti se kretao 19-29 godina, a prosečna starost iznosila je 21,77 ± 1,93 godina. Nešto više od dve trećine studenkinja je bilo uzrasta 19-22 godine, kao i od prve do treće godine studija, a 91,3% je živelo u Beogradu ili je došlo u Beograd iz nekog grada u unutrašnjosti Srbije (tabela 1). Probleme po pitanju nabavke menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci je imalo 5,1% studentkinja. U slučaju da studentkinje nisu imale dovoljno novca da kupe menstrualni proizvod neophodan za održavanje higijene tokom menstruacije, 1,4% studentkinja je koristilo zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir, i dr.), 1,8% je pozajmljivalo menstrualne proizvode od prijatelja, rođakata, idr, 1,1% je koristilo menstrualne proizvode duže vreme nego

Tabela 1. Demografske karaktestike studentkinja medicine (N=277) i njihovo ponašanje i stav po pitanju menstrualnih proizvoda

Karakteristike	Broj	%
Uzrast (godine)		
19-22	192	69,3
23-29	85	30,7
Ukupno	277	100,0
Godina studija		
I, II i III	178	64,3
IV i V	99	35,7
Ukupno	277	100,0
Stalno mesto stanovanja van školske godine		
Grad	253	91,3
Selo	24	8,7
Ukupno	277	100,0
Da li ste imali probleme sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci?*		
Da	14	5,1
Ne/Ne znam	259	94,9
Ukupno	273	100,0
Da li ste uradili nešto od sledećeg, jer niste imali dovoljno novca da kupite menstrualni proizvod neophodan za održavanje higijene tokom menstruacije?		
Koristim zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir, idr.)*	4	1,4
Pozajmljujem menstrualni proizvod od prijatelja, rođaka, itd.*	5	1,8
Koristim menstrualni proizvod duže vreme nego što to uobičajeno radim*	3	1,1
Kupujem jeftiniji menstrualni proizvod*	13	4,7
Da li biste želeli da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji?		
Da	271	97,8
Ne/ Ne interesuje me	6	2,2
Ukupno	277	100,0

*Ukupno 277

use of contraception (methods of contraception and frequency of use), the sixth to menstrual products (difficulty obtaining a menstrual product, what do they do if they do not have money to buy menstrual products, whether they think that menstrual products should be free), and the seventh related to sexual harassment (how often they receive sexual messages, whether they are harassing, whether they know who sent them the messages, whether someone forced them to have sexual intercourse without their consent, etc.). In this study, we analyzed only the data related to demographic characteristics of respondents and menstrual products.

In the statistical analysis of data, the following methods of descriptive statistics were used (mean value, standard deviation, median, minimum and maximum). The appropriate χ^2 test was used for the comparison of two groups of respondents. The difference was marked as significant when $p < 0.05$. The SPSS 23.0 program (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis of data.

Results

The research included 277 female students of the Faculty of Medicine of the University of Belgrade (I-V years of study). The age range was 19-29 years, and the average age was 21.77 ± 1.93 years. Slightly more than two thirds of female students were 19-29, from the first to the third year of studies, while 91.3% lived in Belgrade or came to Belgrade from some other city in Serbia (Table 1). 5.1% of female students had difficulty obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months. When students did not have enough money to buy a menstrual product necessary for maintaining hygiene during menstruation, 1.4% of female students used a substitute for the given menstrual product (e.g. cloth, toilet paper, etc.), 1.8% borrowed menstrual

Table 1. Demographic characteristics of female medical students (N=277) and their behavior and attitudes regarding menstrual products

Characteristics	Number	%
Age (years)		
19-22	192	69.3
23-9	85	30.7
Total	277	100.0
Year of study		
I, II and III	178	64.3
IV and V	99	35.7
Total	277	100.0
Permanent place of residence outside the course of the school year		
City	253	91.3
Village	24	8.7
Total	277	100.0
Did you have any difficulties obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months?		
Yes	14	5.1
No/I do not know	259	94.9
Total	273	100.0
Did you do any of the following because you did not have enough money to buy a menstrual product necessary for maintaining hygiene during your period? *		
I use substitutes for the given menstrual product (e.g. cloth, toilet paper, etc.)	4	1.4
I borrow menstrual products from friends, relatives, etc.	5	1.8
I use menstrual products longer than I usually do	3	1.1
I buy cheaper menstrual products	13	4.7
Would you like the products necessary for maintaining hygiene during menstruation to be free for all pupils and students in Serbia?		
Yes	271	97.8
No/ Not interested	6	2.2
Total	277	100,0

*Total is 277

Tabela 2. Distribucija studentkinja medicine prema njihovom ponašanju i stavu po pitanju menstrualnih proizvoda u odnosu na uzrast

Ponašanje i stav po pitanju menstrualnih proizvoda	Uzrast (godine) 19-22 N=192 Broj (%)	23-29 N=85 Broj (%)	p*
Da li ste imali probleme sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci?			
Da	6 (3,2)	8 (9,5)	0,028
Ne/ Ne znam	183 (96,8)	76 (90,5)	
Da li ste uradili nešto od sledećeg, jer niste imali dovoljno novca da kupite menstrualni proizvod neophodan za održavanje higijene tokom menstruacije?			
Koristim zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir, i dr.)	2 (1,0)	2 (2,4)	0,766**
Pozajmljujem menstrualni proizvod od prijatelja, rođaka, itd.	4 (2,1)	1 (1,2)	0,973**
Koristim menstrualni proizvod duže vreme nego što to uobičajeno radim	1 (0,5)	2 (2,4)	0,466**
Kupujem jeftiniji menstrualni proizvod	7 (3,6)	6 (7,1)	0,215**
Da li biste želeli da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji?			
Da	186 (96,8)	85 (100,0)	0,453**
Ne/ Ne interesuje me	6 (3,2)	0 (0,0)	

*p vrednost prema χ^2 testu, ** Jejtsova korekcija χ^2 test

što to rade uobičajeno i 4,7% je kupovalo jeftinije menstrualne proizvode. Većina studentkinja (97,8%) je želela da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji.

Probleme sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci su značajno češće imale starije studentkinje, tj. studentkinje uzrasta 23-29 godina, nego mlađe studentkinje, tj. studentkinje uzrasta 19-22 godine (tabela 2). Starije studentkinje su češće, usled nedostatka novca, koristile zamenu za uobičajeni korišćeni menstrualni proizvod (npr. tkanina itd.), duže su ga koristile nego uobičajeno i češće su kupovale jeftini menstrualni proizvod, u odnosu na mlađe. Među-

Tabela 3. Distribucija studentkinja MFUB u odnosu na njihovo ponašanje i stav po pitanju menstrualnih proizvoda i mesto stanovanja van školske godine

Ponašanje i stav po pitanju menstrualnih proizvoda	Stalno mesto stanovanja Grad Broj (%)	Selo Broj (%)	p*
Da li ste imali probleme sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci			
Da	12 (4,8)	2 (8,3)	0,456
Ne/ Ne znam	237 (95,2)	22 (91,7)	
Ukupno	249 (100,0)	24 (100,0)	
Da li ste uradili nešto od sledećeg, jer niste imali dovoljno novca da kupite menstrualni proizvod neophodan za održavanje higijene tokom menstruacije?* **			
Koristim zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir, i dr.)	3 (1,2)	1 (4,2)	0,792**
Pozajmljujem menstrualni proizvod od prijatelja, rođaka, itd.	5 (2,0)	0 (0)	0,946**
Koristim menstrualni proizvod duže vreme nego što to uobičajeno radim	3 (1,2)	0 (0)	0,813**
Kupujem jeftiniji menstrualni proizvod	13 (5,1)	0 (0)	0,832**
Da li biste želeli da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji?			
Da	247 (93,0)	24 (93,8)	0,785**
Ne/ Ne interesuje me	6 (7,0)	0 (6,3)	
Ukupno	253 (100,0)	24 (100,0)	

*p vrednost prema χ^2 testu, ** Jejtsova korekcija χ^2 test, *** Računato u odnosu na 253 studenkinje iz grada i 24 studentkinje iz sela

Table 2. Distribution of female medical students in relation to their behavior and attitudes regarding menstrual products and age

Behavior and attitudes regarding menstrual products	Age (years) 19-22 N=192 Number (%)	23-29 N=85 Number (%)	p*
Did you have any difficulties obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months?			
Yes	6 (3.2)	8 (9,5)	0.028
No/ I do not know	183 (96.8)	76 (90,5)	
Did you do any of the following because you did not have enough money to buy a menstrual product necessary for maintaining hygiene during your period?			
I use substitutes for the given menstrual product (e.g. cloth, toilet paper, etc.)	2 (1.0)	2 (2.4)	0.766**
I borrow menstrual products from friends, relatives, etc.	4 (2.1)	1 (1.2)	0.973**
I use menstrual products longer than I usually do	1 (0.5)	2 (2.4)	0.466**
I buy cheaper menstrual products	7 (3.6)	6 (7.1)	0.215**
Would you like the products necessary for maintaining hygiene during menstruation to be free for all pupils and students in Serbia?			
Yes	186 (96.8)	85 (100.0)	0.453**
No/ Not interested	6 (3.2)	0 (0.0)	

*p value according to the chi-square test, ** the chi-square statistic with Yates correction

products from friends, relatives, 1.1% used menstrual products longer than they usually did, and 4.7% bought cheaper menstrual products. The majority of female students (97.8%) would like that products necessary for maintaining hygiene during menstruation were free for all school girls and students in Serbia.

Difficulties obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months were significantly more common among older female students, that is, female students aged 23-29 years, than among younger female students, i.e. female students aged 19-22 (Table 2). Older female students more often, due to the lack of money, used a substitute for the usual menstrual

Table 3. Distribution of female medical students of the Faculty of Medicine, University of Belgrade in relation to their behavior and attitudes regarding menstrual products and year of study

Behavior and attitudes regarding menstrual products	Permanent place of residence City Number (%)	City Number (%)	p*
Did you have any difficulties obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months			
Yes	12 (4.8)	2 (8.3)	0.456
No/ I do not know	237 (95.2)	22 (91.7)	
Total	249 (100,0)	24 (100,0)	
Did you do any of the following because you did not have enough money to buy a menstrual product necessary for maintaining hygiene during your period?* **			
I use substitutes for the given menstrual product (e.g. cloth, toilet paper, etc.)	3 (1.2)	1 (4.2)	0.792**
I borrow menstrual products from friends, relatives, etc.	5 (2.0)	0 (0)	0.946**
I use menstrual products longer than I usually do	3 (1.2)	0 (0)	0.813**
I buy cheaper menstrual products	13 (5.1)	0 (0)	0.832**
Would you like the products necessary for maintaining hygiene during menstruation to be free for all pupils and students in Serbia?			
Yes	247 (93.0)	24 (93.8)	0.785**
No/ Not interested	6 (7.0)	0 (6.3)	
Total	253 (100,0)	24 (100,0)	

*p value according to the chi-square test, ** the chi-square statistic with Yates correction*** calculated in relation to 253 students from the city and 24 students from the village

Tabela 4. Distribucija studentkinja medicine prema njihovom ponašanju i stavu po pitanju menstrualnih proizvoda u odnosu na godinu studija

Ponašanje i stav po pitanju menstrualnih proizvoda	Godina studija		
	I-III Broj (%)	IV i V Broj (%)	p*
Da li ste imali probleme sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci			
Da	7 (4,0)	7 (7,1)	0,259
Ne/ Ne znam	168 (96)	91 (92,9)	
Ukupno	175 (100,0)	98 (100,0)	
Da li ste uradili nešto od sledećeg, jer niste imali dovoljno novca da kupite menstrualni proizvod neophodan za održavanje higijene tokom menstruacije?* **			
Koristim zamenu za dati menstrualni proizvod (npr. tkaninu, toaletni papir, dr.)	2 (1,2)	2 (2,0)	0,954**
Pozajmljujem menstrualni proizvod od prijatelja, rođaka, itd.	4 (2,3)	1 (1,0)	0,773**
Koristim menstrualni proizvod duže vreme nego što to uobičajeno radim	1 (0,6)	2 (2,0)	0,615**
Kupujem jeftiniji menstrualni proizvod	6 (3,4)	7 (7,1)	0,286
Da li biste želeli da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji?			
Da	172 (96,6)	99 (100,0)	0,417**
Ne/ Ne interesuje me	6 (3,4)	0 (0,0)	
Ukupno	178 (100,0)	99 (100,0)	

*p vrednost prema χ^2 testu, ** Jejtsova korekcija χ^2 test, ***Računato u odnosu na 175 studenkinja I-III godine i 99 studentkinja IV-V

tim, razlike nisu bile statistički značajne. Mlađe, studentkinje su, u poređenju sa starijim, češće pozajmljivale menstrualna sredstva, ali statistički značajna razlika nije uočena. Većina mlađih studentkinja i sve starije studentkinje su smatrale da menstrualna sredstva za učenice i studentkinje u Srbiji treba da budu besplatna.

U odnosu na stalno mesto stanovanja, tj. mesto stanovanja van školske godine, nije postojala značajna razlika između studentkinja koje žive u gradu i na selu u odnosu na postojanje problema sa nabavkom mestrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci (tabela 3). Studentkinje sa stalnim mestom stanovanja u gradu i studentkinje sa stalnim mestom stanovanja na selu nisu se značajno razlikovale u odnosu na svoje ponašanje po pitanju nabavke menstrualnih sredstava usled nedostatka novca da kupe menstrualni proizvod neophodan za održavanje higijene tokom menstruacije kao i odnosu na stav da je neophodno da menstrualna sredstva za učenice i studentkinje u Srbiji treba da budu besplatna.

Kada se radi o problemima sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom poslednjih 12 meseci u odnosu na godinu studija, utvrđeno je da su studentkinje IV i V godine imale više problema sa nabavkom menstrualnih proizvoda tokom poslednjih 12 meseci nego studenkinje I-III godine studija, ali razlika nije bila statistički značajna (tabela 4). Između prethodno navedenih ispitivanih grupa nije bilo statistički značajne razlike u odnosu na ponašanje po pitanju dolaženja do menstrualnih proizvoda u slučajevima nedostatka novca za njihovu kupovinu, kao i u odnosu na stav da menstrualni proizvodi treba da budu besplatni za sve učenice i studentkinje u Srbiji.

Diskusija

U našoj studiji problem sa nabavkom menstrualnih proizvoda, kao što su higijenski ulošci, tamponi i menstrualne čašice, tokom poslednjih 12 meseci, je imalo 5,1% studentkinja Medicinskog fakulteta Univerziteta u Beogradu (uzrasta 19-29 godina) (skoro svaka dvadeseta studentkinja), što je za oko tri puta manje nego kod studentkinja Univerziteta Ilinois u Čikagu (17,1%, svaka šesta studentkinja) (4). Od 106 studentkinja Univerziteta Ilinois u Čikagu, uzrasta 18-42 godine (prosek 24 godine), njih 55,8% je navelo da je odsustvovalo sa nastave zbog razloga vezanih za menstruaciju, a 47,5% je izbegavalo da menja menstrualne proizvode dok su boravile na kampusu (4). Izveštaj Ujedinjenih nacija iz 2014. godine je pokazao da 1 od 10 adolescentkinja koje imaju menstruaciju

Table 3. Distribution of female medical students of the Faculty of Medicine, University of Belgrade in relation to their behavior and attitudes regarding menstrual products and year of study

Behavior and attitudes regarding menstrual products	Permanent place of residence		
	I-III Number (%)	IV and V Number (%)	p*
Did you have any difficulties obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months			
Yes	7 (4.0)	7 (7.1)	0.259
No/ I do not know	168 (96)	91 (92.9)	
Total	175 (100,0)	98 (100,0)	
Did you do any of the following because you did not have enough money to buy a menstrual product necessary for maintaining hygiene during your period?* **			
I use substitutes for the given menstrual product (e.g. cloth, toilet paper, etc.)	2 (1.2)	2 (2.0)	0.954**
I borrow menstrual products from friends, relatives, etc.	4 (2.3)	1 (1.0)	0.773**
I use menstrual products longer than I usually do	1 (0.6)	2 (2.0)	0.615**
I buy cheaper menstrual products	6 (3.4)	7 (7.1)	0.286
Would you like the products necessary for maintaining hygiene during menstruation to be free for all pupils and students in Serbia?			
Yes	172 (96.6)	99 (100.0)	0.417**
No/ Not interested	6 (3.4)	0 (0.0)	
Total	178 (100.0)	99 (100,0)	

*p value according to the chi-square test, ** the chi-square statistic with Yates correction,***calculated in relation to 175 students of I-III years and 99 students of IV-V year

product (e.g. cloth), they used it longer than usual, and they more often bought cheaper menstrual products in comparison to younger female students. However, the differences were not significant. Younger female students compared to older ones borrowed menstrual products more often, but no significant difference was observed. The majority of younger female students and all older students believed that menstrual products should be free for school girls and female students in Serbia.

In regard to the permanent place of residence, that is, the place of residence outside the course of the school year, there was no significant difference between female students who lived in the city and in the village in relation to the existence of problems with obtaining menstrual products (sanitary pads, tampons, menstrual cups) in the last 3 months (Table 3). There was no significant difference between female students with a permanent place of residence in the city and those with a permanent place of residence in the village regarding their behavior when accessing menstrual products due to a lack of money to purchase the necessary items for maintaining hygiene during menstruation. Additionally, there was no significant difference in their attitude that menstrual products should be made free for school girls and female students in Serbia.

Considering problems with menstrual products in relation to the year of study, it was shown that the 4th and 5th year female students had more problems with obtaining menstrual products (than the 1st- 3rd year female students in the last 12 months, but the difference was not statistically significant (Table 4). There was no statistically significant difference between the previously mentioned groups in terms of behavior regarding access to menstrual products in cases of a lack of money for their purchase, nor in terms of the opinion that menstrual products should be free for all schoolgirls and female students in Serbia.

Discussion

In our study, 5.1% of female students of the Faculty of Medicine, University of Belgrade (aged 19-29 years) had difficulty obtaining menstrual products such as sanitary pads, tampons and menstrual cups (almost one in twenty female students), which is about three times less than among female students of the University of Illinois in Chicago (17.1%, every sixth female student) (4). Of 106 female students at the University of Illinois at Chicago, aged 18-42 years (average 24 years), 55.8% of them stated that they missed classes for reasons related to menstruation, while 47.5% avoided changing menstrual products during

izostane iz škole zbog nedostupnosti menstrualnih proizvoda (6). Efekti lošeg menstrualnog zdravlja na obrazovanje pored apsentizma, uključuju i povećani nivo celodnevnog stresa, smanjenje koncentracije u školi i pogoršanje mentalnog zdravlja (7). Još jedna studija sprovedena na kampusu univerziteta u Americi (8) pokazala je da je od 471 studentkinje, uzrasta 18–24 godine, 14% njih iskusilo menstrualno siromaštvo najmanje jednom u proteklih godinu dana. U takvim situacijama, studentkinje su najčešće pozajmljivale menstrualne proizvode (72,8%), koristile druge materijale kao zamenu za menstrualne proizvode (52,6%), duže koristile menstrualni proizvod (48,3%), a neke studentkinje su bile bez bilo kakvih proizvoda tokom menstruacije (26,3%).

Naša studija pokazuje da su studentkinje koje nisu imale dovoljno novca da kupe menstrualni proizvod neophodan za održavanje higijene tokom menstruacije rešavale ovaj problem korišćenjem drugih materijala (npr. tkanine, toaletnog papira i slično) (1,4%), pozajmljivanjem menstrualnog proizvoda (1,8%), korišćenjem menstrualnih proizvoda duže vreme nego što to rade uobičajeno (1,1%) i korišćenjem jeftinijih menstrualnih proivoda (1,4%). U drugim studijama takođe se navodi da usled siromaštva, posebno žene u zemljama sa niskim i srednjim prihodima, imaju poteškoća sa nabavkom menstrualnih proizvoda, te su prinuđene da menstrualne proizvode koriste duže od preporučenog perioda i da ih menjaju za menstrualne proizvode kao što su tkanine, papir itd. (6,9). U studiji sprovedenoj među 3418 žena (uzrasta 13-29 godina) u ruralnoj zapadnoj Keniji (9) uočeno je da 25% žena koristi tradicionalne materijale, kao što su tkanina, papir ili maramice, a 75% komercijalne proizvode. Tradicionalne materijale koristi dve trećine žena bez obrazovanja, a čak 10% devojčica mlađih od 15 godina koristi improvizovane predmete (9). Korišćenje komercijalnih uložaka je češće među ženama (kako udatim tako i neudatim) koje pohađaju škole, a čak 1,3% žena se bavi seksom za novac da bi kupile uložak. Sprovedena je studija u Sjedinjenim Američkim Državama (10) u vreme COVID-19 pandemije, sa ciljem da se prikaže pogoršanje menstrualnog siromaštva u pomenutom periodu, kroz nedostupnost menstrualnih proizvoda. Rezultati studije su pokazali da među 1037 ispitanica (uzrasta 18-49 godina) 29% njih je imalo problema sa nabavkom menstrualnih proizvoda u toku prethodnih 12 meseci, a 18% ispitanica je odsustvovalo sa posla zbog nedostatka menstrualnih proizvoda. Dokaz da se menstrualno siromaštvo ne javlja samo u zemljama sa niskim i srednjim prihodima, jeste studija sprovedena u Velikoj Britaniji (11). Rezultati pomenute studije pokazuju da 10% devojaka nije bilo u mogućnosti da kupi menstrualne proizvode, a 19% je prešlo na manje odgovarajuće alternativne proizvode zbog visokih troškova nabavke primarnih (11). Na pitanje istraživača Univerziteta u Maleziji (6) vezano za upravljanje novcem u nabavci osnovnih potreba, ženama se menstrualni proizvodi nisu našli na listi osnovnih potrepština, što je za posledicu imalo korišćenje alternativnih menstrualnih proizvoda i njihovo produženo korišćenje.

U našoj studiji 1,4% studentkinja je imalo potrebu da koristi alternativne proizvode za održavanje higijene tokom menstruacije, kao što su tkanine i toalet papir, dok je u južnoj Nigeriji (12)15% ispitanica koristilo odeću, tampone ili druge materijale kao apsorbent u toku menstruacije. Brojne studije su, takođe, pokazale da adolescentkinje, u nedostatku odgovarajućih menstrualnih proizvoda, kao zamenu koriste nehigijenska sredstva (staru tkaninu, maramice, lišće i komade vune ili pamuka) (6,13,14), što može da dovede do iritacije, osećaja diskomfora i infekcije reproduktivnog trakta (13,14). Iako su menstrualni proizvodi za višekratnu upotrebu (npr. menstrualna čašica) finansijski dugoročno isplativiji, većina žena radije bira da koristi jednokratne higijenske uloške (4), što stvara zabrinutost oko neadekvatnog sanitarnog odlaganja pomenutih proizvoda i problem sa mogućim zagađenjem životne sredine (7). Istraživači su prepoznali i druge prepreke u korišćenju višekratnih menstrualnih proizvoda, kao što su nedostatak obrazovanja o načinu njihovog korišćenja, nesvesnost o njihovom postojanju i stigma vezana za pomenute proizvode (15).

Pored pristupa adekvatnim menstrualnim proizvodima, važne komponente menstrualnog zdravlja su i dobri sanitarni uslovi (sapun i čista voda) i bezbedna mesta za promenu pomenutih menstrualnih proizvoda i odlaganje upotrebljenih. U literaturi je pokazano da u zemljama sa niskim i srednjim prihodima, adolescentkinje i mlade žene nemaju pristup jednom i/ili više pomenutih resursa za održavanje menstrualnog zdravlja i higijene (16). Zbog nedostatka adekvatnih privatnih prostorija i sanitarnih uslova (čista voda i sapun), devojčice su izbegavale promenu upijajućih sredstava dok

their stay at the campus (4). The 2014 United Nations report showed that 1 in 10 adolescent girls who had menstruation did not go to school due to the unavailability of menstrual products (6). In addition to absenteeism, the impact of poor menstrual health on education includes increased levels of stress throughout the day, decreased concentration in school and worsening of mental health (7). Another study conducted on a university campus in America, showed that of 471 female students aged 18-24 years, 14% of them experienced period poverty at least once in the last year (8). In such situations, students most often borrowed menstrual products (72.8%), used other materials as a substitute for menstrual products (52.6%), used the product longer than usually (48.3%), and some of them were without any products during menstruation (26.3%).

In our study, female students who did not have enough money to buy a menstrual product necessary for maintaining hygiene during menstruation solved this problem by using other materials (e.g. cloth, toilet paper, etc.) (1.4%), by borrowing a menstrual product (1.8%), by using menstrual products longer than usually (1.1%) and by using cheaper menstrual products (1.4%). It was also observed in other studies that due to poverty, especially women in low- and middle-income countries had difficulties with the access to menstrual products, and therefore, they had to use menstrual products longer than it was recommended and to use other products such as cloths, paper, etc. (6,9). In a study, which included 3418 women (aged 13-29 years) in rural western Kenya (9), it was observed that 25% of women used traditional materials such as cloths, paper or handkerchiefs, while 75% of them used commercial products. Traditional materials were used by two thirds of women without education, and even 10% of girls younger than 15 used improvised things (9). The use of commercial pads was more common in women (both single and married) who attended school, while 1.3% of women engaged in sex for money to buy sanitary pads. A study was conducted in the United States of America (10) during the COVID-19 pandemic in order to show worsening of period poverty in the mentioned period, in relation to the unavailability of menstrual products. The results of the study showed that among 1037 respondents (aged 18-49 years), 29% of them had difficulty accessing menstrual products in the past 12 months, and 18% of respondents were absent from work due to the lack of menstrual products. A study, which was conducted in Great Britain (11), proved that period poverty did not only occur in low- and middle-income countries. The results of the mentioned study showed that 10% of girls could not buy menstrual products, while 19% of them switched to less appropriate alternative products due to the high cost of primary products (11). When women were asked by researchers from the University of Malaysia (6) about money management related to the procurement of basic needs, they did not put menstrual products on the list of basic needs, which results in the use of alternative menstrual products and their prolonged use.

In our study, 1.4% of female students needed to use alternative products for maintaining hygiene during menstruation, such as cloths and toilet paper, while in Southern Nigeria (12), 15% of female respondents used clothes, tampons or other materials, as absorbents during menstruation. Numerous studies have also shown that adolescent girls, in the absence of appropriate menstrual products, use unhygienic products (old cloth, handkerchiefs, leaves, and pieces of wool and cotton) as substitutes (6,13,14), which could lead to irritation, discomfort and infections of the reproductive tract (13,14). Although reusable menstrual products (e.g. menstrual cup) are financially more profitable in the long run, the majority of women prefer single-use sanitary pads (4), which raises concerns about inadequate sanitary disposal of mentioned products and possible environmental pollution (7). Researchers have recognized other barriers related to the use of reusable menstrualproducts, such as the lack of education on how to use them, unawareness of their existence, and stigma related to the mentioned products (15).

In addition to access to adequate menstrual products, important components of menstrual health are good sanitary conditions (soap and clean water) and safe places to change the mentioned products and dispose of them. It has been shown in the literature that in low- and middle-income countries, adolescent girls and young women do not have access to one and/or several mentioned products for maintaining menstrual health and hygiene (16). Due to the lack of adequate private rooms and sanitary conditions (clean water and

su boravile u školama (16). Korišćenje menstrualnih proizvoda duže nego uobičajeno, povećava rizik od nastanka infekcija i ozbiljnih oboljenja genitalnog trakta žena (6). Pored infekcija kao što su bakterijska vaginoza i infekcija urinarnog trakta i prevremenog porođaja, u literaturi je prikazan i fenomen psihosocijalnog stresa povezanog sa lošim sanitarnim uslovima (engl. *Sanitation-related psychosocial stress*) (17). U našoj studiji 1,1% ispitanica je koristilo menstrualni proizvod duže nego uobičajeno, što zahteva edukaciju mladih i obezbeđivanje sredstavava za menstrualne proizvode. Jasno je da nakon duge primene menstrualnih proizvoda može da dođe do brojnih komplikacija (npr. toksični šok sindrom). Istraživači navode da duže korišćenje menstrualnih proizvoda, može biti posledica postojanja neadekvatnih sanitarnih uslova i neadekvantih mesta za menjanje pomenutih proizvoda (7,13,14). Takva mesta mogu da budu slabo osvetljena, izolovana i ne mogu se zaključati (7), što može dovesti i do povećanja rizika od seksualnog nasilja (13,14). Prirodne katastrofe, kao što je zemljotres, koji je 2021. godine pogodio Haiti, mogu pogoršati već loše sanitarne uslove i dodatno otežati održavanje menstrualnog zdravlja ženama (7). U pomenutom periodu prijavljeno je da mnoge porodice nemaju pristup privatnim, pokrivenim toaletima i da su se mnoge žene žalile na neadekvatne sanitarne uslove i pojavu vaginalnih infekcija (7). Takođe, jedna petina devojčica sa Haitija kao glavni razlog odsustvovanja iz škole navela je nedostatak menstrualnih proizvoda, a njih 97% je smatralo da je program vezan za MHM neophodno uvesti u zemlju (7). Međutim, problemima je doprinelo i raseljavanje stanovništa po kampovima sa ograničenim pristupom sanitarnim prostorijama ili bez pomenutih prostorija, kao i postojanje neadekvatnog sistema za upravljanje i odlaganje otpada (18).

Ciljevi održivog razvoja Ujedinjenih nacija za 2023. godinu ističu poboljšanje pristupa resursima, kao što su čista voda, dobra sanitacija i odgovarajući proizvodi za održavanje higijene, radi poboljšanja menstrualnog zdravlja žena (19). Sveobuhvatna definicija menstrualnog zdravlja je predstavljena kao „stanje potpunog fizičkog, mentalnog i socijalnog blagostanja, a ne samo odsustvo bolesti ili slabosti, u vezi sa menstrualnim ciklusom" (20). Loše upravljanje menstrualnim zdravljem i neadekvatni uslovi za održavanje higijene, prvenstveno utiču na fizičko zdravlje devojčica u zemljama u razvoju, a zatim i na njihovo dostojanstvo, uklapanje u društvenu zajednicu i edukaciju (12). Jedna trećina adolescentkinja uključenih u studiju u Indiji smatra menstruaciju prljavom i shvata je kao problem (21). *Abraham* i saradnici (22) su, takođe, pokazali da kod 80% devojaka u Australiji menstruacija izaziva osećaj srama i nelagode.

Iako se trudimo da živimo u svetu oslobođenom od tabua, MHM i sama menstruacija su teme koje često izazivaju negativne emocije u društvu i stoga su nepravedno zapostavljene u određenim delovima sveta i kulturama. Zato se pitanja, odgovori i akcije vezani za ovu osetljivu temu moraju pažljivo kulturološki prilagoditi. Zbog prethodnih podataka smatrali smo važnim da ispitamo i analiziramo ponašanje i stavove studentkinja Medicinskog fakulteta u Beogradu po pitanju menstrualnih proizvoda, kao na koje rešavaju probleme vezane za nabavku menstrualnih proizvoda u slučaju da nemaju finansijskih sredstava. Iako je procenat studentkinja koje su imale problem sa nabavkom menstrualnih proizvoda u našoj studiji mali (5,1%), jasno je da je neophodno poboljšati MHM u školama i fakultetima u Srbiji i preduzeti mere protiv nastajanja menstrualnog siromaštva. Većina studentkinja (97,8%) naše studije, iskazala je želju da proizvodi neophodni za održavanje higijene tokom menstruacije budu besplatni za sve učenice i studentkinje u Srbiji. Odličan primer borbe protiv menstrualnog siromaštva predstavljaju zakoni Velike Britanije, koja je uklonila porez na tampone, i Škotske, koja je usvojila zakon u kome menstrualni proizvodi moraju biti obezbeđeni svakome kome budu potrebni (23). Takođe, države kao što su Kenija, Kanada, Indija, Kolumbija, Jamajka, Nigerija, Uganda, Trinidad i Tobago su zemlje koje se zalažu za smanjivanje poreza na sredstva za održavanje higijene tokom menstruacije (24). Nevladina organizacija „*MyCorps*" u Maleziji je 2019. godine organizovala inicijativu kojom se obezbeđuju sanitarni ulošci svim studentkinjama univerziteta nižeg socio-ekonomskog statusa. Iste godine, u svim državnim školama u Viktoriji (Australija) su obezbeđeni besplatni higijenski ulošci (6). U nadi da će i druge zemlje smanjiti ili ukinuti porez na menstrualne proizvode sa ciljem povećanja njihove dostupnosti, a samim tim doprineti poboljšanju kvaliteta života žena, Američka medicinska asocijacija je intervenisala da Poreska uprava imenuje menstrualne proizvode kao „nužnu zdravstvenu zaštitu" i ukine porez na njih (6). U Libanu je formi-

soap), girls avoided changing absorbents while they stayed in schools (16). The use of menstrual products longer than usual increases the risk of infections and serious diseases of the female genital tract (6). In addition to infections such as bacterial vaginosis, urinary tract infections and premature birth, the phenomenon of sanitation-related psychosocial stress has also been shown in the literature (17). In our study, 1.1% of respondents used menstrual products longer than usual, which requires education of young people and provision of resources for menstrual products. It is clear that after long-term use of menstrual products, numerous complications can occur (e.g. toxic shock syndrome). Some researchers state that the prolonged use of menstrual products may be a consequence of inadequate sanitary conditions and inadequate places where these products are changed (7,13,14). Such places can be poorly lit, isolated and they cannot be locked (7), which may lead to the increase in the risk of sexual violence (13,14). Natural disasters, such as the earthquake that struck Haiti in 2021, can worsen already poor sanitary conditions and make it even more difficult for women to maintain menstrual health (7). In the mentioned period, it was reported that many families did not have access to private, covered toilets and that many women complained about inadequate sanitary conditions and the occurrence of vaginal infections (7). Also, 1/5 of girls from Haiti stated that the lack of menstrual products was the main reason for being absent from school, and 97% of them believed that the program related to the MHM should necessarily be introduced in the country (7). However, problems occurred when the population was evacuated to camps with a limited access to sanitary facilities or camps without such facilities, as well as due to inadequate waste management and disposal systems (18).

The United Nations Sustainable Development Goals for 2023 emphasized the improvement of access to resources, including clean water, good sanitation and appropriate hygiene products aimed at improving the women's menstrual health (19). A comprehensive definition of menstrual health is "a state of complete physical, mental, social well-being, and not only the absence of disease or weakness related to the menstrual cycle" (20). Poor management of menstrual health and inadequate conditions for maintaining hygiene primarily affect the physical health of girls in developing countries, and then also their dignity, integration into the social community and education (12). According to the literature, one third of adolescent girls included in a study in India considered menstruation dirty and perceived it as problem (21). Abraham et al. (22)also showed that in 80% of girls in Australia, menstruation caused feelings of shame and discomfort (22).

Although we try to live in a taboo-free world, MHM and menstruation itself are topics that often evoke negative emotions in society and are, therefore, unfairly neglected in certain parts of the world and cultures. Therefore, questions, answers and actions related to this sensitive topic must be carefully culturally adjusted. Due to the mentioned data, we considered it important to examine and analyze the behavior and attitudes of female medical students in Belgrade regarding menstrual products, as well as the ways in which they solve problems related to obtaining menstrual products when they lacked financial resources. Although the percentage of respondents who had difficulty obtaining menstrual products was low in our study (5.1%), it is clear that it is necessary to improve MHM in schools and faculties in Serbia and to take measures to prevent period poverty. The majority of female students (97.8%) in our study pointed to the necessity that products for maintaining hygiene during menstruation should be free for all schoolgirls and female students in Serbia. An excellent example of the struggle against period poverty are the laws of Great Britain, which removed the tax on tampons and Scotland, which adopted a law, in which menstrual products must be provided to anyone who needs them (23). Also, countries such as Kenya, Canada, India, Columbia, Jamaica, Nigeria, Uganda, Trinidad and Tobago are countries that speak in favor of reducing taxes on menstrual hygiene products (24). In 2019, the non-governmental organization "My Corps" in Malaysia organized an initiative to provide sanitary pads to all female students of lower socio-economic status. In Victoria, Australia, in the same year, all public schools were provided with free sanitary pads (6). Hoping that other countries would reduce or eliminate the tax on menstrual products in order to increase the availability of menstrual products, and therefore, improve the quality of life of women, the American Medical Association intervened to make Tax Administration designate

ran nacionalni fond, sa ciljem da svakog meseca ženama obezbedi besplatan pristup sredstvima za održavanje menstrualnog zdravlja (25).

U našoj studiji su starije studentkinje tj. studentkinje sa 23 i više godina, usled nedostatka novca, imale značajno više problema sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) tokom proteklih 12 meseci, nego mlađe studentkinje. Možemo pretpostaviti da je pomenuti problem posledica preusmeravanja finansijskih resursa na druge potrebe i aktivnosti kao što su noćni izlasci, kafići, putovanja i školarina. Sve starije studentkinje, u našem istraživanju su iskazale želju da menstrualni proizvodi budu besplatni za sve učenice i studentkinje u Srbiji.

Naša studija ukazuje da nije postojala značajna razlika u postojanju problema sa nabavkom menstrualnih proizvoda tokom poslednjih 12 meseci između studentkinja iz gradskih i seoskih sredina. To govori o dobroj dostupnosti menstrualnih proizvoda u svim delovima zemlje, kao i dobroj finansijskoj situaciji onih porodica iz ruralnih područja koje mogu da školuju svoju decu u glavnom gradu Srbije. Pomenuta razlika nije uočena ni u studiji Kukreja i saradnika (26), koji su poredili korišćenje higijenskih uložaka između ispitanica ruralnih i urbanih područja u Indiji. Međutim, u studiji sprovedenoj u ruralnim delovima Haitija (7), dostupnost menstrualnih proizvoda je bila bolja u urbanim nego ruralnim sredinama, kao i za osobe sa višem socio-ekonomskim statusom. Takođe, u studiji El-Gilany i saradnika (16), upotreba menstrualnih uložaka je bila značajno veća kod mlađih devojčica iz urbanih krajeva Egipta, koje pripadaju srednjem i višem društvenom sloju nego kod mlađih devojčica iz ruralnih područja Egipta, koje pripadaju nižem društvenom sloju. Zaključeno je da su glavni prediktori korišćenja higijenskih uložaka pristup masovnim medijima, pripadanje višoj društvenoj klasi i život u gradu. U našoj studiji, studentkinje ruralnih i urbanih naselja nisu se značajno razlikovale u odnosu na to šta su uradile u situacijama kada nisu imale dovoljno novca da kupe menstrualni proizvod neophodan za održavanje higijene tokom menstruacije, kao i u odnosu na želju da menstrualni proizvodi budu besplatni za sve učenice i studentkinje u Srbiji. Rezultat naše studije ukazuje da, takođe, nije postojala značajna razlika ni po pitanju postojanja problema sa nabavkom menstrualnih proizvoda (higijenski ulošci, tamponi, menstrualne čašice) u poslednjih 12 meseci u odnosu na godine studija koje pohađaju studentkinje.. Dobijeni podaci su slični rezultatima koji se odnose na njihov uzrast, jer studentkinje IV i V godine studija u stvari predstavljaju studentkinje starijeg uzrasta (23 i više godina).

Glavni nedostaci ove studije preseka odnose se na neuključivanje pitanja koja se odnose na menstruaciju, higijenske uslove prostorija na fakultetu gde je moguće zameniti menstrualna sredstva, blizinu objekata od fakulteta gde se menstrualna sredstva mogu nabaviti, kao i o učestalosti izostajanja sa nastave tokom menstruacije i razlozima izostajanja. S druge strane, ova studija preseka predstavlja osnov za druga istraživanja u ovoj oblasti u cilju unapređenja kvaliteta života mladih.

Zaključak

Sve studentkinje medicine smatraju da menstrualna sredstva treba da budu besplatna, a 5,1% njih je tokom poslednjih 12 meseci imalo problem sa nabavkom menstrualnog proizvoda. Neophodno je kontinuirano ispitivati ponašanje i stavove studentkinja po pitanju menstrualnih proizvoda i faktore koji su sa njima povezani, kako na Medicinskom fakultetu Univerziteta u Beogradu, tako i na svim ostalim fakultetima, te dobijene rezultate koristiti kao osnovu za kreiranje i implementaciju aktivnosti u cilju unapređenja zdravlja i kvaliteta života studentkinja.

Zahvalnica

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Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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menstrual products as "necessary health care" and eliminate the tax on menstrual products (6). In Lebanon, a national fund was created with the aim of providing women with free access to means for maintaining menstrual health every month (25).

In our study, older female students, that is, students aged 23 and older, had difficulty obtaining menstrual products (sanitary pads, tampons, menstrual cups) significantly more often due to the lack of money in the past 12 months in comparison to younger students. It can be assumed that the mentioned problem is the consequence of redirecting financial resources to other needs and activities, such as night outs, cafes, travels and school fees. All older female students believed that menstrual products should be free and accessible to all students in Serbia.

Also, in our study, no significant difference was observed between female students from urban and rural areas regarding difficulties they had obtaining menstrual products. This speaks of the good availability of menstrual products in all parts of the country, as well as the good financial situation of those families from rural areas that can educate their children in the capital city of Serbia. The above mentioned difference was not observed in the study by Kukreja et al. (26) who compared the use of sanitary pads between respondents from rural and urban areas in India. However, in a study, which was conducted in rural parts of Haiti, the availability of menstrual products was better in urban than in rural areas, as well as among persons of higher socio-economic status (7). Also, in a study by El-Gilany et al. (16), the use of menstrual pads was significantly higher among younger girls from urban areas of Egypt, who belong to middle and upper social classes. It was concluded that the main predictors of using sanitary pads are access to mass media, higher social class and living in the city. In our study, there was no significant difference between female students from urban and rural areas regarding their behavior towards obtaining alternative menstrual products due to the lack of money and attitudes about free menstrual products. The result of our study indicates that there was also no significant difference in the issue of having problems with the procurement of menstrual products (sanitary pads, tampons, menstrual cups) in the last 12 months compared to the years of study attended by female students. The obtained data are similar to the results relating to their age, because female students in the 4th and 5th year of study are older students (aged 23 and more).

The main limitations of this study refer to the non-inclusion of questions relating to menstruation, hygienic conditions of premises at the faculty, where one can replace menstrual products, the proximity of facilities from the faculty where menstrual products can be obtained, as well as the frequency of absence from classes during menstruation and the reasons for absence. On the other hand, this cross-sectional study is the basis for further research in this field aimed at improving the quality of life of young people.

Conclusion

All female medical students believe that menstrual products should be free, while 5.1% of them had difficulty obtaining menstrual products in the last 12 months. It is necessary to continuously examine the behavior and attitudes of female students regarding menstrual products and the factors associated with them, both at the Faculty of Medicine of the University of Belgrade and at all other faculties, and use the results obtained as a basis for creating and implementing activities aimed at improving health. and the quality of life of female students.

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Competing interests

The author declared no competing interests.

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ZADOVOLJSTVO INTERNOM KOMUNIKACIJOM U ZDRAVSTVENOJ USTANOVI

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SAŽETAK

Uvod/Cilj: Interna komunikacija je osnovni stub uspešnog funkcionisanja zdravstvenih ustanova, jer direktno utiče na zadovoljstvo zaposlenih, produktivnost i smanjenje nesporazuma. Cilj ovog rada je istraživanje zadovoljstva internom komunikacijom u Domu zdravlja Šid, sa posebnim fokusom na identifikaciju glavnih izazova i predlaganje mera za unapređenje.
Metode: Sprovedeno je kvantitativno istraživanje u vidu studije preseka među 145 zaposlenih u Domu zdravlja Šid. Kao glavni instrument korišćen je Upitnik o zadovoljstvu internom komunikacijom (UPZIK). Istraživanje je obavljeno u maju 2023. godine, a za analizu podataka korišćen je program Excel.
Rezultati: Većinu ispitanika činile su žene (81%), starosne grupe između 31 i 50 godina (52%), sa srednjom stručnom spremom (53%) i zaposleni kao zdravstveno osoblje (78%). Najveće zadovoljstvo zabeleženo je u komunikaciji sa članovima tima (5,53±1,41) i kolegama (5,34±1,45), dok je najmanje zadovoljstvo bilo sa informacijama o finansijskom uspehu (3,73±1,70) i promenama u organizaciji (3,81±1,72). Analizom dimenzija UPZIK, uočeno je da su horizontalna komunikacija (5,17±1,33) i komunikacija sa nadređenima (4,72±1,54) najbolje ocenjene, dok su korporativna informisanost (3,93±1,57) i povratne informacije (4,02±1,56) imale najniže ocene. Zabrinjavajuće je nisko zadovoljstvo količinom tračeva (širenja glasina) (3,57±1,74), što je pokazatelj negativnih komunikacionih praksi. Muškarci su pokazali veće zadovoljstvo (4,67±1,96) nego žene (4,34±1,59). Najveće zadovoljstvo je primećeno kod mlađih od 25 godina (5,57±0,95), dok su stariji od 50 godina bili najmanje zadovoljni (4,18±1,37). Ispitanici sa višim obrazovanjem imali su najviši nivo zadovoljstva (4,98±1,27), dok su ispitanici sa nižim obrazovanjem bili najmanje zadovoljni (3,16±0,72). Administrativno osoblje imalo je najviše zadovoljstvo (5,16±1,22), a pomoćno osoblje najniže (3,95±1,48).
Zaključak: Neophodno je unaprediti internu komunikaciju u Domu zdravlja Šid kroz uvođenje redovnih edukacija o komunikacionim veštinama, razvoj etičkog kodeksa, te implementaciju strategija vidljivosti, komunikacije i priznanja, kako bi se poboljšala radna atmosfera i povećalo zadovoljstvo zaposlenih.

Ključne reči: interna komunikacija, zadovoljstvo zaposlenih, zdravstvena ustanova, komunikacione strategije, etički kodeks

Uvod

Interna komunikacija je osnova uspešnog funkcionisanja zdravstvenih ustanova, značajno utiče na zadovoljstvo zaposlenih, produktivnost i smanjenje nesporazuma. Strategija poboljšanja interne komunikacije može direktno uticati na efikasnost rada i povećanje zadovoljstva zaposlenih u zdravstvenim ustanovama (1). Prema Radić - Hozo i Hozo, efikasna interna komunikacija ne samo da poboljšava kvalitet nege pacijenata već i smanjuje mogućnost grešaka i povećava sigurnost pacijenata (2). Uspešna komunikacija između zdravstvenih radnika omogućava efikasnu razmenu informacija o stanju pacijenata, dijagnostičkim i terapijskim procedurama, kao i lekovima, što je bitno za rešavanje problema koji se javljaju tokom lečenja (3,4). Efikasna interna komunikacija, takođe, može poboljšati angažovanost zaposlenih i njihovu posvećenost organizaciji, što dalje pozitivno utiče na ukupne performanse organizacije (5,6). Liderstvo oblikuje komunikacionu klimu u organizaciji,

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SATISFACTION WITH INTERNAL COMMUNICATION IN A HEALTHCARE INSTITUTION

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SUMMARY

Introduction/Aim: Internal communication is the cornerstone of the successful functioning of healthcare institutions, as it directly influences employee satisfaction, productivity, and the reduction of misunderstandings. The aim of this paper is to investigate satisfaction with internal communication at the Health Center Šid, with a special focus on identifying the main challenges and proposing measures for improvement.
Methods: A quantitative cross-sectional study was conducted among 145 employees at the Health Center Šid. The main instrument was the Internal Communication Satisfaction Questionnaire (ICSQ). The study was conducted in May 2023, and data analysis was performed using Excel programe.
Results: The majority of respondents were women (81%), aged between 31 and 50 years (52%), with secondary education (53%) and working as healthcare personnel (78%). The highest satisfaction was recorded in communication with team members (5.53±1.41) and colleagues (5.34±1.45), while the lowest satisfaction was with information on financial success (3.73±1.70) and organizational changes (3.81±1.72). The analysis of ICSQ dimensions showed that horizontal communication (5.17±1.33) and communication with superiors (4.72±1.54) were rated highest, while corporate information (3.93±1.57) and feedback (4.02±1.56) received the lowest ratings. Low satisfaction with the amount of gossip (spreading rumors) (3.57±1.74) is concerning, indicating the presence of negative communication practices. Men showed higher satisfaction (4.67±1.96) than women (4.34±1.59). The highest satisfaction was observed among those under 25 years old (5.57±0.95), while those over 50 years old were the least satisfied (4.18±1.37). Respondents with higher education had the highest level of satisfaction (4.98±1.27), while those with lower education were the least satisfied (3.16±0.72). Administrative staff reported the highest satisfaction (5.16±1.22), and support staff the lowest (3.95±1.48).
Conclusion: The research highlighted the need for improving internal communication at the Health Center Šid through the introduction of regular communication skills training, the development of a code of ethics, and the implementation of visibility, communication, and recognition strategies to improve the working atmosphere and increase employee satisfaction.

Keywords: internal communication, employee satisfaction, healthcare institution, communication strategies, code of ethics

Introduction

Internal communication is the foundation of the successful functioning of healthcare institutions, significantly impacting employee satisfaction, productivity, and the reduction of misunderstandings. A strategy to improve internal communication can directly influence work efficiency and increase employee satisfaction in healthcare institutions (1). According to Radić - Hozo and Hozo, effective internal communication not only improves the quality of patient care but also reduces the possibility of errors and increases patient safety (2). Successful communication among healthcare workers enables efficient exchange of information about the patient's condition, diagnostic and therapeutic procedures, as well as medications, which is crucial for resolving issues that arise during treatment (3,4). Effective internal communication can also improve employee engagement and their commit-

što može direktno uticati na zadovoljstvo zaposlenih (7). Precizno merenje zadovoljstva internom komunikacijom omogućava održavanje pozitivne radne atmosfere i unapređenje organizacionih procesa (8).

U Domu zdravlja Šid, kvalitetna interna komunikacija je posebno važna zbog složenosti organizacionih procesa i interakcija među zaposlenima. Istraživanja su pokazala da efikasna interna komunikacija uključuje jasne i koncizne poruke, aktivno slušanje, otvorene i iskrene povratne informacije, kao i liderstvo koje podstiče kulturu transparentnosti i saradnje (9,10). Takođe, savremene tehnologije, kao što su društveni mediji i digitalne platforme, mogu značajno unaprediti internu komunikaciju i olakšati saradnju između zdravstvenih radnika (11). Ovaj trend je posebno izražen u zdravstvenim ustanovama gde brza i precizna razmena informacija može biti presudna za ishode lečenja (12).

Cilj ovog rada je istraživanje zadovoljstva internom komunikacijom u Domu zdravlja Šid, sa posebnim fokusom na identifikaciju glavnih izazova i predlaganje mera za unapređenje. Rezultati ove analize pružaju osnovu za razvoj strategija koje bi mogle doprineti efikasnijem funkcionisanju ustanove i povećanju zadovoljstva zaposlenih.

Metode

Istraživanje je sprovedeno kao kvantitativna studija koristeći Upitnik o zadovoljstvu internom komunikacijom (UPZIK) na radnom mestu kao glavni instrument za prikupljanje podataka (13,14). Pored ovog upitnika, korišćen je i opšti upitnik za prikupljanje demografskih podataka, uključujući pol, uzrast, stepen obrazovanja i radno mesto. Istraživanjem je obuhvaćeno 145 od 210 zaposlenih u Domu zdravlja Šid. Prikupljanje podataka obavljeno je tokom maja 2023. godine, uz poštovanje anonimnosti i dobrovoljnog učešća, a svim ispitanicima je sugerisano da daju iskrene odgovore.

Etički odbor Doma zdravlja Šid doneo je odluku br. 05-799/2 od 05.05.2023. godine, kojom je odobreno korišćenje UPZIK upitnika za prikupljanje informacija o internoj komunikaciji. Odluka se zasnivala na etičkoj proceni istraživanja i zaštiti podataka.

UPZIK je dizajniran da obuhvati ključne aspekte interne komunikacije, uključujući komunikaciju sa nadređenima, horizontalnu komunikaciju, neformalnu komunikaciju i povratne informacije. UPZIK je razvijen od strane Verčič Tkalac i sar. 2009. godine (13). Pitanja u upitniku su koncipirana da procene percepciju zaposlenih o komunikacionim praksama unutar organizacije, koristeći Likertovu skalu od 7 kategorija. Na ovoj skali, najmanja vrednost (1) označava „izrazito nezadovoljan“, dok najviša vrednost (7) označava „izrazito zadovoljan“. UPZIK se sastoji od 32 stavke raspoređene u osam dimenzija: zadovoljstvo povratnim informacijama, zadovoljstvo komunikacijom sa nadređenima, horizontalna komunikacija, neformalna komunikacija, korporativna informisanost, komunikaciona klima, kvalitet medija komunikacije i zadovoljstvo komunikacijom na sastancima. Ovaj upitnik je već korišćen u različitim organizacijama i sektorima, što potvrđuje njegovu pouzdanost i primenljivost u različitim radnim okruženjima (15-17).

U analizi podataka je korišćen *Excel* (*Microsoft® Excel®* za *Microsoft 365 MSO*).

Rezultati

Većinu ispitanika su činile osobe ženskog pola 81% (117/145). Starosna struktura pokazuje da je većina ispitanika pripadala uzrastu 31-40 godina (25%), 41-50 godina (27%) i preko 50 godina (38%), a najmanje među mlađima od 25 godina (3%) i 25-30 godina (7%).

Obrazovna struktura pokazuje da 53% (77/145) ispitanika ima srednju stručnu spremu, a 27% (39/145) visoku. Manji procenat ispitanika ima višu stručnu spremu (8% ili 12/145), završen fakultet i poslediplomske studije (7% ili 10/145), a samo 5% (7/145) nižu stručnu spremu.

Većina ispitanika (78%) je radila kao zdravstveno osoblje, a administrativne poslove je obavljalo 6% ispitanika, tehničke 12% i upravljačke 4%.

Na tabeli 1 prikazane su prosečne vrednosti za sva pitanja koja se odnose na zadovoljstvo komunikacijom prema UPZIK. Ispitanici su najviše bili zadovoljni komunikacijom sa članovima svoga tima (5,53±1,41), komunikacijom sa kolegama (5,34±1,45) i dostupnošću kolega (5,27±1,45), a najmanje sa količinom tračeva (širenja glasina) u organizaciji (3,57±1,74), informacijama o prometu, dobiti i finansijskom uspehu organizacije (3,73±1,70), informacijama o promenama u organizaciji (3,81±1,72) i informacijama o zakonskim propisima koji utiču na poslovanje organizacije (3,84±1,71).

Analizom osam dimenzija UPZIK-a utvrđeno je da je najveće zadovoljstvo izraženo u horizon-

ment to the organization, which further positively affects overall organizational performance (5,6). Leadership shapes the communication climate within the organization, which can directly impact employee satisfaction (7). Accurate measurement of satisfaction with internal communication allows for maintaining a positive work atmosphere and improving organizational processes (8).

In the Health Center Šid, quality internal communication is particularly important due to the complexity of organizational processes and interactions among employees. Research has shown that effective internal communication involves clear and concise messages, active listening, open and honest feedback, as well as leadership that fosters a culture of transparency and collaboration (9, 10). Additionally, modern technologies such as social media and digital platforms can significantly enhance internal communication and facilitate collaboration among healthcare workers (11). This trend is particularly evident in healthcare institutions where rapid and precise information exchange can be crucial for treatment outcomes (12).

The aim of this paper is to investigate satisfaction with internal communication at the Health Center Šid, with a special focus on identifying the main challenges and proposing measures for improvement. The results of this analysis provide a basis for developing strategies that could contribute to more efficient functioning of the institution and increased employee satisfaction.

Methods

The research was conducted as a quantitative study using the Internal Communication Satisfaction Questionnaire (ICSQ) at work as the main instrument for data collection (13, 14). In addition to this questionnaire, the general questionnaire was used for the collection of demographic data, including gender, age, level of education and workplace. The study included 145 of 210 employees of the Health Center Šid. Data collection took place in May 2023, respecting anonymity and voluntary participation, while all respondents were encouraged to provide honest answers.

The Ethics Committee of the Health Center Šid issued decision no. 05-799/2 on May 5th, 2023, approving the use of the ICSQ for collecting information on internal communication. The decision was based on the ethical assessment of the research and data protection.

The ICSQ was designed to cover key aspects of internal communication, including communication with superiors, horizontal communication, informal communication, and feedback. The ICSQ was developed by Verčič Tkalac et al. in 2009 (13). The questions in the questionnaire were designed to assess employees' perceptions of communication practices within the organization, using a 7-point Likert scale. On this scale, the lowest value (1) indicates “extremely dissatisfied”, while the highest value indicates “extremely satisfied”. The ICSQ consists of 32 items distributed across eight dimensions: satisfaction with feedback, satisfaction with communication with superiors, horizontal communication, informal communication, corporate awareness, communication climate, media quality, and satisfaction with communication in meetings. This questionnaire has already been used in various organizations and sectors, confirming its reliability and applicability in different work environments (15,16,17).

Excel (Microsoft® Excel® for Microsoft 365 MSO) was used for data analysis.

Results

The majority of respondents were female (117/145; 81%). The age structure shows that most respondents belong to the age group 31-40 years (25%), 41-50 years (27%), and over 50 years (38%), while the least of them are under the age of 25 (3%) and in the age group 25-30 years (7%).

The educational structure of the respondents shows that 53% (77/145) have a secondary education, while 27% (39/145) have a higher education. A smaller percentage of respondents have completed colleges (8% or 12/145), university or postgraduate studies (7% or 10/145), while only 5% of them (7/145) have lower educational levels.

Most employees work as healthcare staff (78%), while the rest are in administrative (6%), technical (12%), and managerial (4%) positions.

Table 1 shows the average values for all questions related to satisfaction with communication according to ICSQ. The respondents were most satisfied with communication with the members of their team (5.53+1.41), communication with colleagues (5.34+1.45) and availability of colleagues (5.27+1.45), while they were least satisfied with the amount of gossip (spreading rumors) in the organization (3.57+1.74), information on turnover, profit and financial success of the organiza-

Tabela 1. Osnovna metrika Upitnika o zadovoljstvu internom komunikacijom

Br.	Pitanja	Srednja vrednost	Standardna devijacija
1.	Informacijama o posledicama lošeg obavljanja posla	3,91	1,581
2.	Informacijama o tome koliko pridonosim zajedničkom uspehu	4,11	1,667
3.	Informacijama o tome koliko se moj posao ceni unutar organizacije	3,96	1,763
4.	Povratnim informacijama o tome kako obavljam svoj posao	4,14	1,620
5.	Dostupnošću neposredno nadređenog	4,86	1,682
6.	Koliko je moj nadređeni upoznat sa problemima sa kojima se susrećem na poslu	4,73	1,613
7.	Koliko moj nadređeni razume moje probleme	4,72	1,661
8.	Prepoznavanjem mog potencijala od neposredno nadređenog	4,55	1,658
9.	Dostupnošću kolega	5,27	1,454
10.	Koliko uspešno komuniciram sa članovima svog tima	5,53	1,405
11.	Rezultatima komuniciranja sa kolegama	5,34	1,452
12.	Spremnošću mojih kolega da prime kritiku	4,54	1,612
13.	Brojem odluka koje se donose na osnovu neformalne komunikacije	4,43	1,549
14.	Količinom tračeva u organizaciji	3,57	1,739
15.	Količinom vremena koje provodim u neformalnoj komunikaciji	4,54	1,414
16.	Korisnošću informacija prenesenih neformalnim putem	4,42	1,508
17.	Informacijama o pravilniku o radu	4,34	1,713
18.	Informacijama o prometu, dobiti i finansijskom uspehu organizacije	3,73	1,701
19.	Informacijama o promenama u organizaciji	3,81	1,717
20.	Informacijama o zakonskim propisima koji utiču na poslovanje moje organizacije	3,84	1,707
21.	Koliko komunikacija u organizaciji pomaže da se osećam kao važan deo nje	4,24	1,733
22.	Koliko komunikacija u organizaciji pomaže da se s njom identifikujem (poistovećujem)	4,23	1,623
23.	Koliko komunikacija u organizaciji promoviše organizacijske vrednosti	4,06	1,701
24.	Koliko me komunikacije u organizaciji podstiču u ostvarivanju organizacijskih ciljeva	4,30	1,663
25.	Medijima komuniciranja (pisana obaveštenja, intranet, usmene komunikacije i sl.)	4,26	1,546
26.	Mogućnošću komuniciranja putem savremenih medija	4,27	1,626
27.	Kvalitetom komuniciranja putem savremenih medija	4,26	1,670
28.	Načinom koji drugi biraju za komunikaciju sa mnom	4,51	1,650
29.	Koliko su dobro organizovani sastanci na kojima učestvujem	4,01	1,766
30.	Korisnošću informacija dobijenih na sastancima	4,08	1,758
31.	Primam li informacije važne za obavljanje posla na vreme	4,28	1,694
32.	Trajanjem sastanaka	4,32	1,698

talnoj komunikaciji (5,17±1,33) i komunikaciji sa nadređenima (4,72±1,54), dok je najniže zadovoljstvo primećeno u korporativnoj informisanosti (3,93±1,57) i povratnim informacijama (4,02±1,56). Ostale dimenzije uključuju neformalnu komunikaciju (4,24±1,30), komunikacijsku klimu (4,21±1,58), kvalitet medija komunikacije (4,33±1,52) i komunikaciju na sastancima (4,18±1,62). Ukupno zadovoljstvo komunikacijom je zabeleženo sa imalo vrednost od 4,35±1,29 (grafikon 1).

Muškarci su imali viši nivo zadovoljstva internom komunikacijom (4,67±1,96) nego žene (4,34±1,59) (grafikon 2).

Table 1. Basic metric of the Internal Communication Satisfaction Questionnaire

No.	Questions	Mean value	Standard deviation
1	Information on the consequences of doing my job poorly	3.91	1.581
2	Information on how much I contribute to the organization's success	4.11	1.667
3	Information on how much my job is appreciated within the organization	3.96	1.763
4	Feedback on how well I do my job	4.14	1.620
5	Availability of my immediate superior	4.86	1.682
6	How well my immediate superior is informed about the problems that I may encounter at work	4.73	1.613
7	How well my immediate superior understands my problems	4.72	1.661
8	Recognition of my potential by my immediate superior	4.55	1.658
9	Availability of colleagues	5.27	1.454
10	How successfully I am able to communicate with the members of my team	5.53	1.405
11	The outcomes of communicating with colleagues	5.34	1.452
12	Readiness of my colleagues to accept critical feedback	4.54	1.612
13	The number of decisions made based on informal communications	4.43	1.549
14	The amount of gossip in the organization	3.57	1.739
15	The amount of time I spend in informal communication	4.54	1.414
16	Usefulness of information transferred through informal channels	4.42	1.508
17	Information on work protocols	4.34	1.713
18	Information on revenues profit and the financial status of the organization	3.73	1.701
19	Information on changes in the organization	3.81	1.717
20	Information on legal regulations that affect the organization's operations	3.84	1.707
21	How much communication within the organization helps me to feel I am an important part of the organization	4.24	1.733
22	How much communication within the organization helps me to identify with the organization	4.23	1.623
23	How much communication within the organization promotes organizational values	4.06	1.701
24	How much communication within the organization encourages me to accomplish the organization's goals	4.30	1.663
25	Communication media (e.g. written announcements, intranet, oral communication)	4.26	1.546
26	The possibility of communicating through new media	4.27	1.626
27	Quality of communication through new media	4.26	1.670
28	The mode of communication others choose to communicate with me	4.51	1.650
29	How well organized are the meetings that I participate in	4.01	1.766
30	Usefulness of information received in meetings	4.08	1.758
31	Receiving information relevant for job accomplishment on time	4.28	1.694
32	Duration of meetings	4.32	1.698

tion (3.73+1.70), information about changes in the organization (3.81+1.72) and information about legal regulations that affect the organization's operations (3.84+1.71).

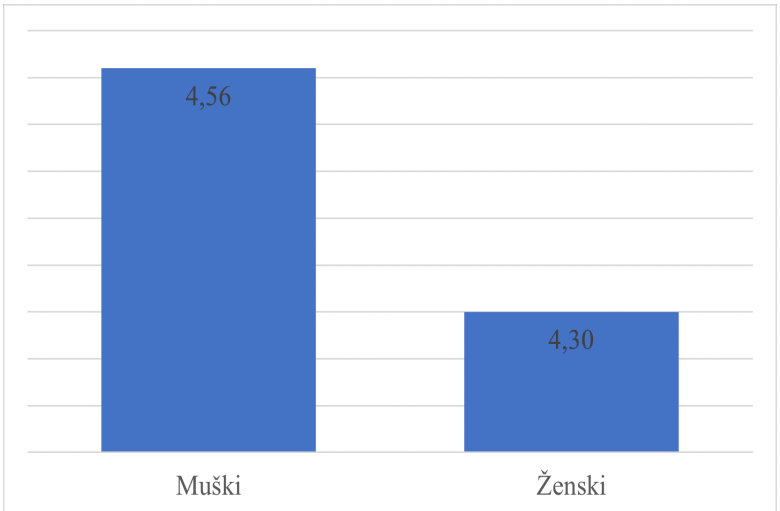
The analysis of eight dimensions of the ICSQ showed that the highest satisfaction was expressed in horizontal communication (5.17+1.33), and communication with superiors (4.72+1.54), while

Grafik 1. Prosečne vrednosti zadovoljstva za osam dimenzija Upitniku o zadovoljstvu internom komunikacijom

Stariji ispitanici (25 i više godina) (<25 godina – 5,57±0,95; 25-30 godina – 4,41±1,39; 31-40 godina – 4,37±1,25; 41-50 godina – 4,42±1,18; više od 50 godina – 4,18±1,37) su pokazivali niži nivo zadovoljstva internom komunikacijom nego mlađi (5,57±0,95) (grafikon 3).

Ispitanici sa višim nivoom obrazovanja imali su najviši nivo zadovoljstva internom komunikacijom (4,98±1,27), dok su ispitanici sa nižim nivoom obrazovanja pokazali najniži nivo zadovoljstva (3,16±0,72). Ispitanici sa završenim poslediplomskim studijama i srednjom stručnom spremom imali su slične nivoe zadovoljstva (4,42±1,08 i 4,44±1,27) (grafikon 4).

Zaposleni na administrativnim (5,16±1,22) i upravljačkim pozicijama (4,70±1,49) pokazivali su veće zadovoljstvo internom komunikacijom nego zdravstveni radnici (4,34±1,24) i pomoćno osoblje (3,95±1,48) (grafikon 5).



Grafik 2. Prosečne vrednosti ukupnog skora zadovoljstvaprema Upitnika o zadovoljstvu internom komunikacijom u odnosu na pol

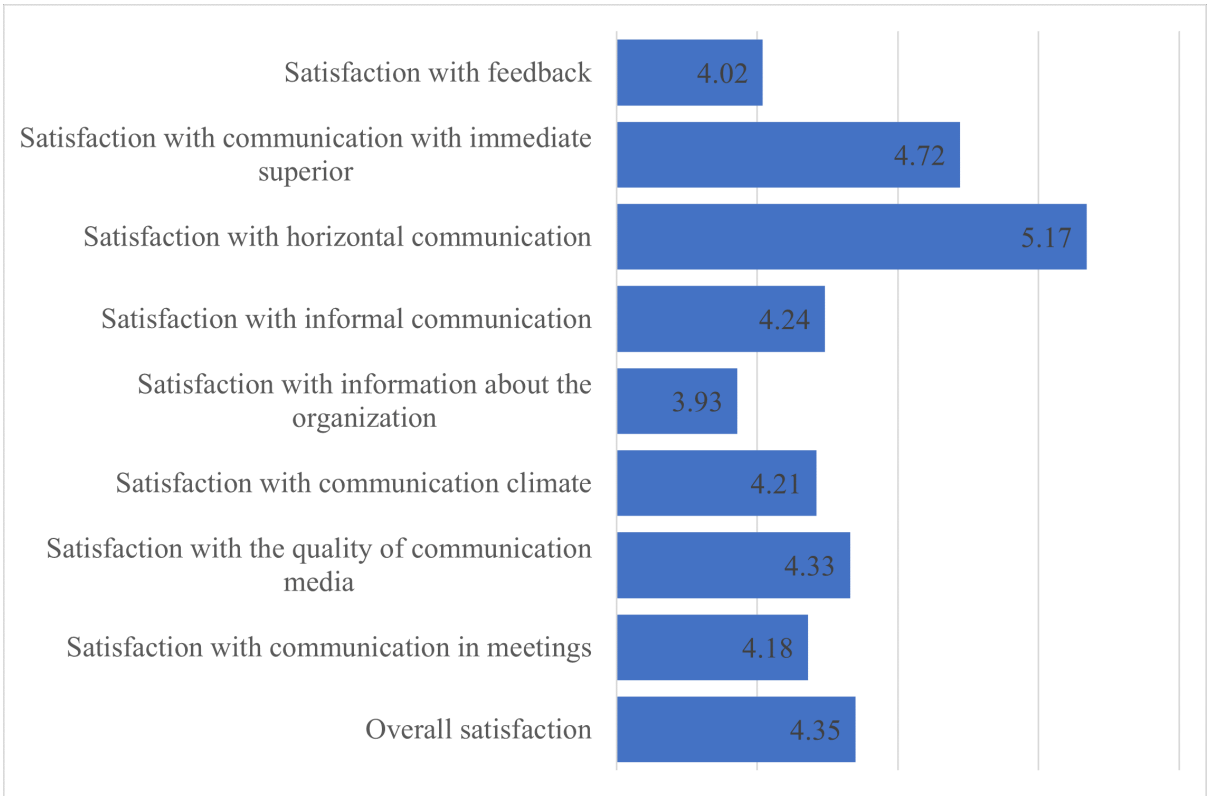


Figure 1. Average satisfaction values for eight dimensions of the Internal Communication Satisfaction Questionnaire

the lowest satisfaction was observed in corporate information (3.93+1.57) and feedback (4.02+1.56). Other dimensions include informal communication (4.24+1.30), communication climate (4.21+1.58), quality of communication media (4.33+1.52) and communication at meetings (4.18+1.62). Overall satisfaction with communication was recorded with a mean value of 4.35+1.29 (Figure 1).

Men had a higher level of satisfaction with internal communication (4.67+1.96) than women (4.34+1.59) (Figure 2).

Older respondents (25 years and over) (<25 years – 5.57+0.95; 25-30 years – 4.41+1.39; 31-40 years – 4.37+1.25; 41-50 years – 4.42+1.18; older than 50 – 4.18+1.37) showed a lower level of satisfaction with internal communication than younger people (5.57+0.95) (Figure 3).

Respondents with a higher level of education had the highest level of satisfaction with internal communication (4.98+1.27), while respondents

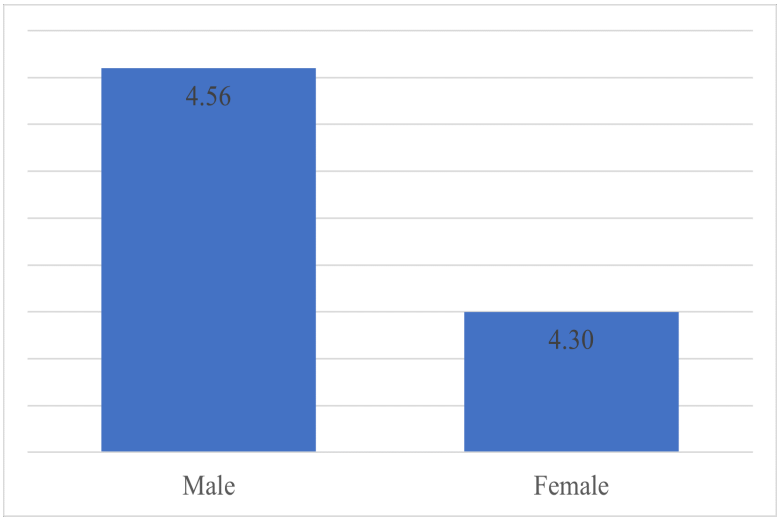
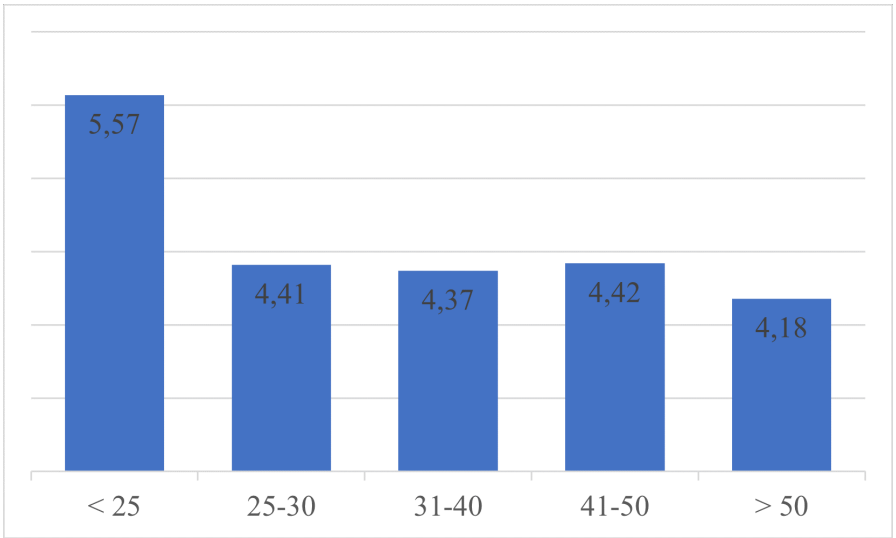
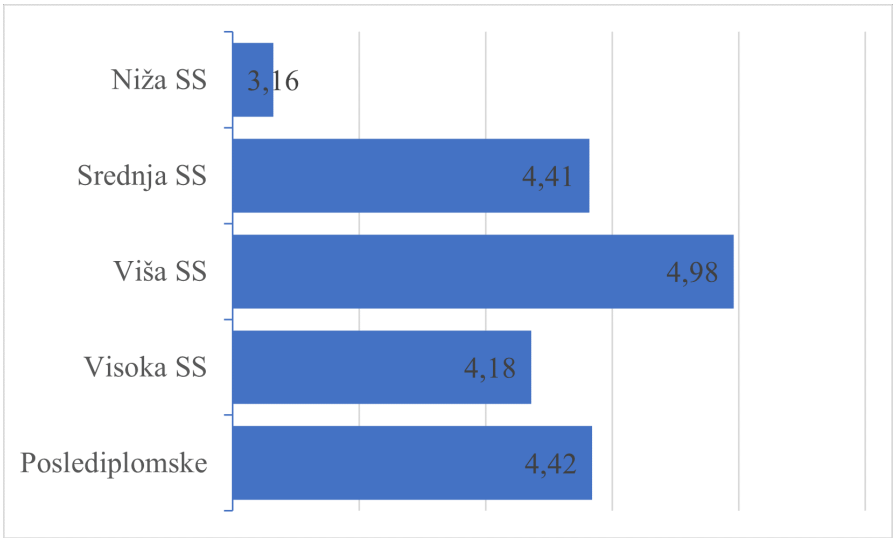


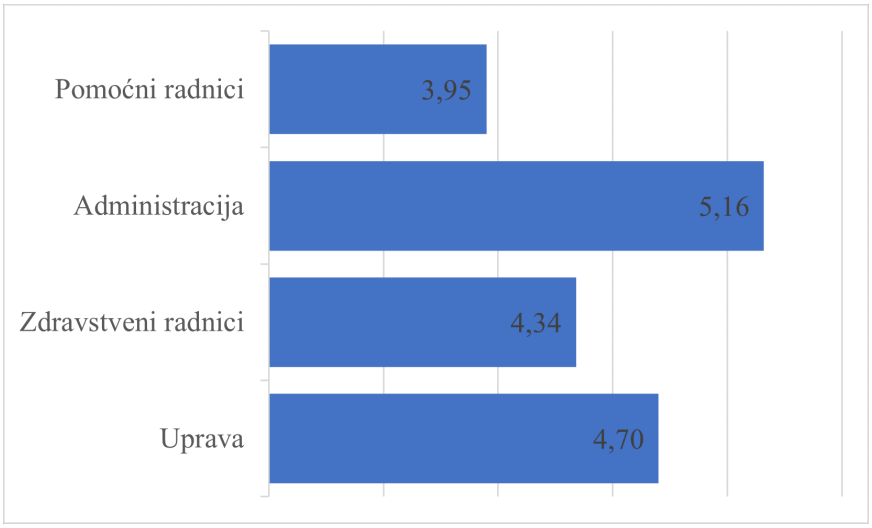
Figure 2. Average values of total satisfaction score according to the Internal Communication Satisfaction Questionnaire in relation to gender



Grafik 3. Prosečne vrednosti ukupnog skora zadovoljstva prema Upitniku o zadovoljstvu internom komunikacijom u odnosi na starost ispitanika



Grafik 4. Prosečne vrednosti ukupnog skora zadovoljstva prema Upitniku o zadovoljstvu internom komunikacijom u odnosu na stepen obrazovanja



Grafik 5. Prosečne vrednosti ukupnog skora zadovoljstva prema Upitniku o zadovoljstvu internom komunikacijomu odnosu na radno mesto

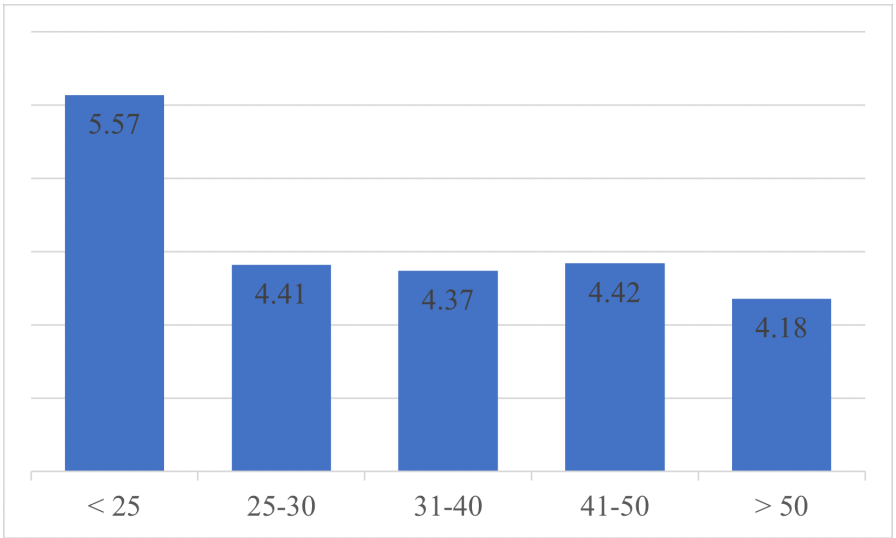


Figure3. Average values of the total satisfaction score of the Internal Communication Satisfaction Questionnaire in relation to age

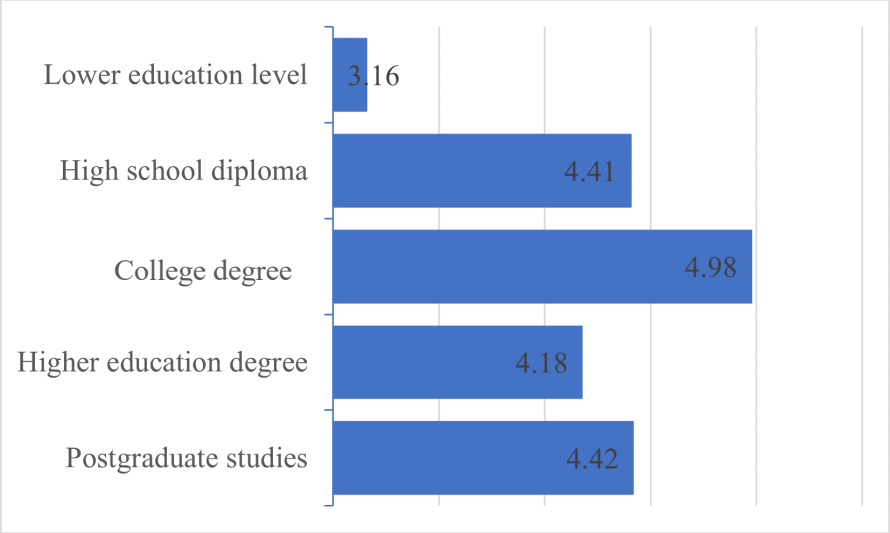


Figure 4. Average values of the total satisfaction score according to the Internal Communication Satisfaction Questionnaire in relation to the level of education

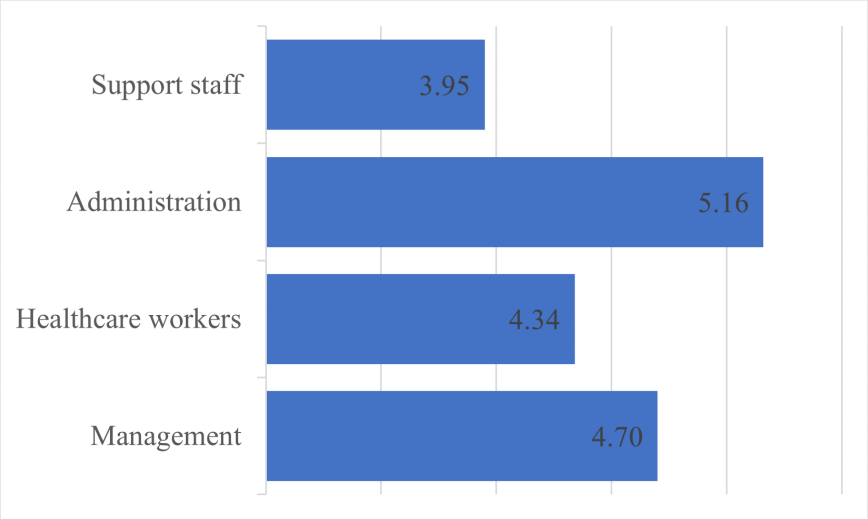


Figure 5. Average values of the total satisfaction score according to the Internal Communication Satisfaction Questionnaire in relation to the job position

Diskusija

Rezultati istraživanja ukazuju na nekoliko ključnih oblasti za unapređenje interne komunikacije u Domu zdravlja Šid. Uočene su razlike u zadovoljstvu između različitih demografskih grupa, pri čemu su žene, zaposleni sa nižim stepenom obrazovanja i stariji zaposleni često izražavali niži nivo zadovoljstva. Posebno je istaknuto nezadovoljstvo korporativnom informisanošću i povratnim informacijama, što sugeriše potrebu za jasnijim i konzistentnijim informisanjem zaposlenih o važnim pitanjima. Ovi nalazi su u skladu sa istraživanjima *Hargie* (9) i *Varona* (6), koji su naglasili važnost transparentnosti i dvosmerne komunikacije za povećanje zadovoljstva zaposlenih. Pored toga, istraživanje je pokazalo da mlađi radnici, za razliku od starijih kolega, imaju pozitivniju percepciju brenda organizacije, što može značajno doprineti njihovom angažovanju i zadovoljstvu poslom. Ova razlika u percepciji brenda među demografskim grupama poklapa se sa nalazima *Myrden* i sar (18) koji su pokazali da simbolični aspekti brenda, kao što su reputacija organizacije i mogućnost identifikacije sa njom, imaju snažan uticaj na privlačnost organizacije kod mladih radnika. U njihovom istraživanju, utvrđeno je da mlađi radnici više vrednuju ove simbolične aspekte brenda u poređenju sa funkcionalnim atributima, kao što su plata i beneficije, i da ovaj efekat postaje još izraženiji sa porastom radnog iskustva. Na osnovu ovih saznanja, možemo zaključiti da strategije interne komunikacije u Domu zdravlja Šid treba da se fokusiraju na jačanje simboličnih aspekata brenda, posebno kod mlađih radnika, kako bi se povećalo njihovo angažovanje i lojalnost prema organizaciji. Zbog toga strategije interne komunikacije moraju se prilagoditi različitim demografskim grupama kako bi se obezbedilo sveobuhvatno zadovoljstvo svih zaposlenih.

Jedan od najvažnijih izazova identifikovanih u istraživanju je prisustvo širenja glasina (tračeva), što negativno utiče na radnu atmosferu i timsku koheziju. Ovaj problem se može rešiti kroz obuku zaposlenih o efikasnoj komunikaciji i razvijanje etičkog kodeksa koji bi regulisao komunikaciju unutar organizacije bez širenja glasina. Ovakav pristup podržan je istraživanjima Novaković Božić i sar. (7) i *Clampitt* i sar. (5), koje naglašavaju potrebu za etičkim standardima i transparentnim procesima u organizacijama. Prema Ožegović i sar. (18), efikasna komunikacija unutar organizacije ima presudnu važnost u sprečavanju dezinformacija i širenja glasina, što direktno doprinosi boljoj organizacionoj klimi i većoj timskoj koheziji.

Preporučuje se primena strategije poput „Vidljivost, komunikacija, priznanje“ (VCR) za poboljšanje angažovanosti osoblja i promociju kulture priznanja, što je naglašeno u istraživanjima *Viji* i sar. (1). Ova strategija može doprineti unapređenju komunikacione klime i smanjenju negativnih efekata, kao što su sagorevanje i odliv kadrova (20). Implementacija ovakvih strategija može doprineti boljoj koordinaciji timova i poboljšanju opšteg radnog okruženja u zdravstvenim ustanovama, što je potvrđeno i u radu *Loveman*-a (21) koji povezuje zadovoljstvo zaposlenih sa lojalnošću i performansama. Pored toga, kako navodi *Kim* (22), efikasne interne komunikacione prakse ne samo da jačaju socijalni kapital unutar organizacije, već i poboljšavaju odnose između zaposlenih i menadžmenta, što je ključno za održavanje pozitivne radne atmosfere. Pandemija COVID-19 je dodatno naglasila važnost efikasne interne komunikacije u održavanju organizacione kohezije i adaptaciji na nove uslove rada (23).

Istraživanje je pokazalo da je najviše zadovoljstvo izraženo u pogledu horizontalne komunikacije i komunikacije sa nadređenima, što ukazuje na dobre odnose među zaposlenima na istom nivou i sa njihovim nadređenima. Visoka ocena zadovoljstva komunikacijom sa nadređenima ukazuje na važnost efikasne komunikacije u smanjenju rizika od sagorevanja i odliva kadrova. *Hargie* (9) i *Vermeir* i sar. (3), ističu važnost komunikacione satisfakcije za opšte zadovoljstvo poslom i smanjenje rizika od sagorevanja.

Glavni nedostatak ove studije odnosi se na relativno mali broj ispitanika, što može ograničiti generalizaciju nalaza. Ipak, uprkos ovom ograničenju, studija pruža značajan doprinos, jer postavlja temelje za dalja istraživanja u oblasti interne komunikacije. Ovi rezultati mogu poslužiti kao polazna tačka za razvijanje i implementaciju strategije koja će unaprediti komunikaciju unutar organizacija, čime se doprinosi poboljšanju radne atmosfere i efikasnosti timova.

Zaključak

Istraživanje je pokazalo da je ukupno zadovoljstvo internom komunikacijom u Domu zdravlja Šid

with a lower level of education showed the lowest level of satisfaction (3.16+0.72). Respondents with completed postgraduate studies and secondary vocational education had similar levels of satisfaction (4.42+1.08 and 4.44+1.27) (Figure 4).

Employees in administrative (5.16+1.22) and management positions (4.70+1.49) showed higher satisfaction with internal communication than health workers (4.34+1.24) and support staff (3.95+1.48) (Figure 5).

Discussion

The research results indicate several key areas for improving internal communication in the Health Center Šid. Differences in satisfaction were observed between different demographic groups, while women, employees with lower education levels, and older employees often expressed lower levels of satisfaction. Dissatisfaction with corporate awareness and feedback was particularly highlighted, suggesting a need for clearer and more consistent communication with employees on important issues. These findings are consistent with the research of Hargie (9) and Varona (6), who emphasized the importance of transparency and two-way communication for increasing employee satisfaction. Additionally, the research showed that younger workers, unlike their older colleagues, had a more positive perception of the organization's brand, which could significantly contribute to their engagement and job satisfaction. This difference in brand perception between demographic groups is consistent with the findings of Myrden et al. (18), who showed that symbolic brand attributes, such as the organization's reputation and the possibility of identifying with it had a strong influence on the attractiveness of the organization among young workers. In their study, they found that younger workers appreciate these symbolic aspects of the brand more than functional attributes, such as salary and benefits, and that this effect becomes more pronounced with the increase in work experience. Based on these findings, we can conclude that internal communication strategies at the Health Center Šid should focus on strengthening symbolic brand attributes, especially in younger workers in order to increase their engagement and loyalty to the organization. Therefore, internal communication strategies must be adapted to different demographic groups in order to ensure the comprehensive satisfaction of all employees.

One of the most important challenges identified in the research is the presence of rumors, which negatively affects the work atmosphere and team cohesion. This problem can be addressed through employee training on effective communication and the development of an ethical code that would regulate communication within the organization without spreading rumors. This approach is supported by the research of Novaković Božić et al. (7) and Clampitt et al. (5), who emphasize the need for ethical standards and transparent processes in organizations. According to Ožegović et al. (18), effective communication within the organization plays a crucial role in preventing misinformation and spreading rumors, directly contributing to a better organizational climate and greater team cohesion.

It is recommended to implement strategies such as VCR (Visibility, Communication, Recognition) to improve employee engagement and promote a culture of recognition, as emphasized in the research of Viji et al. (1). These strategies can significantly contribute to improving the communication climate and reducing negative effects such as burnout and staff turnover (20). The implementation of such strategies can improve team coordination and the overall work environment in healthcare institutions, as confirmed by Loveman's work (21), which links employee satisfaction with loyalty and performance. Furthermore, as Kim notes (22), effective internal communication practices not only strengthen social capital within the organization but also improve relationships between employees and management, which is crucial for maintaining a positive work atmosphere. The COVID-19 pandemic has further highlighted the importance of effective internal communication in maintaining organizational cohesion and adapting to new working conditions (23).

The research showed that the highest satisfaction was expressed regarding horizontal communication and communication with superiors, indicating good relationships among employees at the same level and with their superiors. The high satisfaction with communication with superiors indicates the importance of effective communication in reducing the risk of burnout and staff turnover. Hargie (9) and Vermeir et al. (3) emphasize the importance of communication satisfaction for overall

na umerenom nivou, s prostorom za unapređenje zadovoljstva internom komunikacijom i to posebno u segmentima korporativne informisanosti i povratnih informacija. Preporučuje se uvođenje redovnih edukacija za zaposlene o veštinama komunikacije, kao i razvijanje i primena etičkog kodeksa koji bi regulisao komunikaciju unutar organizacije. Simetrična i dvosmerna komunikacija može značajno unaprediti međuljudske odnose i doprineti poboljšanju interne komunikacije i zadovoljstva zaposlenih. Strategija vidljivosti, komunikacije i priznanja može unaprediti angažovanje osoblja i poboljšati radnu atmosferu. Takođe, treba raditi na smanjenju širenja glasina kroz promotivne aktivnosti koje će podržati pozitivnu i transparentnu komunikaciju. Ove mere mogu značajno doprineti poboljšanju radne atmosfere i povećanju zadovoljstva zaposlenih.

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Konflikt interesa

Autor je izjavio da nema konflikta interesa.

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job satisfaction and reducing the risk of burnout.

The main limitation of this study refers to the relatively small number of respondents, which may limit the generalization of findings. However, in spite of this limitation, the study provides a significant contribution, because it lays the foundations for future research in the field of internal communication. These results may serve as a starting point for developing and implementing strategy that will improve communication within organizations, thus contributing to improving the working atmosphere and the efficiency of teams.

Conclusion

The research showed that overall satisfaction with internal communication at the Health Center Šid is at a moderate level, with room for its improvement, especially in the areas of corporate awareness and feedback. The introduction of regular training for employees on communication skills is recommended, as well as the development and implementation of an ethical code that would regulate communication within the organization. Symmetrical and two-way communication can significantly improve interpersonal relationships and contribute to better internal communication and employee satisfaction. A strategy of visibility, communication, and recognition can enhance employee engagement and improve the work atmosphere. Additionally, efforts should be made to reduce the spread of rumors through promotional activities that will support positive and transparent communication. These measures can significantly contribute to improving the work atmosphere and increasing employee satisfaction.

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Competing interests

The author declared no competing interests.

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RANO OTKRIVANJE I EFIKASNO UPRAVLJANJE REFRAKCIONIM ANOMALIJAMA KOD DECE I ADOLESCENATA: PERSPEKTIVE, IZAZOVI I PREPREKE ZA INTERVENCIJU

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SAŽETAK

U okviru ovog preglednog rada analizirani su rezultati različitih istraživanja u oblasti ranog otkrivanja i efikasnog upravljanja refrakcionim anomalijama kod dece i adolscenata uzrasta 0-19 godina s ciljem smanjenja invaliditeta i unapređenja zdravlja organa čula vida. Refraktivne greške nastaju kada oko ne može pravilno da fokusira svetlost na mrežnjaču, što dovodi do zamućenog vida. Refraktivne greške uključuju miopiju (kratkovidost), hipermetropiju (dalekovidost) i astigmatizam. Globalno 448 miliona dece i adolescenata pati od refraktivnih anomalija. Većina njih može se lako ispraviti nošenjem naočara ili kontaktnih sočiva, a u nekim slučajevima i hiruskom intervenciom. Vizuelni poremećaji mogu imati ozbiljne i dugoročne posledice na fizički, mentalni i socijalni razvoj deteta. Efikasno upravljanje ovim problemima je ključno za očuvanje vida i poboljšanje obrazovnih i socijalnih aspekata života deteta.

Ključne reči: Refraktivne greške, prevencija, oftalmologija, skrining, deca.

Uvod

Na globalnom nivou, gubitak vida predstavlja ozbiljan zdravstveni problem koji se značajno odražava na kvalitet života. Prema podacima iz 2020. godine, procenjeno je da je 43,3 miliona ljudi bilo slepo, dok je 295 miliona imalo umereno do teško oštećenje vida, a 258 miliona blago oštećenje vida (1). Refraktivne greške nastaju kada postoji nesklad između dužine oka i njegove sposobnosti da pravilno prelama svetlost, što dovodi do zamućenog vida. Postoje četiri glavne vrste refraktivnih grešaka: kratkovidost (miopija), gde osoba jasno vidi objekte koji su blizu, ali su udaljeni objekti zamagljeni; dalekovidost (hipermetropija), kod koje su udaljeni objekti jasni, dok su bliži zamagljeni; astigmatizam, koji uzrokuje zamućenje vida na svim udaljenostima zbog nepravilnog oblika rožnjače ili sočiva; i presbiopija, povezana sa starenjem, koja otežava fokusiranje na bliske objekte i obično se javlja nakon 40. godine (1-11). Ako se ne koriguju, refraktivne greške su jedan od glavnih uzroka slepila širom sveta. Istraživanja pokazuju (2,3) da je nekorigovana refraktivna greška, posebno miopija (kratkovidost), najčešći uzrok oštećenja vida globalno, sa procenjenim brojem od 108 miliona pogođenih osoba u 2010. godini. Godišnji ekonomski teret nekorigovane miopije procenjuje se na 202 milijarde dolara (1,2).

Prema procenama Međunarodne agencije za prevenciju slepila (engl. *The International Agency for the Prevention of Blindness* - IAPB) (3), refraktivne greške predstavljaju jedan od ključnih zdravstvenih izazova kod dece i adolescenata uzrasta od 0 do 19 godina. Procenjuje se da oko 448 miliona dece i adolescenata pati od refraktivnih anomalija, od čega je 339,4 miliona pogođeno kratkovidošću (miopijom), dok 109,3 miliona ima

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REVIEW ARTICLE

EARLY DETECTION AND EFFECTIVE MANAGEMENT OF REFRACTIVE ANOMALIES IN CHILDREN AND ADOLESCENTS: PERSPECTIVES, CHALLENGES, AND BARRIERS TO INTERVENTION

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SUMMARY

This review paper analyzes the results of various studies on early detection and effective management of refractive errors in children and adolescents aged 0-19, with the aim of reducing disability and improving ocular health. Refractive errors occur when the eye cannot properly focus light onto the retina, resulting in blurred vision. These errors include myopia (nearsightedness), hypermetropia (farsightedness), and astigmatism. Globally, 448 million children and adolescents suffer from refractive errors. Most of these cases can be easily corrected with eyeglasses or contact lenses, and in some instances, surgical intervention. Visual impairments can have serious and long-lasting effects on the physical, mental, and social development of a child. Effective management of these issues is crucial for preserving vision and improving the educational and social aspects of child life.

Keywords: Refractive errors, prevention, ophthalmology, screening, children.

Introduction

Globally, vision loss is a serious health issue that significantly impacts quality of life. According to the data from 2020, it was estimated that 43.3 million people were blind, 295 million had moderate to severe visual impairment, and 258 million had mild visual impairment (1). Refractive errors occur when there is a mismatch between the length of the eye and its ability to properly focus light, which leads to blurred vision. There are four main types of refractive errors: myopia (nearsightedness), where a person can clearly see objects that are close, but distant objects appear blurred; hypermetropia (farsightedness), where distant objects are clear but nearby objects are blurred; astigmatism, which causes blurred vision at all distances due to an irregularly shaped cornea or lens; and presbyopia, age-related difficulty in focusing on close objects, usually occurring after the age of 40 (1-11). If left uncorrected, refractive errors are one of the leading causes of blindness worldwide. Research shows (2,3) that uncorrected refractive error, particularly myopia, is the most common cause of visual impairment globally, with an estimated number of 108 million affected people in 2010. The annual economic burden of uncorrected myopia is estimated at $202 billion (1,2).

According to the estimates of the International Agency for the Prevention of Blindness (IAPB) (3), refractive errors are one of the key health challenges in children and adolescents aged 0 to 19 years. It is estimated that around 448 million children and adolescents suffer from refractive anomalies, with 339.4 million affected by myopia, and 109.3 million having farsightedness (hypermetropia/hyperopia), both of which affect their vision. Additionally, the IAPB highlights that

dalekovidost (hipermetropiju/hiperopija) koja utiče na njihov vid. Pored toga, IAPB ističe da oko 90 miliona dece i adolescenata živi sa različitim stepenom gubitka vida. U ovu grupu spadaju 2 miliona dece koja su slepa, 30 miliona sa umerenim do teškim oštećenjem vida, i 58 miliona dece sa blagim gubitkom vida (3). Važno je napomenuti da se ove dve brojke ne mogu sabirati jer predstavljaju različite kategorije i ne postoji precizan podatak o preklapanju između dece koja imaju refraktivne anomalije i onih sa gubitkom vida usled drugih uzroka (3,4). Prevalencija gubitka vida kod dece varira značajno unutar i između zemalja i regiona, ali je opšte smanjenje slepila kod dece prisutno u svim regionima, posebno zahvaljujući smanjenju kornealnog slepila izazvanog nedostatkom vitamina A i malih boginja (5).

Prema preglednom radu koji je obuhvatio 40 različitih studija (6), prevalencija hiperopije (dalekovidosti) kod školske dece varira u zavisnosti od uzrasta: oko 8,4% kod šestogodišnjaka, opada na 2-3% kod dece u uzrastu od 9 do 14 godina, i približno 1% kod petnaestogodišnjaka. Ovo istraživanje takođe pokazuje da starost ima obrnuti odnos sa prevalencijom hiperopije, što znači da je učestalost ove refraktivne greške manja kako deca rastu. Hipermetropija je češća kod dece bele rase i onih koji žive u ruralnim područjima. Međutim, studije nisu identifikovale jasnu povezanost između hipermetropije i pola, prihoda porodice ili obrazovanja roditelja (6). Uzroci gubitka vida kod dece uključuju neispravljene refraktivne greške, kataraktu, retinopatiju nedonoščadi, urođene anomalije oka, ožiljke na rožnjači i cerebralne vizuelne poremećaje (7-9). Refraktivne greške, naročito miopija, predstavljaju vodeći i sve češći uzrok oštećenja vida i slepila kod dece (8,9). Prevalencija miopije kod dece i adolescenata brzo raste u mnogim delovima sveta. Ovaj nagli porast kratkovidosti sugeriše da, osim genetskih faktora, i okruženje igra važnu ulogu u razvoju oka i nastanku miopije (6,7). U 2020. godini, miopija je bila prisutna kod 60% dece u Aziji i 40% dece u Evropi (10,11). Procene ukazuju da je čak 40% slučajeva slepila kod dece moglo biti sprečeno ili adekvatno kontrolisano da su imali pristup pravovremenoj oftalmološkoj nezi (12). Oštećenje vida kod dece može ozbiljno uticati na obrazovne rezultate (3), doprineti niskom samopouzdanju (3) i smanjenju socijalno-ekonomskog potencijala u budućnosti (3). Prema izveštaju Komisije za globalno zdravlje očiju iz *The Lancet*-a, deca sa gubitkom vida u zemljama sa niskim i srednjim prihodima imaju do pet puta manju verovatnoću da budu uključena u formalno obrazovanje (7,13). *Malik* i saradnici su istakli da slepa deca imaju veću verovatnoću da umru tokom detinjstva u poređenju sa decom sa dobrim vidom, posebno u zemljama sa niskim prihodima (14).

Za poboljšanje zdravlja očiju kod dece i smanjenje invaliditeta, neophodne su sveobuhvatne usluge na svim nivoima zdravstvene zaštite (5). Prema izveštaju *Lancet* Komisije, nošenje naočara predstavlja jednu od najefikasnijih intervencija za očuvanje zdravlja očiju kod dece, jer može smanjiti verovatnoću ponavljanja razreda za 44% (7,12). Programi koji se fokusiraju na zdravlje vida u školama nude efikasan i isplativ model za preventivne mere i pravovremenu dijagnostiku refrakcionih grešaka kod školske dece (15-19).

Cilj ovog preglednog rada je da analizira rezultate različitih istraživanja u oblasti ranog otkrivanja i efikasnog upravljanja refrakcionim anomalijama kod dece i adolescenata u cilju smanjivanja invaliditeta i unapređenja zdravlja očiju kod dece.

Metode

U ovom preglednom radu izvršena je pretraga elektronske baze podataka PubMed koristeći sledeće ključne reči: „deca“, „refraktivne greške“, „prevencija“, „oftalmologija“ i „skrining“. Pretraga je obuhvatila radove objavljene u poslednjih deset godina. Analizirani su samo radovi koji su bili napisani na engleskom jeziku.

Rano otkrivanje (skrining) vizuelnih poremećaja

Vizuelni poremećaji mogu imati ozbiljne i dugoročne posledice na fizički, mentalni i socijalni razvoj deteta. Ovi poremećaji nastaju kada bolest oka ošteti vizuelni sistem, a klasifikuju se prema oštrini vida. U oftalmologiji, oštrina vida se meri pomoću različitih sistema. U Sjedinjenim Američkim Državama, najčešće korišćen sistem je „20/20”, koji označava standardnu vizuelnu oštrinu kojom osoba može videti objekat sa udaljenosti od 20 stopa, što je smatrano kao normalna oštrina vida (20). Sa druge strane, u mnogim drugim evropskim zemljama koristi se decimalni sistem za merenje oštrine vida (21-22). U ovom sistemu, oštrina vida se izražava decimalnim brojevima, gde je vrednost 1,0 (ili 100%) ekviva-

about 90 million children and adolescents live with varying degrees of vision loss. This group includes 2 million blind children, 30 million with moderate to severe visual impairment, and 58 million with mild vision loss (3). It is important to note that these figures cannot be summed, as they represent different categories, and there is no precise data on the overlap between children with refractive anomalies and those with vision loss due to other causes (3,4). The prevalence of vision loss in children varies significantly within and between countries and regions, but a general reduction in childhood blindness has been observed in all regions, particularly due to the decrease in corneal blindness caused by vitamin A deficiency and measles (5).

According to a review of 40 different studies (6), the prevalence of hyperopia (farsightedness) among school children varies by age: approximately 8.4% of six-year-olds, dropping to 2-3% in children aged 9 to 14, and around 1% in 15-year-olds. The study also indicates an inverse relationship between age and the prevalence of hyperopia, meaning that the incidence of this refractive error decreases as children grow. Hypermetropia is more common among white children and those living in rural areas. However, the studies did not identify a clear association between hypermetropia and gender, family income, or parental education (6). Causes of vision loss in children include uncorrected refractive errors, cataracts, retinopathy of prematurity, congenital eye anomalies, corneal scarring, and cerebral visual disorders (7-9). Refractive errors, particularly myopia, are the leading and increasingly common cause of visual impairment and blindness in children (8,9). The prevalence of myopia in children and adolescents is rising rapidly in many parts of the world. This rapid increase of myopia suggests that, in addition to genetic factors, the environment plays a significant role in eye development and the onset of myopia (6,7). In 2020, myopia was present in 60% of children in Asia and 40% of children in Europe (10,11). Estimates suggest that up to 40% of childhood blindness cases could have been prevented or adequately controlled if timely ophthalmological care had been accessible (12). Vision impairment in children can severely impact educational outcomes (3), contribute to low self-esteem (3), and reduce future socio-economic potential (3). According to the Lancet Global Commission report on Global Eye Health, children with vision loss in low- and middle-income countries are up to five times less likely to be enrolled in formal education (7,13). Malik and colleagues highlighted that blind children have a higher likelihood of dying during childhood compared to children with good vision, especially in low-income countries (14).

Comprehensive services at all levels of healthcare are essential for improving children's eye health and reducing disability (5). According to The Lancet Commission report, wearing glasses is one of the most effective interventions for preserving children's eye health, as it can reduce the likelihood of grade repetition by 44% (7,12). School-based vision health programs offer an efficient and cost-effective model for preventive measures and timely diagnosis of refractive errors in school children (15-19).

The aim of this review paper is to analyze the results of various studies on the early detection and effective management of refractive anomalies in children and adolescents, with the goal of reducing disability and improving eye health in children.

Methods

This review paper involved a search of the electronic database PubMed using the following keywords: “children,” “refractive errors,” “prevention,” “ophthalmology,” and “screening.” The search included studies published in the past ten years. Only articles written in English were analyzed.

Early detection (screening) of visual impairments

Visual impairments can have serious and long-term consequences for a child's physical, mental, and social development. These impairments occur when eye disease damages the visual system and are classified based on visual acuity. In ophthalmology, visual acuity is measured using different systems. In the United States, the most commonly used system is "20/20," which denotes standard visual acuity, where a person can see an object from a distance of 20 feet, which is considered normal visual acuity (20). In contrast, many other European countries use a decimal system for measuring visual acuity (21-22). In this system, visual acuity is expressed as

Tabela 1. Prilagođene metode skrininga vida kod dece i kriterijumi za dalju dijagnostiku

Metod	Indikacije za uput	Preporučena Starost
Test crvenog refleksa	Odsutan, beo, mutan, neproziran ili asimetričan refleks. Ovaj test pomaže u otkrivanju ozbiljnih problema kao što su katarakte ili retinoblastom.	Novorođenče – 6 meseci
Spoljni pregled	Prisutne strukturne abnormalnosti kao što je ptoza (opadanje kapka) koje mogu uticati na vid.	Novorođenče – 6 meseci
Pregled zenica	Nepravilan oblik, nejednaka veličina, loša ili neujednačena reakcija na svetlo.	Novorođenče – 6 meseci
Fiksacija i praćenje	Nemogućnost fiksacije (usmeravanje očiju ka objektu) i praćenje pokreta objekta.	Saradljivo dete ≥3 meseca
Refleks svetla sa rožnjače	Asimetričan ili pomeren refleks svetlosti može ukazivati na poremećaje u rožnjači ili drugim delovima oka.	Saradljivo dete ≥3 meseca
Instrumentalni skrining	Nemogućnost ispunjavanja kriterijuma skrininga može ukazivati na probleme sa vidom koji zahtevaju dodatnu evaluaciju.	Saradljivo dete ≥6 meseci
Cover test	Refiksacioni pokret nepokrivenog oka može ukazivati na probleme sa vidom kao što je strabizam (razrokost)	Saradljivo dete ≥6 meseci
Vid na daljinu (monokularno)	Lošija od 20/50 na bilo kojem oku ili razlika od 2 reda na optotipu između očiju može ukazivati na značajne probleme sa vidom koji zahtevaju dalje ispitivanje.	Saradljivo dete ≥6 meseci
Vid na daljinu (monokularno)	Lošija od 20/40 na bilo kojem oku ili razlika od 2 reda između očiju takođe može ukazivati na poteškoće koje treba dodatno ispitati.	Saradljivo dete ≥6 meseci

Izvor: Hagan JF, Shaw JS, Duncan PM, eds. 2017, Bright Futures: Guidelines for Health Supervision of Infants, Children and Adolescents. 4th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2017.)

NAPOMENA: Preporuke su zasnovane na konsenzusu stručnjaka. U slučaju da skrining ne daje konačne ili zadovoljavajuće rezultate, dete bi trebalo ponovo testirati u roku od šest meseci. Ako ni ponovljeno testiranje nije konačno ili se ne može sprovesti, preporučuje se upućivanje na sveobuhvatan oftalmološki pregled. Subjektivno testiranje vidne oštrine se preferira kod dece koja mogu pouzdano učestvovati, dok je instrumentalni skrining koristan za mlađu decu i decu sa razvojnim poteškoćama. Preferirani optotipovi su LEA Simboli, HOTV, i Sloan Slova.

lentna normalnoj oštrini vida. Ova metoda omogućava lakše poređenje i interpretaciju rezultata oštrine vida u evropskim standardima. Jedinice mere (20/400, 20/200, 20/40, 20/20) koriste se za kvantifikaciju oštrine vida i omogućavaju preciznu klasifikaciju stepena slabovidosti. Prema definiciji Svetske zdravstvene organizacije (22) slabovidost se definiše na osnovu intenziteta na:

a) Slabovidost visokog intenziteta: Vizuelna oštrina u najboljem oku je manja od 20/400. Ovo stanje se često smatra slepilom, jer osoba sa ovim stepenom oštećenja vida može videti samo velike predmete iz vrlo bliske udaljenosti.

b) Slabovidost srednjeg intenziteta: Vizuelna oštrina varira između 20/200 i 20/400. Osobe sa ovim stepenom slabovidosti mogu prepoznati oblike i boje, ali imaju značajne poteškoće u svakodnevnim aktivnostima i čitanju.

c) Slabovidost niskog intenziteta: Vizuelna oštrina je između 20/40 i 20/200. Osobe sa ovim stepenom slabovidosti obično mogu obavljati većinu svakodnevnih aktivnosti uz pomoć korektivnih pomagala, ali i dalje imaju poteškoće u vidu na daljinu i u vidu u uslovima slabog osvetljenja.

Iako se istraživanja često fokusiraju na stariju populaciju, podaci o prevalenciji i uzrocima slabovidosti kod dece su ograničeni i verovatno potcenjeni. Slabovidost i slepilo su različita stanja. Slabovidost je češće i često se može značajno poboljšati rehabilitacijom, dok slepilo zahteva specijalizovane metode prilagođavanja i obrazovanja. Deca sa slabovidostima različitih intenziteta suočavaju se sa izazovima u obrazovanju, socijalizaciji i svakodnevnim aktivnostima (23). Naočare i kontaktna sočiva predstavljaju osnovne metode za korekciju refraktivnih grešaka kao što su miopija, hipermetropija i astigmatizam (24). Ortokeratologija, koja koristi specijalizovana kontaktna sočiva koja se nose tokom noći, može pružiti privremeno poboljšanje vida tokom dana (25,26). U okviru reha-

Table 1. Adapted vision screening methods for children and criteria for further diagnosis

Method	Indications for referral	Recommended age
Red Reflex Test	Absence, white, cloudy, opaque, or asymmetric reflex. This test helps detect serious issues such as cataracts or retinoblastoma.	Newborn – 6 months
External Examination	Presence of structural abnormalities such as ptosis (drooping eyelid) that may affect vision.	Newborn – 6 months
Pupil Examination	Irregular shape, unequal size, poor or uneven reaction to light.	Newborn – 6 months
Fixation and Tracking	Inability to fixate (direct eyes towards an object) and track object movements.	Cooperative child ≥3 months
Corneal Light Reflex	Asymmetric or displaced light reflex may indicate corneal or other eye disorders.	Cooperative child ≥3 months
Instrumental Screening	Failure to meet screening criteria may indicate vision problems requiring further evaluation.	Cooperative child ≥6 months
Cover Test	Refixation movement of the uncovered eye may indicate vision problems such as strabismus (squint).	Cooperative child ≥6 months
Distance Vision (Monocular)	Worse than 20/50 in either eye or a 2-line difference on the optotype between eyes may indicate significant vision problems requiring further investigation.	Cooperative child ≥6 months
Distance Vision (Monocular)	Worse than 20/40 in either eye or a 2-line difference between eyes may also indicate issues that need further examination.	Cooperative child ≥6 months

Source: Hagan JF, Shaw JS, Duncan PM, eds. 2017, Bright Futures: Guidelines for Health Supervision of Infants, Children and Adolescents. 4th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2017.)
NOTE: Recommendations are based on expert consensus. If screening does not yield conclusive or satisfactory results, the child should be retested within six months. If repeated testing is still inconclusive or not feasible, a comprehensive ophthalmological examination is recommended. Subjective visual acuity testing is preferred for children who can reliably participate, while instrumental screening is useful for younger children and those with developmental difficulties. Preferred optotypes are LEA Symbols, HOTV, and Sloan Letters.

decimal numbers, where a value of 1.0 (or 100%) is equivalent to normal visual acuity. This method allows for easier comparison and interpretation of visual acuity results according to European standards. Units of measure (20/400, 20/200, 20/40, 20/20) are used to quantify visual acuity and allow for precise classification of degrees of visual impairment. According to the World Health Organization (22), visual impairment is defined based on intensity as follows: a) High-intensity visual impairment: Visual acuity in the better eye is less than 20/400. This condition is often considered blindness, as individuals with this level of vision loss can only see large objects from a very close distance. b) Medium-intensity visual impairment: Visual acuity ranges between 20/200 and 20/400. Individuals with this degree of visual impairment can recognize shapes and colors but have significant difficulties with daily activities and reading. c) Low-intensity visual impairment: Visual acuity is between 20/40 and 20/200. Individuals with this level of visual impairment can usually perform most daily activities with the aid of corrective devices but still have difficulties with distance vision and vision in low-light conditions.

Although research often focuses on older populations, data on the prevalence and causes of visual impairment in children are limited and likely underestimated. Visual impairment and blindness are distinct conditions. Visual impairment is more common and can often be significantly improved with rehabilitation, while blindness requires specialized adaptation and education methods. Children with visual impairments of varying degrees face challenges in education, socialization, and daily activities (23). Eyeglasses and contact lenses are fundamental methods for correcting refractive errors such as myopia, hypermetropia, and astigmatism (24). Orthokeratology, which uses specialized contact lenses worn overnight, can provide temporary vision improvement during the day (25,26). As part of rehabilitation, visual

bilitacije, vizuelni programi fokusirani na vežbe za poboljšanje vizuelnih vešina i tehnike za prilagođavanje svakodnevnim aktivnostima mogu značajno unaprediti preostale vizuelne sposobnosti (27). Pomoćne tehnologije, kao što su magnifikatori i specijalizovani računarski programi, takođe igraju važnu ulogu u obavljanju svakodnevnih zadataka i poboljšanju vizuelnog iskustva (28,29).

S druge strane, slepilo zahteva posebne strategije za prilagođavanje koje uključuju obrazovanje i pomoćne tehnologije (30,31). Obrazovni programi specijalizovani za decu sa slepilom često uključuju učenje brajevog pisma, tehnike orijentacije i mobilnosti, kao i veštine za samostalno obavljanje svakodnevnih aktivnosti. Individualizovani obrazovni planovi mogu pomoći u zadovoljenju specifičnih potreba deteta, omogućavajući mu da maksimalno iskoristi svoje potencijale. U rehabilitaciji vida kod slabovide dece, tehnologija igra ključnu ulogu u unapređenju percepcije i funkcionalnih veština. Sistem *TechArm* (31) je razvijen kao inovativno tehnološko sredstvo za procenu i rehabilitaciju vizuelnih sposobnosti. Ovaj sistem pruža kvantitativnu procenu razvoja perceptivnih i funkcionalnih veština, koje su obično zavisne od vida, i integriše se u prilagođene programe obuke. *TechArm* omogućava jednosenzornu i multisenzornu stimulaciju, pomažući slabovidim osobama da treniraju sposobnost pravilnog interpretiranja ne-vizuelnih signala iz okoline. Posebno je prilagođen za veoma malu decu, kada je potencijal za rehabilitaciju maksimalan. Sistem je testiran na deci sa različitim stepenima oštećenja vida i pokazao je da je multisenzorna stimulacija, posebno audio-taktička, korisna kada je perceptivna preciznost niska (31).

Skrining vida kod dece predstavlja ključnu komponentu zdravstvenih programa, sa ciljem otkrivanja i tretiranja poremećaja kao što je ambliopija. Deca sa binokularnim refrakcionim anomalijama često će sama prijaviti problem sa vidom ili će biti identifikovana kroz ciljani nadzor unutar specifičnih zdravstvenih programa, kao što su pregledi novorođenčadi i dece. Nasuprot tome, deca sa jednostranim smanjenjem vida, posebno kada je prisutno od ranog uzrasta, često nisu svesna problema, što ambliopiju čini skrivenim rizikom koji može ostati neotkriven bez specijalizovanog skrininga (32). Ambliopija nosi značajan rizik od slepila u kasnijem životu, ukoliko dođe do gubitka vida na zdravom oku (33,34). Zbog toga je od suštinskog značaja da se ovakvi poremećaji otkriju u ranoj fazi kako bi se omogućila pravovremena intervencija. Osnovni principi populacionog skrininga nalažu da se ovaj proces sprovodi samo za poremećaje za koje postoje pouzdani testovi i efikasni tretmani. Nedavna istraživanja pokazuju da skrining vida dece i adolescenata kao deo populacionih zdravstvenih programa u zemljama sa visokim i srednjim prihodima, igra ključnu ulogu u smanjenju tereta ambliopije na javno zdravlje (21-27).

Ipak, pristupi skriningu variraju od zemlje do zemlje, pri čemu se neki programi fokusiraju na identifikaciju ambliopije, dok drugi ciljaju na otkrivanje „ambliogenih“ faktora rizika (32-43). U različitim pristupima skriningu, ambliogeni faktori rizika koji se uzimaju u obzir mogu uključivati nepravilnosti u refrakcionim greškama, strabizam, prisusvo kongenitalne katarakte, poteškoće u percepciji dubine i kontrasta, probleme u praćenju pokreta i koordinaciji očiju. Jedan od ključnih faktora za uspeh skrining programa je njegova prihvatljivost među roditeljima i starateljima. Visoke stope učešća u studijama ukazuju na to da je skrining proces za identifikaciju ambliopije generalno dobro prihvaćen. Međutim, svaki test nosi rizik od lažno pozitivnih ili lažno negativnih rezultata. Kada se skrining vida sprovodi u ranom uzrastu, može doći do većeg broja lažnih upućivanja, što znači da test može pogrešno sugerisati potrebu za dodatnim pregledima. Lažna upućivanja se odnose na situacije kada skrining test daje rezultate koji sugerišu da dete ima problem, iako nema. Ova situacija može nastati zbog nedostataka u samom testu, prirodnog razvoja vida kod dece koji se može razlikovati od očekivanog, ili grešaka tokom testa. Kao posledica, test može nepotrebno sugerisati dodatne preglede i izazvati brigu kod roditelja, iako dete zapravo nema stvarni problem sa vidom. Ovo je primećeno kod dece koja su sa tri godine bila dijagnostikovana sa ambliopijom, ali je njihov vid značajno poboljšan do pete godine. (32). Iako neuroplastičnost, sposobnost mozga da se prilagođava i menja tokom života, traje sve do odraslog doba, ključno je da se intervencije kod dece sa ambliopijom sprovedu pre nego što dete navrši 6-7 godina. Istraživanja pokazuju da rano otkrivanje i lečenje mogu značajno poboljšati vizuelni razvoj, naročito kod dece sa težim oblicima ambliopije (40). Pravovremena intervencija može omogućiti deci da dostignu svoj puni vizuelni potencijal i značajno poboljša njihovu vizuelnu funkciju.

programs focused on exercises to enhance visual skills and techniques for adapting to daily activities can significantly improve remaining visual abilities (27). Assistive technologies, such as magnifiers and specialized computer programs, also play a crucial role in performing daily tasks and enhancing the visual experience (28,29).

On the other hand, blindness requires specialized adaptation strategies that include education and assistive technologies (30,31). Educational programs tailored for blind children often involve learning Braille, orientation and mobility techniques, and skills for independently performing daily activities. Individualized educational plans can help address the specific needs of the child, allowing them to maximize their potential. In visual rehabilitation for visually impaired children, technology plays a crucial role in enhancing perception and functional skills. The TechArm system (31) has been developed as an innovative technological tool for assessing and rehabilitating visual abilities. This system provides a quantitative assessment of the development of perceptual and functional skills, which are usually dependent on vision, and integrates into customized training programs. TechArm enables both unisensory and multisensory stimulation, helping visually impaired individuals train their ability to interpret non-visual environmental signals. It is especially suited for very young children, when the potential for rehabilitation is highest. The system has been tested on children with varying degrees of vision impairment and has shown that multisensory stimulation, particularly audio-tactile, is beneficial when perceptual accuracy is low (31).

Vision screening in children is a crucial component of health programs, aimed at detecting and treating disorders such as amblyopia. Children with binocular refractive anomalies will often report vision problems themselves or be identified through targeted monitoring within specific health programs, such as newborn and child screenings. In contrast, children with unilateral vision loss, especially when present from an early age, are often unaware of the problem, making amblyopia a hidden risk that may remain undetected without specialized screening (32). Amblyopia carries a significant risk of blindness later in life if vision loss occurs in the healthy eye (33,34). Therefore, it is essential to detect such disorders at an early stage to enable timely intervention. The basic principles of population screening require that this process be implemented only for disorders for which reliable tests and effective treatments exist. Recent studies indicate that vision screening for children and adolescents as part of population health programs in high- and middle-income countries plays a key role in reducing the burden of amblyopia on public health (21-27).

However, screening approaches vary from country to country, with some programs focusing on identifying amblyopia, while others target the detection of "amblyogenic" risk factors (32-43). In different screening approaches, amblyogenic risk factors, which are taken into consideration, may include refractive errors, strabismus, presence of congenital cataracts, difficulties in depth and contrast perception, and problems with tracking movements and eye coordination. One key factor for the success of a screening program is its acceptability among parents and caregivers. High participation rates in studies suggest that the screening process for identifying amblyopia is generally well-received. However, every test carries the risk of false-positive or false-negative results. When vision screening is conducted at an early age, there may be a higher number of false referrals, meaning the test may incorrectly suggest the need for further evaluations. False referrals occur when a screening test yields results indicating that a child has a problem, even though they do not. This situation may arise due to deficiencies in the test itself, natural variations in visual development among children that may differ from expectations, or errors during the test. As a result, the test may unnecessarily suggest additional evaluations and cause undue concern for parents, even if the child does not actually have a vision problem. This has been observed in children diagnosed with amblyopia at the age of three, whose vision significantly improved by the age of five (32). Although neuroplasticity, the brain's ability to adapt and change throughout life, continues into adulthood, it is crucial that interventions for amblyopia in children be carried out before the child reaches 6-7 years of age. Research shows that early detection and treatment can significantly improve visual development, particularly in children with severe forms of amblyopia (40). Timely intervention can enable children to reach their full visual potential and significantly enhance their visual function.

U primarnim zdravstvenim ustanovama, školama i vrtićima, skrining vida se najčešće obavlja procenom oštrine vida, što je najbolja pojedinačna mera zdravlja očiju kod dece. Uprkos tome, deca koja ne prođu skrining oštrine vida obavljen u ovim ustanovama možda zapravo nemaju prave deficite u oštrini vida kada se procenjuju u oftalmološkoj klinici (28). Ova varijabilnost može biti rezultat više faktora, uključujući nedosledne tehnike ispitivača, uslove okoline (osvetljenje) i faktore vezane za pacijente (saradnja i razumevanje). Aktuelne smernice Američke akademije za pedijatriju (AAP) (44), ažurirane 2016. godine, navode da skrining oštrine vida „zahteva da dete tačno odgovori na većinu optotipova prisutnih na kritičnoj liniji". „Kritična linija" označava najmanje detalje koje dete treba da bude sposobno da vidi kako bi se smatralo da ima normalnu oštrinu vida za svoj uzrast. Jedinice mere predstavljaju sposobnost oka da razlikuje detalje na određenim udaljenostima i obično se izražavaju kao odnosi, kao što su 20/50, 20/40, i 20/32. Prva brojka označava udaljenost na kojoj je osoba testirana (u ovom slučaju 20 stopa). Druga brojka označava udaljenost na kojoj bi osoba sa normalnom oštrinom vida mogla da vidi iste detalje. Prema smernicama AAP, očekivana oštrina vida kod dece je 20/50 za uzrast od 36 do 47 meseci, 20/40 za uzrast od 48 do 59 meseci, i 20/32 za uzrast od 60 meseci i više. U publikaciji Američkog udruženja za pedijatrijsku oftalmologiju i strabizam (AAPOS) iz 2013. godine (45) sugerisano je da otkrivanje ambliopije i smanjene oštrine vida koristeći optotip-zasnovani skrining treba da bude zasnovano na monokularnoj oštrini vida manjoj od 20/30 i da smernice za procenu nerefektivnih instrumenata za skrining vida treba da uključe analizu senzitivnosti za otkrivanje monokularne oštrine vida manje od 20/30, razliku od tri linije u intraokularnoj oštrini vida, i prisutni strabizam.

Više metoda se koristi u proceni oštrine vida kod dece. Tradicionalno, papirne tablice sa raznim optotipovima (Lea slike, obrnut „E", *Snellen*-ova slova) korišćene su za procenu oštrine vida na daljinu. Nije lako naterati malu decu da razumeju sadržaj testova za oštrinu vida. Na primer, može biti teško objasniti im ciljeve testova oštrine vida na Landoltovom prstenu ili *Snellen*-ovoj tablici. Postoje tablice za ispitivanje oštrine vida kod dece starosti 3-6 godina, koje koriste jednostavne simbole kao vizuelne ciljeve, ali potreba da se razume sam vizuelni cilj nije se promenila (28,32,33,35). Na primer, prilikom korišćenja slike kao vizuelnog cilja, deca moraju da razumeju šta sama slika predstavlja (npr. konj, automobil).

Nedavno su se pojavile alternativne metode koje bi mogle smanjiti varijabilnost u proceni oštrine vida. *Peek Acuity* je nova aplikacija za pametne telefone za procenu oštrine vida, koja koristi sistem obrnutog „E" sa dodatnim linijama koje omogućavaju skrining kod neverbalnih pacijenata koji ne razumeju engleski jezik (46). Iako je procena oštrine vida uz pomoć *Peek Acuity* aplikacije pokazala visoku korelaciju sa *Snellen*-ovim pregledom u odrasloj populaciji u Keniji (28), malo studija je procenilo njenu upotrebu kod dece. Sve prethodne studije koje su procenjivale *Peek Acuity* aplikacije kod dece sprovedene su u zemljama u razvoju među školskom decom i koristile su prag oštrine vida od 20/40 što označava graničnu vrednost ispod koje je potrebno dodatno ispitivanje (28,40). Ključni rezultati pokazali su da je procena oštrine vida pomoću *Peek Acuity* aplikacije u velikoj meri bila u skladu sa rezultatima dobijenim standardnim metodama, posebno kod dece starije od 5 godina. Kod predškolske dece (uzrasta 3 do 5 godina), aplikacija je pokazala visoku senzitivnost, ali su deca u ovoj grupi bila podložnija zamoru tokom pregleda (28).

U zemljama sa niskim i srednjim prihodima, najčešći uzroci oštećenja vida su poremećaji mrežnjače, glaukom kornealni ulkus izazvani nedostatkom vitamina A, i katarakta. U razvijenim zemljama, neurološki poremećaji su glavni uzrok oštećenja vida. Zdravstvene inicijative poput VISION 2020 (42) teže eliminaciji i prevenciji slepila kroz unapređenje oftalmoloških usluga i prevenciju. Studija sprovedena u Tuzli, Bosna i Hercegovina (36), obuhvatila je 7415 dece uzrasta od 4 do 15 godina u periodu od 2015. do 2019. godine. Rezultati su pokazali da je 145 dece imalo refraktivne greške, pri čemu je astigmatizam bio najčešća anomalija, prisutan u 52,4% slučajeva. Ova studija ističe potrebu za implementacijom programa skrininga vida u školama kako bi se omogućilo ranije otkrivanje i lečenje problema sa vidom. S druge strane, istraživanje iz Istočne i Jugoistočne Azije (29) naglašava ozbiljnost porasta miopije i njenih patoloških posledica, kao što su miopska makulopatija i optička neuropatija, koje su među najčešćim uzrocima nepovratnog slepila. Strategije za smanjenje prevalencije miopije uključuju povećanje vremena provedenog na ot-

In primary healthcare institutions, schools, and kindergartens, vision screening is most commonly performed by assessing visual acuity, which is the best single measure of eye health in children. Despite this, children who do not pass vision acuity screenings conducted in these institutions may actually have no true deficits in visual acuity when assessed in an ophthalmological clinic (28). This variability may result from several factors, including inconsistent examiner techniques, environmental conditions (lighting), and patient-related factors (cooperation and understanding). Current guidelines from the American Academy of Pediatrics (AAP) (44), which were updated in 2016, state that visual acuity screening "requires the child to correctly identify most optotypes on the critical line." The "critical line" represents the smallest detail a child should be able to see to be considered to have normal visual acuity for their age. Measurement units represent the eye's ability to distinguish details at specific distances and are usually expressed as ratios, such as 20/50, 20/40, and 20/32. The first number indicates the distance at which the person is tested (in this case, 20 feet). The second number indicates the distance at which a person with normal visual acuity would be able to see the same details. According to AAP guidelines, expected visual acuity in children is 20/50 for ages 36 to 47 months, 20/40 for ages 48 to 59 months, and 20/32 for ages 60 months and older. In a publication of the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) in 2013 (45), it was suggested that the detection of amblyopia and reduced visual acuity using optotype-based screening should be based on monocular visual acuity less than 20/30 and that guidelines for evaluating non-refractive vision screening instruments should include sensitivity analysis for detecting monocular visual acuity less than 20/30, a three-line difference in intraocular visual acuity, and the presence of strabismus.

Several methods are used to assess visual acuity in children. Traditionally, paper charts with various optotypes (Lea symbols, the reversed "E", Snellen letters) have been used to measure distance visual acuity. It is not easy to make young children understand the content of visual acuity tests. For example, it can be difficult to explain the purpose of visual acuity tests using Landolt rings or Snellen charts. There are charts designed for testing visual acuity in children aged 3-6 years that use simple symbols as visual targets, but the need for the child to understand the visual target itself has not changed (28,32,33,35). For example, when using pictures as visual targets, children must understand what the picture represents (e.g., a horse, a car).

Recently, alternative methods have emerged that could reduce variability in visual acuity assessment. Peek Acuity is a new smartphone application for assessing visual acuity that uses a reversed "E" system with additional lines, allowing screening of non-verbal patients who do not understand English (46). Although the assessment of visual acuity using the Peek Acuity app has shown a high correlation with Snellen screening in the adult population in Kenya (28), few studies have evaluated its use in children. All previous studies evaluating the Peek Acuity app in children were conducted in developing countries among school-aged children and used a visual acuity threshold of 20/40, which indicates a borderline value below which further examination is needed (28,40). Key findings showed that the Peek Acuity app's visual acuity assessment was largely consistent with results obtained from standard methods, particularly in children older than 5 years. In preschool children (aged 3 to 5 years), the app demonstrated high sensitivity, but children in this group were more prone to fatigue during the examination (28).

In low- and middle-income countries, the most common causes of visual impairment are retinal disorders, glaucoma, corneal ulcers caused by vitamin A deficiency, and cataracts. In developed countries, neurological disorders are the leading cause of visual impairment. Health initiatives such as VISION 2020 (42) aim to eliminate and prevent blindness through the enhancement of ophthalmological services and prevention efforts. A study conducted in Tuzla, Bosnia and Herzegovina (36), covered 7,415 children aged 4 to 15 years from 2015 to 2019. The results showed that 145 children had refractive errors, with astigmatism being the most common anomaly, present in 52.4% of cases. This study highlights the need for implementing vision screening programs in schools to enable earlier detection and treatment of vision problems. On the other hand, research from East and Southeast Asia (29) underscores the severity of the increase in myopia and its pathological consequences, such as myopic maculopathy

vorenom i korišćenje niskodoznih atropinskih kapi, multifokalnih sočiva i ortokeratologije. Istraživanje dugoročnih promena u miopiji kod školske dece u Kini (37), koja je obuhvatila 773 pacijenta, pokazuje da je prosečan stepen miopije značajno porastao tokom adolescencije, sa prosečnim sfernim ekvivalentom koji se povećao sa -1,92 dioptrije na -6,05 dioptrije do 16. godine. Deca kod kojih se miopija pojavila pre 10. godine imala su visok rizik za razvijanje visoke miopije u kasnijim godinama, što naglašava važnost ranog otkrivanja i praćenja ove refraktivne greške. Udaljene australijske regije sa ograničenim oftalmološkim uslugama pokazuju visoku prevalenciju neotkrivenih problema sa vidom, uključujući značajne refraktivne poremećaje i poremećaje binokularnog vida (38).

Pregled smernica za oftalmološke preglede dece i adolescenata

Smernice koje su razvile stručne organizacije, kao što su Američka akademija za oftalmologiju (AAO) i Američka akademija za pedijatriju (AAP), pružaju detaljna uputstva za oftalmološke preglede kod dece, uz poseban fokus na rizične grupe, kao što su prevremeno rođena deca ili deca sa porodičnom istorijom očnih bolesti (27,38,39). Ove smernice predstavljaju osnovu za preventivne i korektivne mere koje imaju za cilj očuvanje i unapređenje vizuelnog zdravlja od najranijeg uzrasta. Preporuke za oftalmološke preglede počinju od trenutka rođenja. Sva prevremeno rođena deca, posebno ona mlađa od 35 nedelja gestacije ili sa telesnom težinom manjom od 1500 grama, zahtevaju posebnu pažnju. Ova deca, zbog nezrelosti vizuelnog sistema, predstavljaju rizičnu grupu za razvoj različitih patoloških promena na očima, uključujući i ambliopiju. Takođe, deca rođena u terminu, kod kojih se ne može detektovati crveni refleks, zahtevaju ranu oftalmološku procenu. Sa šest meseci starosti, preporučuje se pregled za decu kod koje je prisutna razrokost, dok sa napunjenih godinu dana, posebna pažnja treba da se posveti deci sa porodičnom istorijom ozbiljnih očnih bolesti, slabovidosti ili razrokosti. Deca čiji roditelji imaju izražene refraktivne greške, kao što su velika kratkovidost ili dalekovidost, ili razlika u dioptriji od 1D između očiju, takođe spadaju u rizičnu grupu i zahtevaju pažljivo praćenje. Između druge i četvrte godine života, svi mališani treba da prođu kroz oftalmološki pregled kako bi se identifikovali eventualni problemi sa vidom pre polaska u školu, kada vizuelna funkcija postaje kritična za razvoj i učenje. U kasnijem uzrastu, dalji pregledi se planiraju u skladu sa prethodnim nalazima, u dogovoru sa oftalmologom.

Ambliopija, kao jedan od najčešćih problema u dečijem uzrastu, ispunjava kriterijume Svetske zdravstvene organizacije za bolesti koje zahtevaju skrining. Ambliopija je zdravstveni problem od velike važnosti jer postoje prihvaćeni tretmani koji mogu sprečiti trajni gubitak vida, ukoliko se otkrije na vreme. Prepoznatljivost latentnog ili ranog simptomatskog stadijuma ove bolesti, kao i dostupnost testova za njeno rano otkrivanje, čine je pogodnom za redovni skrining. Američka radna grupa za preventivne usluge (USPSTF) preporučuje skrining vida za svu decu uzrasta od 3 do 5 godina, bar jednom, kako bi se otkrila ambliopija ili faktori rizika za njeno nastajanje (refraktivnih grešaka, kongenitalne katarakte, ptosisa, retiopatije, genetskih faktora). Testiranje vida sa pojedinačnim optotipima može dovesti do precenjenog rezultata oštrine vida kod dece sa ambliopijom. Zato se tačnija procena monokularne oštrine vida postiže korišćenjem niza optotipova (12,21,22,32,47,48). Optotipovi mogu biti u obliku slova, brojeva ili simbola poput "C" i "E". Ovi simboli su postavljeni na tabelama različitih veličina. Na tabeli, simboli su različitih veličina, koje postaju sve manje kako se krećemo prema dnu tabele. Manji simboli predstavljaju bolje oštrinu vida, dok veći simboli predstavljaju lošiju oštrinu. Izbor i raspored optotipova na tablici za određivanje vizuelne oštrine imaju značajan uticaj na rezultate merenja. Svaka linija ili naredni red znakova, simbola ili slova na optotipu označava određeni nivo vidne oštrine, gde je svaka naredna linija sitnija i predstavlja viši nivo oštrine vida. Standardizovani optotipovi (48), kao što su LEA simboli (jednostavni piktogrami, krst, kvadrat, polukrug, krug, prilagođeni mlađoj deci i deci koja ne znaju da čitaju) (HOTV (specifična slova visokog kontrasta odabrana zbog svoje prepoznatljivosti i jednostavnosti H, O, T, i V, što pomaže u preciznom merenju oštrine vida kod dece) i Sloan slova (standardizovana slova koja se koriste za precizno merenje oštrine vida kod svih uzrasta) pružaju validne i pouzdane rezultate, čime se osigurava tačnost dijagnostičkog procesa.

Tehnike skrininga koje se baziraju na instrumentima, kao što su fotoskrining i autorefrakcija, posebno su korisne za detekciju faktora rizika za ambliopiju kod dece uzrasta od 1 do 5 godina,

and optical neuropathy, which are among the most common causes of irreversible blindness. Strategies for reducing the prevalence of myopia include increasing time spent outdoors and using low-dose atropine drops, multifocal lenses, and orthokeratology. A study on long-term changes in myopia among school children in China (37), which included 773 patients, showed that the average degree of myopia significantly increased during adolescence, with the average spherical equivalent rising from -1.92 diopters to -6.05 diopters by age 16. Children who developed myopia before age 10 had a high risk of developing high myopia in later years, emphasizing the importance of early detection and monitoring of this refractive error. Remote Australian regions with limited ophthalmological services show a high prevalence of undetected vision problems, including significant refractive errors and binocular vision disorders (38).

Review of guidelines for pediatric and adolescent ophthalmological examinations

Guidelines developed by professional organizations such as the American Academy of Ophthalmology (AAO) and the American Academy of Pediatrics (AAP) provide detailed instructions for ophthalmological examinations in children, with a special focus on high-risk groups such as premature infants or those with a family history of eye diseases (27,38,39). These guidelines form the basis for preventive and corrective measures aimed at preserving and improving visual health from the earliest age. Recommendations for ophthalmological examinations begin at birth. All premature infants, especially those born before 35 weeks of gestation or weighing less than 1500 grams, require special attention. Due to the immaturity of their visual systems, these infants are at risk for developing various pathological changes in the eyes, including amblyopia. Additionally, full-term infants who do not exhibit a red reflex also require early ophthalmological assessment. At six months of age, screening is recommended for children with strabismus, and at the age of one year, special attention should be given to children with a family history of serious eye diseases, visual impairment, or strabismus. Children whose parents have significant refractive errors, such as high myopia or hyperopia, or a difference in diopters of 1D between the eyes, are also considered at risk and require careful monitoring. Between the ages of two and four years, all children should undergo an ophthalmological examination to identify any vision problems before starting school, as visual function becomes critical for development and learning. In later years, further examinations should be planned based on previous findings, in consultation with an ophthalmologist.

Amblyopia, as one of the most common issues in childhood, meets the criteria set by the World Health Organization for diseases that require screening. Amblyopia is a significant health issue because accepted treatments can prevent permanent vision loss if detected early. The recognizability of the latent or early symptomatic stage of this condition, along with the availability of tests for early detection, makes it suitable for regular screening. The U.S. Preventive Services Task Force (USPSTF) recommends vision screening for all children aged 3 to 5 years at least once, to detect amblyopia or risk factors for its development (refractive errors, congenital cataracts, ptosis, retinopathy, genetic factors). Visual acuity testing with single optotypes may lead to an overestimated visual acuity result in children with amblyopia. Therefore, a more accurate assessment of monocular visual acuity is achieved using a series of optotypes (12,21,22,32,47,48). Optotypes may be in the form of letters, numbers, or symbols like "C" and "E". These symbols are presented on charts of varying sizes. On the chart, symbols decrease in size as you move down the chart. Smaller symbols represent better visual acuity, while larger symbols represent poorer visual acuity. The choice and arrangement of optotypes on the chart significantly impact measurement results. Each line or subsequent row of characters, symbols, or letters on the optotype represents a specific level of visual acuity, with each following line being finer and representing a higher level of visual acuity. Standardized optotypes (48), such as LEA symbols (simple pictograms like crosses, squares, semicircles, circles, tailored for younger children and those who cannot read), HOTV letters (high-contrast specific letters chosen for their recognizability and simplicity H, O, T, and V, which help in precise measurement of visual acuity in children), and Sloan letters (standardized letters used for precise visual acuity measurement across all ages) provide valid and reliable results, ensuring accuracy in the diagnostic process.

što je kritičan period za razvoj vizuelnog sistema (Tabela 1). Ove metode su takođe primenljive i kod starije dece koja nisu u mogućnosti da učestvuju u standardnom skriningu zasnovanom na optotipovima, kao i kod dece sa razvojnim poteškoćama. Skrining zasnovan na instrumentima pokazao je visoku efikasnost u detekciji faktora rizika za ambliopiju i kod ove populacije. Skrining vida treba da bude redovan deo zdravstvene zaštite dece, pri čemu elementi skrininga variraju u zavisnosti od uzrasta i nivoa saradnje deteta, kako bi se na vreme identifikovali i lečili problemi sa vidom koji mogu imati dugoročne posledice na detetov razvoj i kvalitet života.

Zaključak

Rani vizuelni problemi mogu imati dugotrajne posledice po dečji razvoj, zbog čega je neophodno uspostaviti standardizovane protokole pregleda. Rani skrining može pomoći u identifikaciji problema poput ambliopije i refraktivnih grešaka, koje mogu imati dugoročne posledice razvoj dece i aolescenata. Uvođenje smernica razvijenih od strane stručnih organizacija, poput Američke akademije za oftalmologiju i Američke akademije za pedijatriju, pruža okvir za optimalnu pedijatrijsku oftalmološku praksu i može značajno doprineti smanjenju prevalencije ovih problema. Skrining prilagođen uzrastu deteta, od novorođenčadi do starije dece, a posebno je važan u uzrastu od 6 meseci do 5 godina, kada se dečji vid intenzivno razvija, osigurava ranu detekciju problema, što omogućava pravovremeno intervenciono lečenje i smanjenje dugoročnih posledica na razvoj. Pravovremena implementacija ovih skrininga ne samo da poboljšava vizuelno zdravlje, već pozitivno utiče na opšti razvoj i kvalitet života dece. Iako je napredak postignut, neophodno je nastaviti sa istraživanjima i edukacijom, kako bi se osigurali najbolji mogući ishodi za najmlađu populaciju.

Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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Instrument-based screening techniques, such as photoscreening and autorefractors, are especially useful for detecting risk factors for amblyopia in children aged 1 to 5 years, which is a critical period for visual system development (Table 1). These methods are also applicable to older children who cannot participate in standard optotype-based screening, as well as children with developmental disabilities. Instrument-based screening has shown high efficacy in detecting risk factors for amblyopia in this population. Vision screening should be a regular part of children's health care, with screening elements varying based on age and the child's level of cooperation, so as to identify and address vision problems that may have long-term effects on the child's development and quality of life.

Conclusion

Early visual problems can have long-lasting effects on child development, due to which the establishment of standardized screening protocols is essential. Early screening can help identify issues such as amblyopia and refractive errors, which can have long-term consequences on the development of children and adolescents. Implementing guidelines developed by professional organizations, such as the American Academy of Ophthalmology and the American Academy of Pediatrics, provides a framework for optimal pediatric ophthalmological practice and can significantly contribute to reducing the prevalence of these issues. Age-appropriate screening, from infancy to older children, especially between 6 months and 5 years of age when visual development is intensive, ensures early detection of problems, allowing timely intervention and reduction of long-term developmental impacts. Timely implementation of these screenings not only improves visual health but also positively affects overall child development and their quality of life. Although progress has been made, continued research and education are necessary to ensure the best possible outcomes for the youngest population.

Competing interests

The authors declared no competing interests.

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SPECIFIČNOSTI I IZAZOVI U ISHRANI ADOLESCENATA

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SAŽETAK

Cilj ovog preglednog rada je da analizira specifičnosti ishrane adolescenata. Podaci su prikupljenji na osnovu pretraživanja sledećih baza podataka: PubMed, SCOPUS i Google scholar. Loše navike u ishrani adolescenata mogu dovesti do pojave zdravstvenih problema kao što su odloženo polno sazrevanje, osteoporoza, smanjenje u konačnoj telesnoj visini, hiperlipidemija, anemija, gojaznost, anoreksija, bulimija, karijes, a uravnotežena ishrana može da prevenira nastanak dugoročnih zdravstvenih problema kao što su karcinomi, ateroskleroza, moždani udar, osteoporoza,dijabetes, hipertenzija i dr. Procenjuje se da će između 25% i 58% adolescenata koji imaju prekomernu telesnu težinu postati odrasle osobe s prekomernom težinom, a između 24% i 90% gojaznih adolescenata će postati gojazne odrasle osobe. U brojnim radovima uočena je značajna povezanost između preskakanja doručka i veće učestalosti javljanja gojaznosti. Devojčice (26%) značajno češće preskaču doručak u odnosu na dečake (18%). Takođe, adolescenti koji preskaču doručak značajno češće jedu hranu visoke energetske gustine, što ih čini gladnijim i vodi prejedanju i gojaznosti. Preskakanje doručka može dovesti do rizičnih ponašanja, poput, konzumiranja alkohola, sedentarnog načina života, pušenja, nižeg nivoa obrazovanja i pojave simptoma depresije. Fizička neaktivnost je prisutna u nekim zemljama čak kod 50% mladih uzrasta 11-25 godina. Neophodna je edukacija adolescenata po pitanju zdravog načina ishrane i važnosti sprovođenja fizičke aktivnosti, ali je još važnije započeti sa ovom edukacijom od najranijeg uzrasta.

Ključne reči: adolescent, ishrana, fizička aktivnost, gojaznost, prevencija

Uvod

Adolescencija je period odrastanja, tj. prelazno doba između detinjstva i odrasle osobe (1-3). Navike stečene u ovoj dobi, uključujući i navike u ishrani, se u većini slučajeva nastavljaju i kasnije tokom života (1-3). Svetska zdravstvena organizacija (SZO) navodi da je adolescencija razdoblje između 10. i 19. godine života i da započinje pubertetom i karakteriše se kao razdoblje između detinjstva i odrasle osobe (3). Međutim, tokom istorije, starosne granice su se menjale, tako da današnja gornja granica označava 21 godinu života, čime počinje ulazak u odraslo doba. Što se tiče razdoblja adolescencije, ona se najčešće deli u tri faze: rana, srednja i kasna (4).

Adolescenti često konzumiraju brzu hranu, grickalice, drže dijete i preskaču obroke i zbog ovakvog neodgovarajućeg unosa hranljivih materija adolescenti pripadaju nutritivno osetljivoj grupi. Smatra se da je glavni razlog nepravilne ishrane adolescenata neznanje o pravilnom načinu ishrane, što dovodi do usvajanja nezdravih prehrambenih navika i negativnog uticaja nezdrave hrane na zdravlje adolescenata (2). SZO navodi da su 1,3 milijarde svetske populacije adolescenti. Ova populacija podnosi duge periode izloženosti zdravstvenim rizicima i njihovim posledicama, ali nisu često u stanju da utiču na svoju okolinu i da donose

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SPECIFICITIES AND CHALLENGES IN ADOLESCENT NUTRITION

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SUMMARY

The aim of this review is to analyze the specificities of adolescent nutrition. Data were collected based on the search of the following databases: PubMed, SCOPUS and Google scholar. Bad eating habits of adolescents can lead to health problems such as delayed puberty, osteoporosis, reduction in final body height, hyperlipidemia, anemia, obesity, anorexia, bulimia, caries, and a balanced diet can prevent long-term health problems such as cancers, atherosclerosis, stroke, osteoporosis, diabetes, hypertension, etc. It is estimated that between 25% and 58% of overweight adolescents will become overweight adults, and between 24% and 90% of obese adolescents will become obese adults. In numerous works, a significant connection between skipping breakfast and a higher incidence of obesity has been observed. Girls (26%) skip breakfast significantly more often than boys (18%). Also, adolescents who skip breakfast eat food with high energy density significantly more often, which makes them hungrier and leads to overeating and obesity. Skipping breakfast can lead to risky behaviors, such as alcohol consumption, sedentary lifestyle, smoking, lower level of education and symptoms of depression. Physical inactivity is present in some countries as much as 50% of young people aged 11-25. It is necessary to educate adolescents about a healthy diet and the importance of physical activity, but it is even more important to start this education from an early age.

Key words: adolescent, nutrition, physical activity, obesity, prevention

Introduction

Adolescence is the phase of growth that is the transitional phase between childhood and adulthood (1-3). Habits acquired at this age, including eating habits, in most cases continue later in life (1-3). The World Health Organization (WHO) states that adolescence is the phase of life from ages 10 to 19, between childhood and adulthood and that it starts with puberty (3). However, throughout history, age limits have changed, so today the upper limit is 21 years, which is the beginning of adulthood. As far as the stages of adolescence are concerned, adolescence is most often divided into three stages: early, middle and late (4).

Adolescents often consume fast food, snacks, they are on a diet, they skip meals and due to this inadequate intake of nutrients, adolescents belong to a nutritionally sensitive group. It is believed that the main reason for the improper nutrition of adolescents is ignorance about proper diet, which leads to the adoption of unhealthy eating habits and the negative impact of unhealthy food on adolescents' health (2). The WHO states that 1.3 billion of the world's population are adolescents. This population bears long periods of exposure to health risks and their consequences, but they are often unable to influence their environment and

odluke za svoju dobrobit (3). Studija preseka, autora *Kalkan* i sar., iz 2019. godine, koja je rađena u Turskoj na uzorku od 276 adolescenata, pokazala je da su navike u ishrani bile značajno bolje kod adolescentkinja, u odnosu na adolescente, kao i da su zdrave prehrambene navike adolescenata bile značajno pozitivno povezane sa znanjem o pravilnoj ishrani (1). Cilj ovog preglednog rada je da analizira specifičnosti ishrane adolescenata.

Metode

U okviru ovog preglednog rada korišćena je literatura dobijena pretraživanjem naučne medicinske literature objavljene u poslednjih deset godina, s posebnim osvrtom na originalne naučne članke objavljene u poslednjih 5 godina, u naučnim bazama podataka: *PubMed,* SCOPUS i *Google scholar.* Pretraživanje je urađeno korišćenjem sledećih ključnih reči: adolescencija, ishrana, zdravi stilovi života, gojaznost, prevencija i fizička aktivnost. Uključeni su samo oni radovi koji su bili objavljeni na engleskom jeziku.

Gojaznost adolescenata

Gojaznost kod adolescenata jedan je od najvećih problema javnog zdravlja dvadeset i prvog veka i dokazano je da će između 25% i 58% adolescenata koji imaju višak kilograma postati odrasle osobe s prekomernom težinom, a između 24% i 90% gojaznih adolescenata će postati gojazne odrasle osobe (4). SZO procenjuje da je preko pet miliona smtnih ishoda usled nezaraznih bolesti zabeleženo kod lica sa indeksom telesne mase (ITM) većim od optimalnog. Zabrinjava činjenica daljeg porasta broja gojaznih. Kod osoba uzrasta 5-19 godina, u periodu 1990-2020. godine, došlo je do porasta gojaznih sa 2% na 8%, a kod osoba uzrasta 18 i više godina sa 7% na 16% (5).

Ishrana adolescenata

Postoji nekoliko značajnih faktora koji utiču na pojavu loših navika u ishrani adolescenata. Prvi faktor je sam prelazak iz detinjstva u period puberteta, kada mladi teže da budu nezavisni, a samim tim su osetljiviji na socijalne i spoljašnje uticaje van kuće (2). Drugi značajan faktor koji utiče na pojavu loših navika u ishrani adolescenata je široka dostupnost nezdravoj hrani (automati sa grickalicama, čokoladicama, sokovima, itd.) u školama, gradovima, čak i bolnicama. Studija preseka, autora *Hamulka* i saradnika (6), rađena u Poljskoj na uzorku od 1569 studenata, obuhvatila je i 464 studenta edukacionom interventnom studijom, pri čemu su studenti tokom 9 meseci edukovani o pravilnoj ishrani, a njihovo znanje i stavovi su upoređivani pre i posle edukacije. Rezultati su pokazali da je korišćenje automata u školama bilo značajno povezano sa manjim konzumiranjem voća i povrća, kao i sa većim kalorijskim unosom, i značajno većim indeksom telesne mase (ITM) studenata (6).

Lošim navikama u ishrani doprinosi i marketing nezdrave hrane. Marketing nezdrave hrane povećava izloženost adolescenata namirnicama koje podstiču gojaznost, jer oni, za razliku od odraslih osoba, ne shvataju negativan uticaj marketinga na njihov odabir hrane (6). Istraživanja su pokazala da mladi koji preskaču doručak u toku dana konzumiraju veće porcije obroka i grickalice u ostatku dana, pa redovan doručak predstavlja značajnu meru prevencije gojaznosti kod adolescenata. Metaanaliza, autora *Ardeshirlarijani* i sar. (7), rađena 2019. godine, u kojoj je analizirano 16 studija (14 studija preseka i 2 kohortne studije), pokazala je da, deca od 4. godine i adolescenti do 18. godina koji preskaču doručak imaju manju potrošnju celovitih žitarica, mlečnih proizvoda i voća u odnosu na one koji redovno doručkuju. Takođe, u ovoj studiji je pronađena značajna povezanost između preskakanja doručka i veće učestalosti javljanja gojaznosti (OR: 1,43; 95%CI: 1,32; p<0,05). Međutim, veći rizik je bio kod dečaka (OR: 1,64; 95% CI: 1,38, 1,95; I2: 38,3%, p = 0,18) nego devojčica OR:1,56 (95% CI: 1,38, 1,77, I2: 0,0%, p = 0,49) (4). *Moncani* i sar. (6), su u svom sistematskom pregledu, gde su analizirali 39 naučnih članaka, objavljenih u periodu od 2008. do 2018. godine, na ukupnom uzorku od 286.804 dece i adolescenata, pokazali da 10-30% dece od 4. godine i adolescenti do 18. godina preskaču doručak. Takođe, uočili su da je kod 94,7% ispitanika preskakanje doručka značajno pozitivno povezano sa prekomernom telesnom težinom i gojaznošću. Pored toga, preskakanje doručka je bilo povezano i sa pojavom lošijeg lipidnog profila, višim nivoima arterijskog krvnog pritiska, insulinskom rezistencijom i pojavom metaboličkog sindroma. Takođe, adolescenti koji preskaču doručak značajno češće jedu hranu visoke energetske gustine, kao što su npr. brza hrana i grickalice, koje ih čine još gladnijima, što vodi ka pojavi prejedanja i gojaznosti (8). *Kaskales* i sar. (9) su u svojoj studiji, sprovedenoj u

make decisions about their own well-being (3). A cross-sectional study by Kalkan et al. from 2010, which was conducted in Turkey on a sample of 276 adolescents, showed that eating habits were significantly better in adolescent girls compared to male adolescents, as well as that healthy eating habits of adolescents were significantly positively associated with knowledge about proper nutrition (1). The aim of this review article was to analyze the specificities of adolescent nutrition.

Methods

Within this review article, we used literature that was obtained by searching the medical literature published in the last ten years, with a special insight into original scientific articles, which were published in the last five years, in the following scientific databases: PubMed, SCOPUS and Google Scholar. The search was conducted using the following key words: adolescence, nutrition, healthy lifestyles, obesity, prevention and physical activity. Only studies that were published in English were included.

Adolescent obesity

Adolescent obesity is one of the major public health problems of the twenty-first century, and it has been proven that 25% to 58% of overweight adolescents will become overweight adults, while 24% to 90% of obese adolescents will become obese adults (4). The WHO estimates that over five million deathly outcomes caused by non-communicable diseases have been recorded in persons with a body mass index (BMI) higher than optimal. The fact that the number of obese people further increases is worrying. In persons aged 5-19 years, in the period 1990-2020, there was an increase in the number of obese persons from 2% to 8%, while in persons aged 18 years and over, this number increased from 7% to 16% (5).

Nutrition of adolescents

There are several significant factors that influence the appearance of bad eating habits in adolescents. The first factor is the very transition from childhood to the period of puberty, when young people tend to be independent, and therefore, they become more susceptible to social and external influences outside their homes (2). Another significant factor that influences the occurrence of bad eating habits among adolescents is the wide availability of unhealthy food (vending machines with snacks, chocolate bars, juices, etc.) in schools, cities, even in hospitals. A cross-sectional study by Hamulka and associates (6), which was conducted in Poland on a sample of 1,569 students, included 464 students in an educational intervention study, where students were educated about proper nutrition for 9 months, while their knowledge and attitudes were compared before and after the education. The results showed that the use of vending machines in schools was significantly associated with lower consumption of fruit and vegetables, as well as with higher caloric intake and significantly higher body mass index (BMI) of students (6).

Marketing of unhealthy foods also contributes to bad eating habits. Marketing of unhealthy foods increases adolescents' exposure to foods that cause obesity, because they, in contrast to adults, do not understand the negative impact of marketing on their food selection (6). Research has shown that young people who skip breakfast during the day consume larger portions of food and snacks later during the day, and therefore, regular breakfast is a significant measure of obesity prevention in adolescents. A meta-analysis by Ardeshirlarijani et al. (7), which was conducted in 2019 based on the analysis of 16 studies (14 cross-sectional studies and 2 cohort studies), showed that children from the age of 4 and adolescents to the age of 18, who skip breakfast have a lower consumption of whole grains, dairy products and fruit in comparison to those who regularly have breakfast. Also, a significant association was found between skipping breakfast and higher incidence of obesity (OR: 1.43; 95% CI: 1.32; $p<0.05$). However, the risk was higher in boys (OR: 1.64; 95% CI: 1.38, 1.95; I2:38.3%, p=0.18) than in girls (OR: 1.56; 95% CI: 1.38, 1.77, I2: 0.0%, p=0.49) (4). Monzani et al. (6) in their systematic review, in which they analyzed 39 scientific articles that were published between 2008 and 2018, on a total sample of 286,804 children and adolescents, showed that 10-30% of children from the age of 4 and adolescents to the age of 18 skip breakfast. Also, they found that in 94.7% of respondents, skipping breakfast was significantly positively correlated with overweight and obesity. In addition, skipping breakfast was also associated with the occurrence of worse lipid profile, higher levels of arterial blood pressure,

Španiji, 2018. godine, na uzorku od 527 adolescenata, uočili da preskakanje doručka može dovesti do pojave zdravstveno rizičnih ponašanja, poput, konzumiranja alkohola, sedentarnog načina života, pušenja, nižeg nivoa obrazovanja i pojave simptoma depresije. Ovi autori navode da je preskakanje doručka značajno povezano i sa nižim kvalitetom i zadovoljstvom života, češćom pojavom hroničnog stresa i povećanim rizikom za nastanak kardiovaskularnih bolesti. Preskakanje doručka često može uzrokovati i mučninu tokom jutra i ometati procese pamćenja i učenja, dok tokom dana može dovesti do povećanog unosa hrane bogate mastima, a siromašne vlaknima (9).

Studija rađena u Hrvatskoj, od strane autora Kuzmana i sar. (10), je pokazala da samo 41% dečaka i 46% devojčica redovno doručkuje radnim danima, međutim, između dečaka i devojčica nije uočena značajna razlika u učestalosti preskakanja doručka. Druge studije, takođe potvrđuju ove rezultate. Studija preseka *Tumbalis* i sar. (11), sprovedena 2015. godine u Grčkoj na uzorku od 177.091 dece, uzrasta od 8 do 17 godina, je pokazala da skoro jedno od četvoro adolescenata (22,4% dečaka i 23,1% devojčica, bez razlika u učestalosti po polu) preskače doručak, i da je preskakanje doručka značajno češće kod žena, starijih, lica sa prekomernom telesnom težinom ili gojaznošću, lošijim navikama u ishrani, neadekvatnom fizičkom aktivnošću, nedostatkom sna (manje od 8 sati sna dnevno) i većim vremenskim periodom tokom dana provedenim za televizorom, kompjuterom ili telefonom (više od dva sata dnevno). Dodatne analize su pokazale da loše navike u ishrani značajno povećaju rizik od preskakanja doručka za skoro 80% (95% CI: 1,78–1,82),od nedovoljnog sna za 23% (95% CI: 1,20–1,26), a od sedentarnog načina života (tj. više vremena provedenog za ekranom tokom dana) za 22,5% (95% CI: 1,19–1,26) (9). Studija *Yahia* i sar. (12), rađena od 2011. do 2012. godine u SAD, u Mičigenu, na uzorku od 237 adolescenata je utvrdila da samo 53% adolescenata redovno doručkuje, dok je 39% izjavilo da im se doručak sastoji od mleka/kafe/jogurta, a trećina ispitanih adolescenata doručkuje samo voćni sok (12).

Iako je iz prethodno navedenih studija (10-12) uočljivo da devojčice češće preskaču doručak u odnosu na dečake, u većini studija nije uočena značajna razlika u odnosu na pol. Međutim, metanaliza rađena 2017. godine, autora *Gafari*-a i sar. (13), u kojoj su od prvobitnih 322, analizirana 24 naučna članka, je pokazala da devojčice ipak značajno češće preskaču doručak u odnosu na dečake (26% vs. 18%) (13). Studija rađena u Poljskoj na uzorku od 3009 adolescenata je pokazala da 20-30% adolescenata mlađeg uzrasta od 11 do 15 godina ne jede redovno svako jutro pre polaska u školu, a 30% ne uzima nikakav obrok tokom boravka u školi (14). Doručak ne konzumira 12,5% devojčica i oko 9,3% dečaka (14). Slična istraživanja u Holandiji i Portugalu su pokazala da 10% dece dobi do 11 godina i 30% dece dobi do 15 godina ne doručkuju redovno, dok je taj procenat značajno veći u Sloveniji i Rumuniji, pri čemu u ovim zemljama redovan doručak nema oko 40% adolescenata (10,15). Prema istraživanju Sile i sar. (16), koje je rađeno u Hrvatskoj 2019. godine na uzorku od 802 adolescenta i dece, utvrđeno je da 39,5% adolescenata uopšte ne doručkuje, a da su adolescenti koji su redovno doručkovali imali značajno niži ITM, ali i veći ukupni dnevni energetski unos u odnosu na adolescente koji ne doručkuju redovno (16).

Rezultati istraživanja zdravlja stanovnika Republike Srbije u 2013. godini su pokazali da je 93,8% mladih uzrasta od 7 do 14 godina svakodnevno doručkovalo, što je više u odnosu na 2006. godinu (90,5%) (17). Poseban izazov u ishrani dece i adolescenata je povećana učestalost konzumiranja grickalica i slatkiša, a najviše slanih grickalica, čokoladica i bombona, kao i brze hrane. Pokazano je da istovremeno sa porastom stope gojaznosti među adolescentima dolazi i do porasta učestalosti konzumiranja grickalica i slatkiša (18). U odnosu na ostale dobne skupine, adolescenti konzumiraju najveću količinu hrane slabijeg kvaliteta. Unos jako kalorične brze hrane, koja je bogata rafinisanim šećerima i zasićenim mastima, dovodi do pojave gojaznosti, što predstavlja zdravstveni problem koji je u današnje vreme sve prisutniji kod dece i adolescenata (18).

Konzumiranje brze hrane može dovesti do zavisnosti u smislu pojave trajne sklonosti ka ovoj vrsti hrane, a posledica može biti i pojava poteškoća u učenju i pamćenju, što je i pokazala studija *Reichelt*-a i *Rank*-a iz 2017. godine (19). Brza hrana koja se prodaje na kioscima i restoranima je visoke energetske gustine, a nutritivno je veoma siromašna, bogata je rafinisanim šećerima, žitaricama i solju, a siromašna voćem i povrćem. Konzumiranje ovakve hrane je značajno povezano sa gojaznošću i metaboličkim promenama koje vode nastanku dijabetesa, kao i kardiovaskularnih bolesti (20).

insulin resistance and the appearance of metabolic syndrome. Also, adolescents who skip breakfast eat food of high energy density significantly more often, such as fast food and snacks, which make them even hungrier, thus leading to overeating and obesity (8). Cascales et al. (9) in their study, which was conducted in Spain in 2018, on a sample of 527 adolescents, found that skipping breakfast can lead to the occurrence of health-risk behaviors, such as alcohol consumption, sedentary lifestyle, smoking, lower levels of education and the occurrence of the symptoms of depression. These authors state that skipping breakfast is significantly associated with lower quality of life and satisfaction, more frequent appearance of chronic stress and increased risk of cardiovascular diseases. Skipping breakfast can often cause nausea in the morning and disturb the processes of memorizing and learning, while during the day it can lead to the increased intake of food rich in fats and poor in fibers (9).

A study by Kuzman et al. (10), which was conducted in Croatia, showed that only 41% of boys and 46% of girls ate breakfast regularly on weekdays. However, there was no significant difference between boys and girls regarding the frequency of skipping breakfast. Other studies have also confirmed these results. A cross-sectional study by Tambalis et al. (11), which was conducted in Greece in 2015 on a sample of 177,091 participants aged between 8 and 17 years, showed that almost one in four adolescents (22.4% of boys and 23.1% of girls with no differences in frequency by gender) skipped breakfast and that skipping breakfast was significantly more common in women, elderly, in overweight and obese persons, in persons with poor eating habits, inadequate physical activity, lack of sleep (less than 8 hours of sleep a day) and a longer period of time spent in front of TV, computer or phone (more than two hours a day). Additional analyses showed that bad eating habits significantly increased the risk of skipping breakfast by almost 80% (95% CI: 1.78-1.82), insufficient sleep by 23% (95% CI: 1.20-1.26), and of a sedentary lifestyle (that is, more time spent in front of a screen) by 22.5% (95% CI: 1.19-1.26) (9). A study by Yahia et al. (12), which was conducted in the USA, in Michigan from 2011 to 2012 on a sample of 237 adolescents, found that only 53% of adolescents had breakfast regularly, while 39% of them stated that their breakfast consisted of milk/coffee/yoghurt, while one third of the examined adolescents had only fruit juice for breakfast (12).

Although it can be concluded from the above mentioned studies (10-12) that girls skip breakfast more frequently than boys, in most studies there was no significant difference in relation to sex. However, a meta-analysis by Ghafari et al. (13), which was conducted in 2017, and which included the analysis of 24 scientific articles out of the original 322, showed that girls skip breakfast significantly more often than boys (26% vs. 18%) (13). A study, which was conducted in Poland on a sample of 3009 adolescents showed that 20-30% of younger adolescents aged 11 to 15 years did not eat regularly every morning before going to school, while 30% of them did not take any meals during their stay at school (14). Breakfast was not consumed by 12.5% of girls and about 9.3% of boys (14). Similar research in the Netherlands and Portugal showed that 10% of children to the age of 11 and 30% of children to the age of 15 did not have breakfast regularly, while this percentage was significantly higher in Slovenia and Romania, where 40% of adolescents did not have regular breakfast (10,15). According to a study by Sila et al. (16), which was conducted in Croatia in 2019 on a sample of 802 adolescents and children, it was found that 39.5% of adolescents did not have breakfast at all, and that adolescents who regularly had breakfast had a significantly lower BMI, but also a higher total daily energy intake in comparison to adolescents who did not have breakfast regularly (16).

The results of the National Health Survey in the Republic of Serbia in 2013 showed that 93.8% of young people between the ages of 7 and 14 had breakfast every day, which is more in comparison to 2016 (90.5%) (17). A special challenge in the nutrition of children and adolescents is the increased frequency of consumption of snacks and sweets, mostly salty snacks, chocolates and candies, as well as fast food. It was shown that simultaneously with the increase in the obesity rate among adolescents there came to the increase in the frequency of consumption of snacks and sweets (18). Compared to other age groups, adolescents consumed the largest amount of poor quality food. The intake of high-calorie food rich in refined sugars and saturated fats leads to obesity, which is a health problem that is increasingly present in children and adolescents today (18).

S obzirom na ove podatke, Američka akademija pedijatara preporučuje ograničavanje unosa brze hrane i navodi ovu meru kao jedan od načina prevencije gojaznosti, ipak, adolescenti u Sjedinjenim Američkim Državama, jedu u restoranima brze hrane najmanje dva puta nedeljno (21). Prema metaanalizi, autora *Beal*-a i sar. (22), iz 2019. godine, u kojoj je ispitan obrazac konzumiranja voća, povrća i brze hrane od strane adolescenata, utvrđeno je da 93% adolescenata koji potiču iz zemalja sa srednjim i niskim dohotkom konzumiraju brzu hranu najmanje jednom nedeljno (22). *Adams* i sar. (18) su uočili da deca uzrasta od 5 do 8 godina jedu grickalice u proseku tri puta na dan, što čini oko 25% energetskog unosa, a 31% njih svakodnevno konzumira slatkiše. Ukoliko roditelji od ranog detinjstva dece koriste strategiju kontrole unosa grickalica i slatkiša to može pozitivno uticati na stvaranje samokontrole kod ove dece i u kasnijem periodu života, što je puno bolja opcija od potpunog zabranjivanja njihovog konzumiranja, što kasnije može dovesti do njihovog prekomernog konzumiranja (18).

Prema studiji preseka *Jongenelis*-a i sar. (23), objavljenoj 2018. godine, a rađenoj u dva perioda u Australiji, kod dece uzrasta od 12 do 17 godina, u prvom periodu 2009-2010. godine obuhvaćen je 1501 ispitanik, a u drugom 2012-2013. godine 1406 ispitanika, samo 14% adolescenata u prvoj studiji preseka i 13% adolescenata u drugoj studiji preseka, je unosilo preporučene količine povrća (preporuka je pet porcija povrća dnevno), dok je 68% u prvoj studiji, a 71% u drugoj studiji unosilo u organizam preporučene količine voća (preporuka je dve porcije voća dnevno). Takođe, rezultati ove studije su pokazale da devojčice značajno češće ne unose preporučene količine povrća u odnosu na dečake, a samo je 50% adolescenata prepoznalo da njihov sopstveni unos voća i povrća na dnevnom nivou nije adekvatan (23). Koliko je za redovan unos dovoljnih količina voća i povrća u organizam adolecenta važna navika, pokazuje istraživanje *Skaljoni*-a i sar. (24) iz 2018. godine, u kome se navodi da mlade osobe koje se u ranoj adolescenciji redovno imale obroke sa roditeljima, tokom adolescencije jedu značajno više porcija voća i povrća i u periodu kasnije adolescencije i u starijoj dobi, u odnosu na vršnjake koji nikada nisu redovno doručkovali, ručali ili večerali sa roditeljima ili ostatkom porodice (24).

Fizička aktivnost adolescenata

Kumar i sar. (25) navode da su pozitivni efekti umerene svakodnevne fizičke aktivnosti toliko značajni da nadmašuju učinkovitost bilo kakvih lekova ili drugih načina lečenja. U Velikoj Britaniji, samo 21% dečaka i 16% devojčica adolescentske dobi ispunjava minimalne preporuke za zdravu ishranu i fizičku aktivnost, dok je 50% stanovništva Velike Britanije uzrasta od 11 do 25 godina nedovoljno fizički aktivno (25).

Al Kudari i sar. (26) navode da je trenutno najbolja mera za lečenje gojaznosti kod adolescenata mlađih od 18 godina upravo kombinovana primena svakodnevne fizičke aktivnosti uz primenu zdrave, uravnotežene ishrane (26). Dosadašnje studije su potvrdile značajnu povezanost fizičke neaktivnosti i gojaznosti kod dece i adolescenata (26).

Posledice nezdrave ishrane

Nepravilna ishrana je jedan od najznačajnijih problema kod dece i adolescenata, jer je preduslov za pojavu velikog broja psihofizičkih oboljenja (26). Loše navike u ishrani adolescenata mogu dovesti do pojave zdravstvenih problema kao što su odloženo polno sazrevanje, osteoporoza, smanjenje u konačnoj telesnoj visini, hiperlipidemija, anemija, gojaznost, anoreksija, bulimija, karijes, a uravnotežena ishrana može da prevenira nastanak dugoročnih zdravstvenih problema kao što su karcinomi, ateroskleroza, moždani udar, osteoporoza, dijabetes i hipertenzija (26-28).

Prevencija nezdrave ishrane

U nekim studijama se navodi, da je trenutno najbolja mera za lečenje gojaznosti kod adolescenata mlađih od 18 godina upravo kombinovana primena svakodnevne fizičke aktivnosti uz primenu zdrave, uravnotežene ishrane (28,29). Energetske potrebe treba prilagoditi potrebama svakog adolescenta pojedinačno, i to zavisi od velikog broja faktora: fizičke aktivnosti, prisustva nekog poremećaja ishrane poput prekomerne telesne težine ili gojaznosti, komorbiditeta itd. Takođe, pol ima značajan uticaj, jer je dokazano da su energetske potrebe značajno veće kod dečaka u odnosu na devojčice, zbog značajno većeg i bržeg porasta u telesnoj visini, telesnoj težini i porastu nemasne telesne mase (1,2). U zavisnosti od brzine rasta, pola i sprovođenja svakodnevne fizičke aktivnosti, dnevne potrebe za energijom kod dece i adolescenata se značajno razlikuju (6,30). U tabeli 1 je pri-

Consuming fast food can lead to addiction in the sense of the appearance of permanent preference for this kind of food, which can result in difficulties in learning and memory, as it was shown in the study by Reichelt and Rank from 2017 (19). Fast food that is sold at kiosks and restaurants has high energy density, while it is nutritionally very poor, rich in refined sugars, grains and salt and poor in fruits and vegetables. Consuming this kind of food is significantly associated with obesity and metabolic changes that lead to the occurrence of diabetes and cardiovascular diseases (20).

Considering these data, the American Academy of Pediatrics recommends limiting the intake of fast food and states this measure to be one of the ways to prevent obesity. However, adolescents in the United States of America eat at fast food restaurants at least twice a week (21). According to a meta-analysis by Beal et al. (22) from 2019, in which the pattern of consumption of fruit, vegetables and fast food among adolescents was examined, it was found that 93% of adolescents from middle and low-income countries consumed fast food once a week (22). Adams et al. (18) observed that children between the ages of five and eight ate snacks three times a day on average, which accounted for about 25% of their energy intake, while 31% of them consumed sweets every day. If parents use the strategy of controlling the intake of snacks and sweets from an early age, this can have a positive effect on the creation of self-control in these children in the later period of life, which is a lot better option than completely prohibiting their consumption, because it can lead to the excessive consumption of sweets later in life (18).

According to a cross-sectional study by Jongenelis et al. (23), which was published in 2018, conducted in Australia in two periods among children aged 12 to 17, and which included 1501 respondents in the first period 2009-2010 and 1406 respondents in the second period 2012-2013, only 14% of adolescents in the first cross-sectional study and 13% of adolescents in the second cross-sectional study, consumed the recommended amount of vegetables (the recommendation is five servings of vegetables per day), while 68% in the first study and 71% in the second study consumed the recommended amount of fruit (the recommendation is two servings of fruit per day). Also, the results of this study showed that girls significantly more often did not consume the recommended amount of vegetables compared to boys, and only 50% of adolescents recognized that their intake of fruits and vegetables on a daily basis was not adequate (23). How important habit is for the regular intake of sufficient amounts of fruit and vegetables in adolescents was shown by the study conducted by Scaglioni et al. (24) in 2018, in which it was stated that young people who regularly had meals with their parents in early adolescence eat significantly more servings of fruit and vegetables in the period of late adolescence and in older age, in comparison to their peers who never had breakfast, lunch or dinner regularly with their parents or the rest of the family (24).

Physical activity of adolescents

Kumar et al. (25) state that the positive effects of moderate daily physical activity are so significant that they surpass the effectiveness of medications or other treatment methods. In the UK, only 21% of boys and 16% of girls in the adolescent period meet the minimal recommendations for healthy nutrition and physical activity, while 50% of the UK population aged 11 to 25 years are not physically active enough (25).

Al-Khudairy et al. (26) state that currently the best measure for the treatment of obesity in adolescents younger than 18 is precisely the combined application of daily physical activity with the application of a healthy, balanced diet (26). Previous studies have confirmed a significant correlation between physical inactivity and obesity in children and adolescents (26).

Consequences of unhealthy diet

Improper nutrition is one of the most significant problems in children and adolescents, because it is a prerequisite for the occurrence of a large number of psychophysical diseases (26). Bad eating habits in adolescent nutrition can lead to the occurrence of health problems, such as delayed puberty, osteoporosis, reduction in final body height, hyperlipidemia, anemia, obesity, anorexia, bulimia, caries, while balanced diet can prevent long-term health problems such as cancer, atherosclerosis, stroke, osteoporosis, diabetes and hypertension (26-28).

Prevention of unhealthy diet

In some studies, it is stated that the best measure for the treatment of obesity in adolescents under

kazan preporučeni dnevni energetski unos za decu i adolescente prema uzrasnim grupama i polu (31). U adolescentnom periodu mladi razvijaju odgovornost za zdravlje svog tela, pa je ovaj period veoma pogodan za edukaciju mladih o zdravim životnim navikama, jer se na ovaj način mogu sprečiti kasnije komplikacije (32).

Prema preporukama iz SAD iz 2005. godine, koje važe i danas, adolescenti bi za optimalno funkcionisanje organizma trebali unositi 3,5 do 6,5 porcija voća i povrća na dnevnom nivou. Nacionalna istraživanja su pokazala da, ipak, manje od 2% adolescenata unosi manje od preporučene dnevne količine voća i povrća. Uočeno je da je prelaz u adolescenciju posebno kritičan period za unos voća i povrća. Pre adolescencije prehrambene navike dece su više pod kontrolom roditelja, dok su nakon početka adolescencije deca ta koja najviše kontrolišu šta će unositi u svoj organizam (33). Značajni faktori koji utiču na smanjenje unosa voća i povrća u organizam u periodu adolescencije su povećanje nezavisnosti, brži način života, izbor hrane, a sve ovo dovodi do oslanjanja na brzu hranu koja je prilično jeftina i štetna (33).

Jedna od dokazano važnijih preventivnih mera za nastanak nezadovoljstva sopstvenim telom, kao i prevenciju nastanka prekomerne telesne težine ili gojaznosti, kao i drugih poremećaja do kojih dovodi loša, neuravnotežena ishrana u adolescenciji, je primena umerene svakodnevne fizičke aktivnosti. Postoje naučni dokazi da fizički aktivan način života donosi zdravstvene dobrobiti i prevenira nastanak velikog broja hroničnih nezaraznih obolenja, dok fizička neaktivnost i sedentarni način života doprinose nastanku istih oboljenja (34). Preporuke bi bile da u školu treba ići peške, ili biciklom i podsticati učešće u lakim ili umerenim fizičkim aktivnostima, uz smanjenje vremena provedenog za kompjuterom, mobilnim telefonom ili televizorom na manje od 2 sata dnevno (35,36).

U cilju unapređenja ishrane neophodno je izmeniti kurikulume u osnovnim i srednjim školama i formirati obavezan školski predmet na kojem bi se dobijala znanja o pravilnoj ishrani, kao i zdravstvenim posledicama loše, neredovne i nezdrave ishrane. Na nivou države treba formirati nutritivnu komisiju koje će kontrolisati vrste namirnica, njihov kvalitet i distribuciju hrane koja se prodaje u školama za vreme malog i velikog odmora i koja će uticati na poboljšanje kvaliteta hrane, kako bi obrok u školi bio kvalitetan i hranljiv (37).

Zaključak

Adekvatnom edukacijom adolescenta može se podstići smanjivanje broja gojaznih i brojnih drugih hroničnih nezaraznih poremećaja zdravlja. Neophodno je da deca i adolescenti steknu dobre životne navike, i to da doručkuju, kao i da ishranom unose više voća, povrća, integralnih žitarica i složenih ugljenih hidrata, kao i da redovno sprovode fizičku aktivnost.

Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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the age of 18 is the combined application of daily physical activity with the application of a healthy, balanced diet (28,29). Energy requirements should be adapted to the needs of each adolescent individually, and it depends on numerous factors: physical activity, the presence of some eating disorder such as overweight or obesity, comorbidities, etc. Also, gender has a significant influence, because it has been proven that energy needs are significantly higher in boys compared to girls, due to significantly greater and faster growth related to height, weight and lean body mass (1,2). Depending on the speed of growth, gender and daily physical activity, the daily energy needs of children and adolescents differ significantly (6,30). Table 1 shows the recommended daily energy intake for children and adolescents according to age groups and gender (31). In the adolescent period, young people develop responsibility for the health of their bodies, so this period is very suitable for the education of young people about healthy lifestyle habits, because in this way later complications can be prevented (32).

According to recommendations from the USA from 2005, which are still valid today, adolescents should consume 3.5 to 6.5 servings of fruit and vegetables per day for optimal body functioning. However, national surveys have shown that less than 2% of adolescents consume less than the recommended daily amount of fruit and vegetables. It has been observed that the transition to adolescence is a particularly critical period for fruit and vegetable intake. Before adolescence, eating habits of children are under the control of their parents, while after the beginning of adolescence, the intake of food is mostly under the control of children (33). Significant factors that influence the reduction in the intake of fruit and vegetables in the adolescent period include the increase in independence, faster lifestyle, choice of food, while this leads to reliance on fast food, which is quite cheap and harmful (33).

One of important preventive measures for the occurrence of dissatisfaction with one's own body, as well as for the prevention of excess body weight or obesity and other disorders caused by poor, unbalanced nutrition in adolescence, is the application of moderate daily physical activity. There is scientific evidence that a physically active lifestyle brings health benefits and prevents the occurrence of a large number of chronic non-communicable diseases, while physical activity and a sedentary lifestyle contribute to the occurrence of these diseases (34). The recommendations would include walking to school or going by bus, as well as participating in light-intensity or moderate physical activities, thus reducing the time spent in front of the computer screen, mobile phone or TV to less than 2 hours a day (35,36).

In order to improve nutrition, it is necessary to change the curriculum in primary and secondary schools and create a mandatory school subject that would provide knowledge about proper nutrition, as well as the health consequences of poor, irregular and unhealthy nutrition. At the state level, a committee for nutrition should be formed that would control the types of groceries, their quality and the distribution of food sold in schools during short and long breaks, which would influence the improvement of the quality of that food, so that school meals would be of good quality and nutritious (37).

Conclusion

The adequate education of adolescents can encourage the reduction in obesity and numerous other chronic non-communicable health disorders. It is necessary for children and adolescents to acquire good lifestyle habits, to have breakfast, as well as to use more fruit, vegetables, whole grains and complex carbohydrates in their diet, as well as to engage in regular physical activity.

Competing interests

The authors declared no competing interests.

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SAVREMENI PRISTUPI U PREVENCIJI PADOVA KOD STARIJIH OSOBA

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SAŽETAK

Starenjem dolazi do smanjenja funkcionalnih sposobnosti, što utiče na pojavu padova koji neretko mogu dovesti do invaliditeta. Cilj ovog preglednog rada je analiza savremenih pristupa u okviru mera prevencije i kontrole padova kod starijih osoba. Kao izvori podataka u ovom radu korišćeni su publikovani naučni radovi, objavljeni u periodu 2003-2023. godine. Terapijske vežbe primenjene tokom rehabilitacije i postrehabilitacije čine osnovu dobre posturalne stabilnosti. Različiti programi sistematskog vežbanja imaju svoje značajno mesto, ali treba da budu zasnovani na dokazima i precizno dozirani. Sa razvojem tehnologije postaje dostupno sve više metoda i opreme koja se na savremeni način može iskoristiti u prevenciji padova. Robotski sistemi, aplikacije, prenosivi hardverski uređaji, aparatura za virtuelnu realnost, kao i sistemi detekcije i prevencije padova, predstavljaju samo neke od novijih tehnologija koje se primenjuju u prevenciji padova. Multidisciplinarni pristup, koji se odnosi na pružanje informacija, timski rad stručnjaka iz različitih oblasti i praćenje novih tehnologija, bi mogao značajno doprineti prevenciji padova i unapređenju kvaliteta života starijih osoba.

Ključne reči: starija populacija, prevencija, padovi, terapijske vežbe, fizička aktivnost, robotika

Uvod

Prema nedavno objavljenim rezultatima popisa stanovništva iz 2022. godine Republičkog zavoda za statistiku, 22,1% stanovnika u Republici Srbiji čine osobe starosti od 65 i više godina (1). U odnosu na prethodni popis iz 2011. godine, udeo ovih lica u ukupnom broju stanovnika je porastao za 4,7% (1). Predviđa se da će se broj osoba starijih od 65 godina u svetu udvostručiti do 2050. godine (2). Proces starenja je neizbežan i tokom njega se povećava verovatnoća za razvoj bolesti, te se funkcionalnost određenih procesa u telu ograničava i smanjuje. Simptomi starenja su izraženi na telesnom, kognitivnom i psihičkom planu, što zahteva angažovanje multidisciplinarnog tima stručnjaka u cilju što dužeg očuvanja zdravlja (3).

Promene se dešavaju kako na kardiovaskularnom i respiratornom sistemu, tako i na mišićnoskeletnom, nervnom i senzornom sistemu. Starenjem kosti postaju porozne, tkiva ko zgloba gube elastičnost i menja se biomehaničko opterećenje zglobova. Dolazi do gubitka mišićne mase, snage i kontraktilnih sposobnosti mišića (4). Pored toga, smanjuje se funkcija centralnog i perifernog nervnog sistema što uzrokuje oslabljenu koordinaciju, usporeno kretanje i otežano održavanje uspravnog stava (5). Kontrola uspravne posture je dinamičan proces usklađivanja reakcije tela na senzorne informacije koje stižu iz različitih receptora sa periferije ka centralnom nervnom sistemu. Zahvaljujući inputima iz somatosenzornog, vizuelnog i vestibularnog sistema sa jedne strane i alternativnim akcijama antagonističkih mišićnih grupa sa druge strane, sprečavaju se prekomerne balansne reakcije i telo se održava u ravnoteži (6).

Svetska zdravstvena organizacija (SZO) definiše pad kao „iznenadnu i nenamernu promenu položaja koja uzrokuje da se osoba nađe na podu, tlu ili nižem nivou, isključujući namerne promene položaja dok se odmara na nameštaju, zidu ili

REVIEW ARTICLE

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MODERN APPROACHES TO FALLS PREVENTION IN ELDERLY PERSONS

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SUMMARY

Aging leads to the decrease in functional abilities, which affects the occurrence of falls that can often lead to disability. The aim of this review article is to analyze the contemporary approaches within the framework of measures for the prevention and control of falls in elderly persons. Published scientific works from the period 2003-2023 were used as data sources.Therapeutic exercises applied during rehabilitation and post-rehabilitation form the basis of good postural stability. Various systematic exercise programs have a significant place, but they need to be evidence-based and precisely applied. With the development of technology, several different methods and equipment are becoming available that can be used in the prevention of falls in a modern way. Robotic systems, applications, portable hardware devices, virtual reality equipment, as well as fall detection and prevention systems are just some of the newer technologies used in fall prevention. A multidisciplinary approach, which refers to the provision of information, teamwork of experts from different fields and monitoring of new technologies, could significantly contribute to the prevention of falls and improvement in the quality of life of the elderly.

Keywords: elderly population, prevention, falls, therapeutic exercises, physical activity, robotics

Introduction

According to the recently published results of the 2022 Census of the Statistical Office of the Republic of Serbia, 22.1% of inhabitants in the Republic of Serbia are persons aged 65 years and over (1). In comparison to the previous Census from 2011, the share of these persons in the total population increased by 4.7% (1). It is estimated that the number of persons older than 65 will double by 2050 (2). The process of ageing is inevitable and during this process the probability of developing diseases increases, so the functionality of certain processes in the body is limited and reduced. The symptoms of ageing are present at the physical, cognitive and psychological level, which demands the engagement of a multidisciplinary team of professionals aimed at preserving health as long as possible (3).

Changes occur in the cardiovascular and respiratory system, as well as in the musculoskeletal, nervous and sensory system. With ageing, bones become porous, surrounding joint tissues lose elasticity and the biomechanical load of joints changes. There is a loss of muscle mass, strength and contractile abilities of muscles (4). In addition, the function of the central and peripheral nervous system decreases, which causes decreased coordination, slow movement and inability to maintain upright posture (5). Controlling the upright posture is a dynamic process of coordinating the body's reaction to sensory information that arrives from various receptors from the periphery to the central nervous system. Thanks to inputs from somatosensory, visual and vestibular system on the one hand and alternative actions of antagonistic muscle groups on the other hand, excessive balance reactions are prevented and the body is kept in balance (6).

The World Health Organization (WHO) defines a fall as a "sudden and inadvertent change of position which results in a person coming to rest

drugom predmetu“ (7). U proseku jedna od tri osobe starosti 65 i više godina padne jedanput godišnje, a trećina njih prilikom pada doživi teške prelome kuka (8). U starijem životnom dobu padovi su jedan od vodećih uzroka smrtnosti, gubitka funkcionalne nezavisnosti i invaliditeta (9).

Stručnjaci iz oblasti rehabilitacije posturalnu stabilnost ispituju testovima stajanja na jednoj nozi, testovima za procenu stabilnosti tela u pokretu, Rombergovim testom, funkcionalnim testom „dosezanja“ i „tandem“ hodom - hodom po pravoj liniji. Tehnološkim napretkom i uvođenjem kompjuterizovane tehnike u vidu kineziološke platforme omogućeno je objektivno ispitivanje posturalne stabilnosti kroz njenu vizuelnu, vestibularnu i proprioceptivnu komponentu (10).

Cilj ovog preglednog rada je analiza savremenih pristupa u okviru mera prevencije i kontrole padova kod starijih osoba.

Metod

Kao izvori podataka u ovom radu korišćeni su publikovani naučni radovi, koji su identifikovani pretraživanjem sledećih elektronskih baza podataka: Srpski citatni indeks – SCIIndeks, Konzorcijuma biblioteka Srbije za objedinjenu nabavku – KoBSON, *Google Scholar* napredne pretrage i platforma *PubMed*. Pretraga elektronskih baza podataka je izvršena za period 2003-2023. godine. Ključne reči prilikom pretrage literature bile su: starija populacija, prevencija, padovi, terapijske vežbe, fizička aktivnost i robotika. Na osnovu naslova i sažetaka radova izdvojili smo 30 publikacija na srpskom i engleskom jeziku.

Mere prevencije i kontrole padova kod starijih osoba

U cilju održavanja zdravlja i prevencije padova, starijim osobama se preporučuju multimodalne vežbe koje obuhvataju vežbe za jačanje mišićne snage i izdržljivosti, balansa i fleksibilnosti kroz terapijske vežbe, programirano vežbanje ili vežbanje kroz aktivnosti svakodnevnog života. Preporuka je da se započne sa jednom vrstom vežbi, da bi se postepeno dodavale i druge, najviše zbog odlaganja zamora i prilagođavanja (11,12).

Terapijske vežbe u prevenciji padova

Terapijske vežbe (kineziterapija) za stariju populaciju su stručno vođene i dozirane vežbe od strane fizioterapeuta i mogu se sprovoditi u krevetu, na terapijskom stolu, na strunjači, u sali za kineziterapiju i rekreaciju, u bazenu, u prirodi, individualno ili grupno. Nakon analize medicinske dokumentacije, uzimanja anamneze i utvrđivanja faktora rizika, funkcionalnom procenom se definišu mišićnoskeletna ograničenja, posebno ona koja se odnose na mišićnu snagu, izdržljivost, ravnotežu i hod. Koje terapijske vežbe će se primenjivati zavisi od nivoa funkcionalnih sposobnosti, mogućnosti održavanja određenog položaja tela i transfera. Takođe, važno je i da starija osoba učestvuje u donošenju odluka koje se tiču oblika vežbi (npr. u vodi, kroz sportske aktivnosti, kroz radnu terapiju i sl.), kao i da li će vežbe sprovoditi individualno, pod nadzorom ili grupno (13).

Druga vrsta terapijskih vežbi se odnose na pacijente u fazi rehabilitacije zbog trenutnog stanja ili faze bolesti, ali isto tako i u fazi postrehabilitacije, gde postoji potreba za održavanjem postignutog stanja i prevencijom ponovne aktivacije bolesti. Fizioterapeut prilagođava i dozira terapijske vežbe imajući u vidu osnovnu bolest, hronične bolesti i stanja, kao i nivo samostalnosti u funkcionisanju i obavljanju aktivnosti svakodnevnog života (12,13). Terapijski pokret se prilagođava svakom pacijentu u odnosu na početni položaj koji mora obezbediti maksimalnu moguću stabilnost, što predstavlja važnu meru prevencije padova. Pored toga, neophodno je izbegavati one položaje koji zahtevaju veliko opterećenje zglobova, kao što su položaji u visu (kada je telo preko ruku okačeno o neku čvrstu podlogu, švedske lestve, šipku od razboja i sl.), u uporu (npr. osloncem šakama na šipke razboja, sa nogama odvojenim od podloge) i klečeći početni položaj. Vežbe se izvode do granice bola, uz poštovanje principa zamora i prepoznavanja reakcija organizma na napor kroz praćenje vitalnih znakova (pulsa, krvnog pritiska, disanja, temperature i stanja svesti). Takođe, treba biti obazriv kod primene statičkih kontrakcija koje dugo traju, koje uključuju značajno angažovanje velikih mišića, zbog rasta krvnog pritiska i kompresije krvnih sudova (13).

Hod osoba starijih od 70 godina, pored toga što je više gegajući, ima sledeće karakteristike: veća je dinamička površina oslonca, kraća je dužina koraka i javljaju se promene u brzini hoda (12). Na poboljšanje karakteristika hoda značajno utiču višekomponentni programi, kojima po potrebi prethode vežbe za poboljšanje mišićne snage i ravnoteže,

on the floor, ground or lower levels, excluding intentional changes in position to rest in furniture, wall or other objects" (7). On average, one out of three persons aged 65 years and over falls once a year, while a third of them experience severe hip fractures (8). In the elderly, falls present one of the leading causes of mortality, loss of functional independence and disability (9).

Experts from the field of rehabilitation examine postural stability with the help of tests including standing on one leg, tests for the assessment of body stability during motion, Romberg test, functional reach test and tandem walking on a straight line. Technological progress and the introduction of computerized techniques in the form of kinesiology platforms enable the objective examination of postural stability through its visual, vestibular and proprioceptive components (10).

The aim of this review article is to analyze modern approaches within measures for the prevention and control of falls in the elderly.

Method

Published scientific studies were used as a source of data in this review article, and they were identified by searching the following electronic databases: Serbian Citation Index – SCI Index, the Serbian Library Consortium for Coordinated Acquisition – KoBSON, Google Scholar advanced search, and the PubMed platform. The search of electronic databases was conducted for the period 2003-2023. Key words during the literature search were the following: elderly population, prevention, falls, therapeutic exercises, physical activity and robotics. Thirty publications in Serbian and English were selected based on the titles and summaries of articles.

Measures for the prevention and control of falls in older adults

In order to maintain health and prevent falls, older adults are recommended multimodal exercises that include exercises for improving muscular strength and endurance, balance and flexibility through therapeutic exercises, programmed workout or exercising through activities of daily life. It is recommended to start with one type of exercises, to gradually add others, mostly in order to postpone fatigue and to adapt (11,12).

Therapeutic exercises in falls prevention

Therapeutic exercises (kinesitherapy) for the elderly population are professionally guided and dosed by physiotherapist and they can be done in bed, on a treatment table, on a mat, in a kinesitherapy and recreation room, in a swimming pool, in nature, individually or in groups. After the analysis of medical documentation, medical history taking and determination of risk factors, functional assessment defines musculoskeletal limitations, especially those related to muscular strength, endurance, balance and gait. Which therapeutic exercises will be applied depends on the level of functional abilities, the possibility of maintaining certain body positions and transfer. Also, it is important that an older adult takes part in making decisions related to the type of exercises (e.g. in the water, through sport activities, through occupational therapy etc.), as well as whether the exercises will be done individually, under supervision or in groups (13).

Another type of therapeutic exercises refers to patients in the rehabilitation phase due to the current condition or stage of the disease, as well as in the post-rehabilitation phase, where there is a need to maintain the achieved state and prevent the recurring acute phase of the disease. The physiotherapist adjusts and doses therapeutic exercises, taking into account the underlying disease, chronic diseases and conditions, as well as the level of independence related to functioning and carrying out of everyday activities (12,13). The therapeutic movement is adapted to each patient in relation to the initial position, which must ensure the maximum possible stability that is an important measure for the prevention of falls. In addition, it is necessary to avoid those positions that require great joint loading, such as hanging positions (when the body is hanging with both hands from a solid surface, Swedish ladder, stall bars, etc.), resistance training (e.g. when one is supported with hands on stall bars, while legs are separated from the floor) and the kneeling starting position. Exercises are done to the point of pain, while respecting the principle of fatigue, and recognizing the body's reactions to effort through monitoring vital signs (pulse, blood pressure, breathing, temperature and state of consciousness). Also, one should be careful when applying static contractions that last for a

a kasnije i aerobne vežbe. U početku, ovi programi su vrlo dozirani, a trajanje komponente je 5-10 minuta tokom prvih nedelja, a potom 20-30 minuta (14). Starije osobe neretko koriste pomagala prilikom hoda, ne samo u fazama rehabilitacije i postrehabilitacije, nego i kasnije. U cilju prevencije padova važno je i adaptirati prostor u kojem žive starije osobe, ukloniti sve fizičke barijere i postaviti rukohvate i pomagala za aktivnosti svakodnevnog života (15).

Programirano vežbanje kod starijih osoba

Sistematski programi za starije osobe koji su grupno vođeni nisu brojni i za njihovo sprovođenje ima više kontraindikacija nego kada se sprovode u zrelom dobu. Važno je da starije osobe shvate da telo ima sposobnost da se adaptira na vežbanje nezavisno od toga da li su ranije primenjivali vežbe ili ne (16).

Prema preporuci SZO osobe u trećem životnom dobu bi trebalo da primenjuju raznovrsnu fizičku aktivnost umerenog ili većeg intenziteta, tri i više dana u nedelji, kako bi se poboljšao funkcionalni kapacitet i prevenirali padovi (17). Za poboljšanje neuromišićnog i kardiovaskularnog sistema kod ovih osoba fizička aktivnost treba da se izvodi kroz trening sa opterećenjem dva do tri puta nedeljno, kroz tri serije od 8 do 12 ponavljanja, sa progresivnim intenzitetom 20-30% od 1RM (*Repetition Maximum* - maksimalna težina, odnosno težina koju osoba može da podigne samo jednom). U cilju poboljšanja funkcionalnih sposobnosti preporučuju se treninzi izdržljivosti (npr. pešačenje) u trajanju od 5 do 30 minuta. Kombinaciju vežbi snage, izdržljivosti i ravnoteže bi trebalo izvoditi uz postepeno povećavanje obima, intenziteta i težine vežbi (18). Istraživanja pokazuju da primena samo šetnje ne utiče na smanjenje broja padova, iako doprinosi boljoj kondiciji i ima druge blagotvorne efekte na zdravlje. Samo sistematskim i organizovanim delovanjem na slabe tačke pojedinaca specifičnim programima i prilagođenim planovima treniranja se dobijaju najbolji rezultati (19).

Treninzi za razvoj ravnoteže uglavnom uključuju vežbe sa elementima prenosa težine sa jedne na drugu nogu, hodanje po liniji, hod peta-prsti, a jedan od najpoznatijih je modifikovani *Tai Chi* program (18). *Tai Chi* program se pokazao efikasnim u smanjenju straha od pada i stope pada kod žena koje su primenjivale ovaj program u kućnim uslovima (20). Zbog zdravstvenog stanja, mnogim starijim osobama je neophodan trening ravnoteže pre primene aerobnih vežbi zbog zahtevnijih položaja ili pokreta. Međutim, i tokom izvođenja treninga ravnoteže postoji mogućnost iznenadnih padova (21).

Program za starije osobe za poboljšanje ravnoteže i smanjenje rizika od pada može da se odvija i u vodenoj sredini. Vodena sredina pojačava osećaj sigurnosti kod starijih osoba, a rizik od povređivanja je izuzetno mali. Za ovaj program potrebno je da temperatura vode u bazenu bude nešto toplija, odnosno između 29-31 stepen Celzijusa. Vežbe koje se primenjuju u ovom programu obično sadrže komponente *Tai chi*-a, *Ai chi*-a i joge (22).

„Funkcionalne vežbe integrisane u životni stil“ (engl. *Lifestyle-integrated Functional Exercise* (LiFE)) predstavlja savremeni program koji ima za cilj implementaciju vežbi snage donjih ekstremiteta i ravnoteže u svakodnevne aktivnosti kod starijih osoba. Rezultati istraživanja pokazuju da je rizik od pada smanjen za 30% kod ispitanika koji su koristili ovaj program u odnosu na program koji je sadržao lagane vežbe i program koji se sastojao od tradicionalno struktuisanih vežbi (23). Primenom LiFE programa unapređuje se održavanje statičke i dinamičke ravnoteže, utiče se na vestibularni sistem, poboljšava se ravnoteža i snaga stabilizatora donjih ekstremiteta. Vežbe su kreirane tako da se u većoj meri primenjuju u svakodnevnom životu, poput stajanja na jednoj nozi tokom peglanja, stajanja na peti i ljuljanja tela do granice stabilnosti tokom telefoniranja, izvođenja čučnjeva tokom kupovine da bi se došlo do predmeta na nižim policama i slično (23).

„Program za prevenciju padova za starije osobe koji žive u zajednici“ (engl. *Steady As You Go* (SAYGo)) ima kognitivno-bihejvioralni i fokus životne sredine. Odnosi se na kreiranje uslova u kojima starija lica pomažu jedna drugima da identifikuju sopstvene rizike od pada i daju praktične predloge o tome šta da urade kako bi smanjili te rizike. Najznačajnije promene u smanjenju zastupljenosti faktora rizika od pada su uočene unapređenjem obrazaca ponašanja poput „obraćanja pažnje“ i „preuzimanje rizika“, a usled povećanih socijalnih kontakata poboljšao se društveni život i motivacija starijih osoba (24).

long time, which include significant engagement of large muscles, due to the increase in blood pressure and compression of blood vessels (13).

The gait of persons older than 70, in addition to being somewhat waddling, has the following characteristics: the dynamic surface of support is greater, the length of steps is shorter, and there are changes in gait speed (12). The improvement of gait characteristics is influenced by multi-component programs, preceded by, if necessary, exercises to improve muscular strength and balance, and later by aerobic exercises. In the beginning, these programs are carefully dosed, while the duration of the component is 5-10 minutes during the first weeks, and later 20-30 minutes (14). Older adults often use aids while walking, not only in the rehabilitation and post-rehabilitation phases, but also later. In order to prevent falls, it is important to adapt the living space of the elderly, to remove all physical barriers and install hand rails and aids for daily activities (15).

Programmed workout for the elderly

There are not many systematic programs for the elderly that are group-led and there are more contraindications for their implementation than when they are implemented at a mature age. It is important for the elderly to understand that the body has the ability to adapt to exercise no matter whether they have done exercises before or not (16).

According to the WHO recommendations, the elderly should use diversified physical activities of moderate or greater intensity, three or more days a week, in order to improve the functional capacity and prevent falls (17). In order to improve the neuromuscular and cardiovascular system in these persons, physical activity should be performed through weight training two to three times a week, in three series of 8 to 12 repetitions, with progressive intensity of 20-30% of 1RM (Repetition Maximum – maximum weight, that is, the load for which only one repetition can be performed). In order to improve functional abilities, endurance training (e.g. walking) from 5 to 30 minutes is recommended. The combination of strength, endurance and balance exercises should be done with a gradual increase in the volume and intensity of exercises (18). Research shows that when only walking is applied, it does not reduce the number of falls, although it contributes to better physical fitness and has other beneficial effects on health. Only systematic and organized treatment of weak points of an individual with the help of specific programs and adjusted training plans give the best results (9).

Training that develops balance mostly includes exercises that shift weight from one leg to another, walking along a straight line, heel-toe walking, and one of the most famous is the modified Tai Chi program (18). Tai Chi program was shown to be effective in reducing the fear of falling and fall rates in women who applied this program at home (20). Due to their health condition, many elderly people need balance training before aerobic exercises are applied because of some demanding positions and movements. However, even during balance training there is a possibility of sudden falls (21).

A program which is used to improve balance and reduce the risk of falls among the elderly can also take place in the aquatic environment. The aquatic environment enhances the sense of security among the elderly, while the risk of injuries is extremely low. For this program, the temperature of the water in the pool needs to be slightly warmer, between 29 and 31 degrees Celsius. The exercises that are applied in this program usually contain the components of Tai chi, Ai chi and yoga (22).

Lifestyle-integrated functional exercises (LIFE) is a modern program that aims to implement strengthening exercises for lower limbs and balance exercises in daily activities among the elderly. Research results show that the risk of fall was reduced by 30% in subjects who used this program compared to the program that contained light intensity exercises and the program that consisted of traditionally structured exercises (23). The application of LIFE program improves the maintenance of static and dynamic balance, affects the vestibular system, improves the balance and strength of the lower limbs stabilizing muscles. Exercises are designed to be more applicable in everyday life, such as standing on one leg while ironing, standing on a heel, swinging the body to the margin of stability while using the phone, doing squats while shopping to reach items on lower shelves etc. (23).

Steady As You Go (SAYGo), the fall prevention program has a cognitive-behavioral and environmental focus. It implies creating conditions

Nove tehnologije i robotika u prevenciji padova

Sa razvojem tehnologije postaje dostupno sve više metoda i opreme koja se na savremeni način može iskoristiti u prevenciji padova. Postoji veliki broj rešenja koja se baziraju na otkrićima iz robotike, a koja se mogu primeniti sprovođenjem programa koji poboljšavaju sposobnost održavanja ravnoteže i posture tela. Neki robotski sistemi koji su predstavljeni u vidu elektromehaničkih uređaja sa specifičnim senzorima mogu da stupaju u interakciju sa ljudskim telom. U svrhu treninga koji utiče na smanjenje verovatnoće dešavanja pada koriste se uređaji kao što su perturbacione platforme, trake za hodanje i pokretna podnožja. Pojedine sprave mogu se koristiti u vidu konektora na telu (kukovima ili udovima) ili se mogu sastojati od spoljašnje konstrukcije koja je prilagođena da prati pokrete osobe ili je fiksirana u odnosu na okolinu. Često se susreću i kombinacije robotskih sistema u obliku opreme koja se nosi na telu i pokretnih traka i platformi po kojima se osoba kreće ili stoji. Ovim putem omogućeno je obavljanje složenih i posebno konstruisanih vežbi za poboljšanje kvaliteta hoda, koraka, održavanje statičke i dinamičke ravnoteže tela i sakupljanje digitalnih podataka čijom obradom se može usavršiti tehnika prevencije pada (25).

Pojedini robotski sistemi predstavljeni su kao inovacije koje olakšavaju život starijih ljudi u svojim domovima i predstavljeni su u vidu softverskih „robotskih trenera“, koji imaju mogućnost pokazivanja odgovarajućih vežbi i praćenja progresa tokom treninga. U ovom slučaju robotski pratilac ima važnu ulogu u praćenju učinka i motivisanja subjekta, kroz zanimljiv i zabavan interfejs. Scenario primene obuhvata učenje i ponavljanje vežbi od stručnog lica putem posmatranja i imitacije. Dok tokom rada robot izvodi vežbe i vrši nadgledanje učesnika, fizioterapeut ili drugo stručno lice povremeno vrši kućne posete i revidira program vežbanja starijih osoba (26).

Postoje roboti koji koriste pametne sisteme kako bi olakšali kretanje i upozorili korisnike na postojanje rizika od pada. Sam robot kreće se pomoću tri točka i poseduje produžetak za koji se korisnici mogu držati tokom hodanja. Poseduje i komponente u vidu kompjutera i senzora koji prate tačku težišta tela i položaja nogu osobe preračunavajući i predviđajući tok kretanja. Primena ovakve tehnologije ima velike prednosti, jer pored toga što se može koristiti u rehabilitaciji starijih osoba, može pronaći primenu i u svakodnevnim aktivnostima osoba koje imaju otežano kretanje ili povećani rizik od pada (27).

Posebno dizajnirani programi se mogu putem pametne tehnologije ugraditi u domove starijih osoba i učestvovati u njihovim svakodnevnim aktivnostima, upućivati ih u treninge i pravilno izvođenje vežbi, pratiti njihovo stanje i napredak. „Otago program vežbanja“ (engl. *The Otago Exercise Program* (OEP)) je jedan od programa zasnovanih na dokazima (jednostranih ili višestrukih) koji značajno smanjuje rizik od padova i povreda nastalih padom (16). U istraživanju publikovanom 2021. godine ovaj program je primenjivan kroz zajedničku tehnološku platformu tri puta nedeljno, tokom osam nedelja, u kućnim uslovima. Aplikacija *„FallSensing Home“* i prenosivi hardver uređaj *„Kallisto“* su omogućavali otkrivanje i prevenciju padova, a učesnici su imali pozitivne kritike. Ukazali su na potencijal koji tehnologija može pružiti u prevenciji padova i poboljšanju kvaliteta života starijih osoba (28).

U istraživanju koje je sprovedeno u pet zemalja (Belgija, Izrael, Italija, Holandija i Ujedinjeno Kraljevstvo) korišćena je aparatura za virtuelnu realnost u kombinaciji sa pokretnom trakom. Ispitanike su činile osobe starosti između 60 i 90 godina, a vežbe kognitivnih i fizičkih sposobnosti, putem ovog sistema, su realizovane tokom 6 nedelja. Sistem virtuelne realnosti se sastojao od kamere koja prati pokrete i kompjuterske simulacije projektovane na platno oko učesnika. Ovim putem stvara se iluzija stvarnog prostora u kom se osoba nalazi, a program je osmišljen tako da se učesnik suočava sa svakodnevnim problemima poput prepreka, izborom putanje i raznim faktorima distrakcije. Rezultati istraživanja pokazali su da je ovaj tip treninga doprineo smanjenoj stopi padova među učesnicima u odnosu na klasičan trening na pokretnoj traci bez virtulene realnosti (29).

Sistemi detekcije i prevencije padova još uvek predstavljaju novinu u gerijatriji, ali se velikom brzinom usavršavaju. Funkcionišu po principu prikupljanja podataka koje obrađuju putem statističkih alata i tehnika mašinskog učenja. Ovakvi sistemi mogu se sastojati od komponenti koje se instaliraju u neposrednu okolinu korisnika i kamerama prate njegovo kretanje, upozoravajući ga na određeni način o potencijalnim rizicima od pada. Takođe,

where older persons help each other to identify their own risks of falling and make practical suggestions about what to do to reduce those risks. The most significant changes in reducing the prevalence of risk factors related to falls were observed when behavioral patterns were improved, such as "paying attention" and "taking risks", while the social life and motivation of the elderly were improved due to increased social contacts (24).

New technologies and robotics in falls prevention

With the development of technology, more and more methods and equipment are becoming available that can be used in a modern way for falls prevention. There are a lot of solutions that are based on discoveries from the field of robotics, which can be applied using programs that improve the ability of maintaining balance and body posture. Some robotic systems that were presented as electromechanical devices with specific sensors can interact with the human body. Machines such as perturbation platforms, walking pads and treadmills are used for training, which affects the reduction of falling. Certain devices can be used in the form of connectors on the body (hips or limbs) or they can consist of external structure that is adapted to follow the movements of the person or is fixed in relation to the environment. Combinations of robotic systems are often seen and they include the equipment which is worn on the body and walking pads and platforms on which a person moves or stands. Thus, it is possible to do complex and specially designed exercises for improving the quality of gait, steps, maintaining the static and dynamic balance and collecting digital data, whose analysis can improve the technique of falls prevention (25).

Certain robotic systems are presented as innovations that facilitate the lives of the elderly in their homes, as well as software "robotic trainers", which are able to show appropriate exercises and monitor progress during training. In this case, the robotic companion has an important role in monitoring the performance and motivating the subject, through an interesting and fun interface. The scenario of application includes learning and repeating exercises through watching and imitating the professional. While the robot does exercises and monitors participants, the physiotherapist or other professional periodically visits the elderly at home and revises their workout program (26).

There are robots that use smart systems to facilitate movement and warn users about the risk of falling. The robot itself moves using three wheels and it has an extension that the users can hold on to while walking. It also has components in the form of computers and sensors that track the center of gravity of the body and position of the person's legs by calculating and predicting the course of moving. The application of this technology has great advantages because in addition to being used in the rehabilitation of the elderly, it can also be used in everyday activities of people who have difficulty while moving or an increased risk of falling (27).

Specially designed programs can be installed in the homes of the elderly through smart technology and take part in their daily activities, instruct them to train and do exercises correctly, monitor their condition and progress. The Otago Exercise Program (OEP) is one of the evidence-based programs (unilateral or multilateral) that significantly reduces the risk of falls and fall-related injuries (16). In a study, which was published in 2021, this program was implemented using a common technological platform three times a week, during eight weeks, in home environment. The application "FallSensing Home" and the portable hardware device "Kallisto" enabled the detection and prevention of falls, and the participants had positive reviews. They pointed to the potential that technology can provide in preventing falls and improving the quality of life of the elderly (28).

In a study, which was conducted in five countries (Belgium, Israel, Italy, the Netherlands, and the United Kingdom), virtual reality equipment was used in combination with a treadmill. The participants were persons aged 60 to 90 years, while exercises of cognitive and physical abilities, through this system, were realized during six weeks. The virtual reality system included a camera that tracked movements and computer simulations that were projected on the screen around the participants. Thus, the illusion of real space was created, and the program was designed in such a way that the participant faced everyday problems, such as obstacles, path selection and various distraction factors. The results of the study

postoje i senzorni uređaji nosivog tipa koji se lako nose na telu korisnika i koji prate njegovo izlaganje riziku od pada. Senzori su programirani i prate određene algoritme u zavisnosti od situacije u kojoj se korisnik nalazi. Ovi sistemi mogu dodatno biti podržani robotskim komponentama koje mehaničkim putem mogu pomoći osobi koja želi da napravi određeni pokret, dok su mogućnosti softverske komponente gotovo neograničene, s obzirom na to da se radi o pametnoj tehnologiji (30).

Zaključak

Prevencijom padova se bave stručnjaci iz različitih oblasti i svako sa svog aspekta treba da učestvuje u unapređenju psihofizičkih sposobnosti i kvaliteta života starijih osoba. Terapijske vežbe primenjene kroz proces rehabilitacije i postrehabilitacije imaju za cilj da kroz tretman osnovne bolesti osposobe starije osobe i na različita posturalna opterećenja, što ima krucijalni značaj u prevenciji padova. Preventivni programi vežbanja i primene fizičke aktivnosti imaju svoje značajno mesto i treba raditi na stalnom unapređenju postojećih i osmišljavanju novih programa zasnovanih na dokazima. Širenje svesti o benefitima primene terapijskih vežbi i preventivnih programa jeste značajna uloga rehabilitacionog tima, kako u centrima za rehabilitaciju, tako i u široj zajednici. Nove tehnologije, primenu robotike i veštačke inteligencije je potrebno pomno pratiti, jer mogu značajno da doprinesu poboljšanju funkcionisanja starijih osoba i prevenciji padova.

Konflikt interesa

Autori su izjavili da nema konflikta interesa.

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showed that this type of training contributed to a reduced rate of falls among participants compared to classic training on a treadmill without virtual reality (29).

Systems of falls detection and prevention are still a novelty among the elderly, but they are being improved rapidly. They function based on the principle of collecting data, which they analyze with the help of statistical tools and machine learning techniques. Such systems can consist of components that are installed in the immediate surroundings of the user and monitor his movements using cameras, thus warning him about potential risks of falling. Also, there are sensory devices that can easily be worn on the user's body and that monitor his exposure to the risk of falling. The sensors are programmed to monitor certain algorithms depending on the user's situation. These systems can additionally be supported by robotic components that can mechanically help the person who wants to make a certain movement, while the possibilities of software components are almost unlimited, given that it is smart technology (30).

Conclusion

Experts from different fields deal with falls prevention and everyone from their own perspective should take part in improving the psychophysical abilities and quality of life of the elderly. Therapeutic exercises applied in rehabilitation and post-rehabilitation processes, with the treatment of the underlying disease, aim to train older adults for different postural loads, which is of crucial importance in falls prevention. Preventive workout programs and implementation of physical activities have a significant place and therefore, the existing programs should be constantly improved and new ones should be designed based on evidence. Raising awareness about the benefits of applying therapeutic exercises and preventive programs is an important role of the rehabilitation team in rehabilitation centers, as well as in the wider community. New technologies, the application of robotics and artificial intelligence should be carefully monitored, as they can significantly contribute to the improvements related to the functioning of the elderly and falls prevention.

Competing interests

The authors declared no competing interests.

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Parts of the manuscript are: title page, summary in Serbian and English with keywords in Serbian and English, text of the manuscript (Introduction, Methods, Results, Discussion, Conclusion, Literature, Acknowledgment) and appendices.

The manuscript should be written briefly and clearly and abbreviations used only for very long names and for names known as abbreviations (eg AIDS, HIV, etc.).

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Give the name of the manuscript (in capital letters), full names of the authors, their affiliation. Associate author names with institution names indexed by Arabic numerals. Also provide the first and last name for the corresponding author, their institution, institution address, telephone number and e-mail address.

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The second page should include: the title of the manuscript, a structured summary up to 250 words and keywords in Serbian. The summary consists of four parts: Introduction/Aim, Methods, Results and Conclusion. Below the summary 3-8 keywords, should be listed. When presenting one or a series of cases, the abstract should consist of three parts: Introduction/Aim, Case report and Conclusion, and in

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Acknowledgment

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