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ŠKOLSKE INTERVENCIJE FIZIČKE AKTIVNOSTI: EFEKTI NA MOTORIČKU KOMPETENCIJU I ZDRAVSTVENO RELEVANTNE ISHODE KOD DECE – SCOPING REVIEW [1]

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Apstrakt: Nedovoljna fizička aktivnost i opadajući nivo motoričke kompetencije kod dece predstavljaju značajan javnozdravstveni problem. Shodno tome, cilj ovog scoping pregleda je da mapira i sintetiše postojeće dokaze o uticaju školskih intervencija u oblasti fizičke aktivnosti i fizičkog vaspitanja na motoričku kompetenciju dece, uz razmatranje njihove potencijalne uloge u okviru javnozdravstvenog pristupa. Ovaj scoping review sproveden je u skladu sa PRISMA-ScR smernicama. Sistematična pretraga sprovedena je u četiri elektronske baze podataka (PubMed, Web of Science, Scopus, Google Scholar). Dva nezavisna recenzenta su procenjivala studije prema unapred definisanim kriterijumima, a neslaganja su rešavana konsenzusom. U konačan pregled uključeno je osamnaest studija. Metodološki kvalitet uključenih radova u pregled procenjen je pomoću alata Effective Public Health Practice Project (EPHPP). Većina uključenih studija pokazala je pozitivne efekte školskih intervencija na motoričku kompetenciju, pogotovo u oblasti lokomotornih i manipulativnih veština. Intervencije dužeg trajanja, kao i one koje su se odlikovale strukturisanim i razvojno primerenim aktivnostima, takođe imale su pozitivan, ali i izraženiji efekat. Školske intervencije u oblasti fizičke aktivnosti i fizičkog vaspitanja predstavljaju efikasnu javnozdravstvenu strategiju za unapređenje motoričke kompetencije i podršku zdravom razvoju u detinjstvu. Jačanje kvaliteta i doslednosti školskih programa kretanja može doprineti dugoročnim zdravstvenim koristima i prevenciji bolesti na nivou populacije. Ovaj scoping review identifikuje praznine u postojećoj literaturi i predlaže pravce za buduća istraživanja u oblasti školskih intervencija motoričke kompetencije.

Ključne reči: *motorička kompetencija, fizička aktivnost, školska intervencija, zdravlje, deca*

1. UVOD

Manjak fizičke aktivnosti kod mlađe populacije predstavlja ogroman javnozdravstveni problem na globalnom nivou (World Medical Association Declaration of Helsinki, 2013; Xi et al., 2020). Svetska zdravstvena organizacija (WHO) procenjuje da više od 80% adolescenata globalno ne dostiže preporučeni nivo fizičke aktivnosti od najmanje

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60 minuta dnevno umerene do intenzivne aktivnosti (World Medical Association Declaration of Helsinki, 2013). Istraživanja sprovedena u poslednjih nekoliko decenija uočavaju drastičan pad svakodnevnih fizičkih aktivnosti uporedo sa porastom sedentarnog života kod dečije populacije (Jebeile et al., 2022; Ogden et al., 2018). Takav način života dovodi do nepovoljnih zdravstvenih ishoda u kasnijem dobu života. Nizak nivo fizičke aktivnosti u detinjstvu povezan je sa povećanim rizikom od prekomerne telesne težine i gojaznosti, smanjenom fizičkom kondicijom, lošim kardiometaboličkim zdravljem i nepovoljnim psihosocijalnim ishodima (Ogden et al., 2018; Phelps et al., 2024). Iz tog razloga promocija fizičke aktivnosti u ranom životnom dobu smatra se kao temelj prevencije bolesti, ali i unapređenje zdravlja u okviru javnozdravstvenog pristupa.

Motorička kompetencija definiše se kao stepen ovladanosti osnovnim motoričkim veštinama poput lokomotornih, manipulativnih i stabilizacionih veština (Stodden et al., 2008). Ona ima ključnu ulogu u uključivanju dece u fizičku aktivnost i njihovom ukupnom zdravom razvoju (Lopes et al., 2017). Adekvatna motorička kompetencija u detinjstvu povezana je sa višim nivoima fizičke aktivnosti, boljom fizičkom kondicijom i pozitivnijom percepcijom sopstvenih fizičkih sposobnosti (Lopes et al., 2020). Nasuprot tome, deca sa niskom motoričkom kompetencijom sklonija su izbegavanju fizičke aktivnosti, usvajanju sedentarnog načina ponašanja i razvoju negativnih zdravstvenih ishoda (De Meester et al., 2020). Iz perspektive životnog toka, motorička kompetencija nije samo posledica fizičke aktivnosti, već i njen determinant u pogledu dugoročnog učešća u kretanju, što dodatno naglašava njen značaj kao ranog javnozdravstvenog cilja (Lorås, 2020).

Škole se smatraju jednim od najefikasnijih i najpravednijih okruženja za sprovođenje intervencija fizičke aktivnosti usmerenih na unapređenje motoričke kompetencije i zdravlja dece (Verstraete et al., 2007). Kako gotovo sva deca pohađaju školu bez obzira na socioekonomski status, školske intervencije imaju potencijal da obuhvate velike i raznovrsne populacije, smanje zdravstvene nejednakosti i ostvare koristi po zdravlje na nivou populacije (Yuksel et al., 2020). Nastava fizičkog vaspitanja, strukturisani programi fizičke aktivnosti i vannastavne aktivnosti kretanja u školskom okruženju pružaju redovne prilike deci da vežbaju i razvijaju motoričke veštine u nadziranom i razvojno primerenom kontekstu (Neil-Sztramko et al., 2021). Sa javnozdravstvenog stanovišta, ovakve intervencije predstavljaju skalabilne i održive strategije primarne prevencije.

Sve veći broj istraživanja ispituje efekte školskih intervencija fizičke aktivnosti i fizičkog vaspitanja na motoričku kompetenciju dece (Costa et al., 2024; Lämmle et al., 2016; Navarro-Patón et al., 2021). Ove intervencije značajno se razlikuju u pogledu sadržaja, trajanja, intenziteta, pedagoškog pristupa i ciljne populacije. Neki programi fokusirani su na povećanje učestalosti ili kvaliteta časova fizičkog vaspitanja, dok drugi uvode dodatne strukturisane aktivnosti, sportske programe ili inovativne pristupe poput egzergaminga i interdisciplinarnih modela fizičkog vaspitanja. Pored motoričke kompetencije, brojna istraživanja bavila su se i širim zdravstveno relevantnim ishodima, uključujući nivo fizičke aktivnosti, fizičku kondiciju, sedentarna ponašanja, psihosocijalno blagostanje i kognitivno funkcionisanje, ukazujući na višedimenzionalni uticaj školskih intervencija zasnovanih na kretanju (Andermo et al., 2020; Pulling Kuhn et al., 2021). Uprkos rastućem broju interventnih studija, postojeći dokazi ostaju fragmentisani zbog heterogenosti dizajna istraživanja, instrumenata procene i mera ishoda (Guo et al., 2024; Vernadakis et al., 2015; Ye et al., 2018). Zbog toga postoji potreba za integrisanom sintezom postojeće literature koja ne samo da sumira efekte školskih intervencija fizičke aktivnosti na motoričku kompetenciju, već i smešta ove nalaze u širi javnozdravstveni kontekst. Takva sinteza može pružiti dragocene uvide u to koje vrste intervencija su najefikasnije, koji domeni motoričke kompetencije su najosetljiviji na promene i na koji način unapređenja motoričke kompetencije mogu doprineti širim zdravstvenim ishodima u detinjstvu.

Stoga je cilj ovog scoping pregleda da mapira i sintetiše postojeće dokaze o efektima školskih intervencija fizičke aktivnosti i fizičkog vaspitanja na motoričku kompetenciju dece i da razmotri njihov značaj kao javnozdravstvene strategije. Konkretno, ovaj pregled ima za cilj da:

– Identifikuje i mapira tipove školskih intervencija usmerenih na unapređenje motoričke kompetencije;
– Sintetiše nalaze o efektima ovih intervencija na različite domene motoričke kompetencije;
– Identifikuje praznine u literaturi i područja koja zahtevaju dalju istraživačku pažnju;
– Razmotri implikacije za javnozdravstvenu praksu i politiku.

2. METODE

Ova studija je sprovedena kao scoping review u skladu sa PRISMA-ScR smernicama (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews), koje predstavljaju standardizo-

vani metodološki okvir za ovaj tip pregleda literature. Scoping review metodologija omogućava mapiranje opsega i prirode dostupne literature o školskim intervencijama fizičke aktivnosti i fizičkog vaspitanja usmerenih na unapređenje motoričke kompetencije kod dece, identifikaciju ključnih koncepata, praznina u znanju i pravaca za buduća istraživanja. Implementacija ovih smernica obezbedila je sistematičan i transparentan pristup u procesu identifikovanja, selekcije i sinteze relevantnih naučnih publikacija (Page et al., 2021).

2.1. Strategija pretrage

Identifikacija relevantnih publikacija realizovana je kroz sistematičnu pretragu odabranih elektronskih baza podataka. Strategija pretrage obuhvatila je četiri naučne baze: PubMed, Web of Science, Scopus i Google Scholar. Detaljna specifikacija kombinacija ključnih reči i pretraživačkih termina na engleskom jeziku predstavljena je u tabelarnom formatu (Tabela 1).

Tabela 1. *Strategija pretrage*

Baza podataka	Strategija pretrage
PubMed	("Schools" OR "Physical Education and Training" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence" OR "fundamental movement skills") AND ("Exercise" OR "Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent" OR „children“ OR „adolescents“)
Web of Science	("Schools" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence") AND ("Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent")
Scopus	("Schools" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence") AND ("Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent")
Google Scholar	("Schools" OR "Physical Education and Training" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence" OR "fundamental movement skills") AND ("Exercise" OR "Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent" OR „children“ OR „adolescents“)

2.2. Kriterijumi uključivanja

Studije su uključene u pregled ukoliko su ispunjavale sledeće kriterijume: (1) obuhvatale decu predškolskog ili mlađeg školskog uzrasta; (2) ispitivale školske intervencije fizičke aktivnosti ili fizičkog vaspitanja sprovedene tokom redovne nastave ili u okviru vannastavnih školskih programa; (3) procenjivale motoričku kompetenciju ili motoričke veštine kao primarni ili sekundarni ishod, koristeći standardizovane ili validirane instrumente; (4) primenjivale eksperimentalni, kvazieksperimentalni ili longitudinalni interventni dizajn; i (5) bile objavljene u recenziranim naučnim časopisima na engleskom jeziku u definisanom periodu publikovanja (2007-2025).

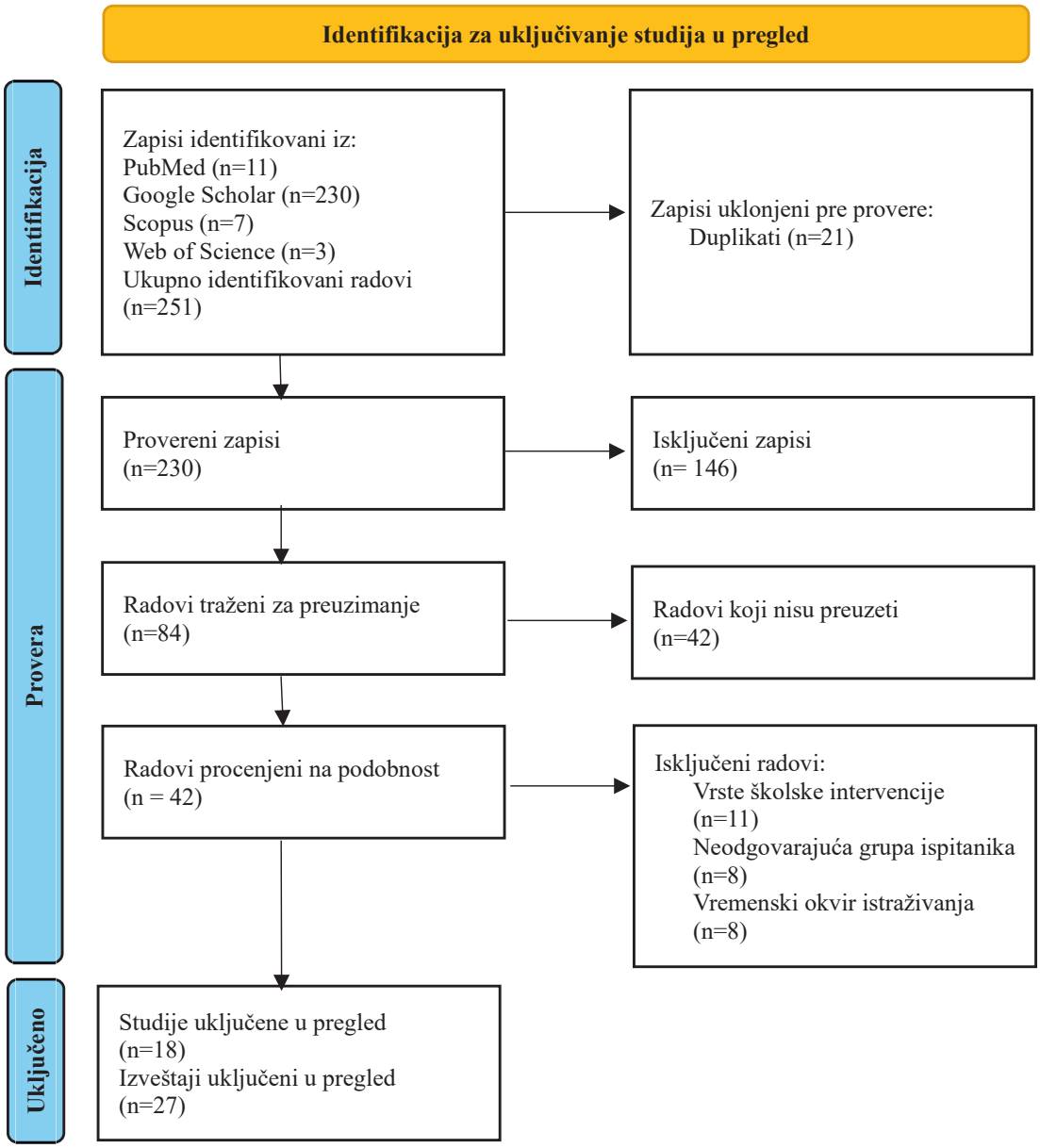
Studije su isključene ukoliko su: (1) bile usmerene isključivo na adolescentsku ili odraslu populaciju; (2) sprovedene van školskog okruženja; (3) nisu uključivale interventnu komponentu; (4) procenjivale isključivo nivo fizičke aktivnosti ili fizičku kondiciju bez mera motoričke kompetencije; ili (5) bile pregledni radovi, sažeci sa konferencija, doktorske disertacije ili publikacije koje nisu prošle recenzentski postupak.

2.3. Selekcija studija

Proces selekcije studija sproveden je u skladu sa PRISMA-ScR metodologijom kroz sledeće faze (Dijagram 1):

- Identifikacija: Sistematična pretraga četiri elektronske baze podataka.
- Skrining naslova i sažetaka: Dva nezavisna recenzenta (SD i MD) procenjivala su naslove i sažetke svih identifikovanih radova prema kriterijumima uključivanja.
- Procena prihvatljivosti: Kompletni tekstovi potencijalno relevantnih studija su detaljno analizirani od strane oba recenzenta kako bi se potvrdilo ispunjavanje svih kriterijuma uključivanja.
- Rešavanje neslaganja: Sva neslaganja između recenzenata razrešena su putem diskusije i konsenzusa.
- Uključivanje: Studije koje su jasno ispunjavale sve kriterijume zadržane su za ekstrakciju podataka i sintezu nalaza.

Dijagram 1. *PRISMA-ScR Flow dijagram procesa selekcije studija*



2.4. Ekstrakcija podataka

Podaci iz uključenih studija ekstrahovani su korišćenjem standardizovanog obrasca koji je pilot-testiran na uzorku od pet studija. Dva recenzenta su nezavisno ekstrahovala sledeće podatke iz svake studije:

– Karakteristike studije - Autor i godina publikacije; Zemlja i okruženje studije; Dizajn istraživanja; Dužina praćenja/trajanje intervencije.
– Karakteristike učesnika - Veličina uzorka (eksperimentalna i kontrolna grupa); Uzrast učesnika.
– Karakteristike intervencije - Tip intervencije (npr. fizičko vaspitanje, strukturisani programi, egzergaming); Trajanje i učestalost intervencije; Sadržaj i struktura programa.
– Mere ishoda - Primarni ishod: motorička kompetencija (instrument, domeni procenjeni); Sekundarni ishodi: nivo fizičke aktivnosti, fizička kondicija, zdravstveni parametri, psihosocijalni ishodi.
– Nalazi - Glavni rezultati vezani za motoričku kompetenciju; Efekti na sekundarne ishode.

Neslaganja u ekstrakciji podataka rešavana su diskusijom između recenzenata. Svi ekstrahovani podaci su organizovani u tabelarnom formatu (Tabela 3) i korišćeni za narativnu sintezu nalaza.

2.5. Procena kvaliteta uključenih studija

Iako procena metodološkog kvaliteta nije obavezna komponenta scoping reviews prema PRISMA-ScR smernicama (Tricco et al., 2018), kvalitet uključenih studija je procenjen korišćenjem EPHPP alata (Effective Public Health Practice Project Quality Assessment Tool) iz sledećih razloga:

– Omogućavanje kontekstualizacije nalaza i identifikacija metodoloških snaga i ograničenja postojeće evidence baze;
– Informisanje interpretacije rezultata;
– Pružanje smernica za metodološka unapređenja u budućim istraživanjima u ovoj oblasti.

EPHPP alat procenjuje šest ključnih domena: selekcionu pristrasnost, dizajn studije, konfuzione faktore, zaslepljivanje, metode prikupljanja podataka i odustajanje ispitanika. Svaka studija je klasifikovana kao jaka, umerena ili slaba (Tabela 2). Procena kvaliteta sprovedena je od strane jednog recenzenta (MD) i verifikovana od strane drugog recenzenta (SD). Ova procena nije korišćena za isključivanje studija, već isključivo za informisanje sinteze rezultata i identifikaciju praznina u metodološkoj rigoroznosti.

Tabela 2. *Metodološka procena kvaliteta uključenih studija korišćenjem EPHPP alata*

Autor (godina)	Dizajn studije	Veličina uzorka	Pristrasnost izbora	Zbunjujući faktori	Metode prikupljanja podataka	Odustajanje	Globalna ocena
Verstraete i sar. (2007)	Klaster RCT	764	Jaka	Jaka	Jaka	Umerena	Jaka
Fotrousi i sar. (2012)	Kvazi-eksperimentalna	36	Umerena	Umerena	Umerena (TGMD-2)	Jaka	Umerena
Sacchetti i sar. (2014)	Klaster intervencija	~500	Jaka	Umerena	Jaka	Umerena	Jaka
Vernadakis i sar. (2015)	Kvazi-eksperimentalna	66	Umerena	Umerena	Jaka	Umerena	Umerena
Bremer i sar. (2015)	Pilot RCT	9	Slaba	Slaba	Umerena	Umerena	Slaba
Senturk i sar. (2015a)	Kvazi-eksperimentalna	100	Umerena	Umerena	Umerena	Umerena	Umerena
Lämmle i sar. (2016)	Longitudinalna intervencija	>1500	Jaka	Jaka	Jaka	Umerena	Umerena-Jaka
Lopes i sar. (2020)	Kvazi-eksperimentalna	60	Umerena	Umerena	Jaka	Umerena	Umerena
Lo i sar. (2017)	Presečna	649.442	Umerena	Umerena	Umerena	N/A	Umerena
Ye i sar. (2018)	Kvazi-eksperimentalna	261	Umerena	Umerena	Jaka	Umerena	Umerena
Chen i sar. (2018)	Presečna	265	Umerena	Umerena	Umerena	N/A	Umerena
Navarro-Patón i sar. (2021)	Kvazi-eksperimentalna	28	Umerena	Umerena	Jaka (MABC-2)	Jaka	Umerena
Kliziene i sar. (2021)	Kvazi-eksperimentalna	186	Umerena	Umerena	Umerena	Umerena	Umerena

Zhang i sar. (2022)	Kvazi-eksperimentalna	4 odeljenja	Umerena	Umerena	Jaka (MABC-2)	Umerena	Umerena
Guo i sar. (2024a)	RCT	88	Umerena	Umerena	Jaka (MCA)	Jaka	Umerena
Nicolosi i sar. (2024)	Kvazi-eksperimentalna	76	Umerena	Umerena	Jaka (TGMD)	Umerena	Umerena
Costa i sar. (2024)	RCT	38	Umerena	Jaka	Jaka (MCA)	Umerena	Jaka
Rodrigues i sar. (2025)	Kontrolisana intervencija	1034	Jaka	Jaka	Jaka (MCA)	Umerena	Jaka

Legenda: *RCT = Randomizovano kontrolisano ispitivanje; TGMD = Test razvoja krupne motorike (Test of Gross Motor Development); MABC-2 = Baterija za procenu kretanja kod dece-2 (Movement Assessment Battery for Children-2); MCA = Procena motoričke kompetencije (Motor Competence Assessment); N/A = Nije primenjivo (Not Applicable); TGMD - 2 = Test razvoja krupne motorike – drugo izdanje (Test of Gross Motor Development - second edition)*

3. REZULTATI

Ovaj pregled je sintetisao nalaze iz 18 studija koje su ispitivale efekte školskih intervencija fizičke aktivnosti na motoričku kompetenciju i zdravstveno relevantne ishode kod dece. Studije su sprovedene u periodu od 2007. do 2025. godine i obuhvatale su različite dizajne intervencija, njihovo trajanje i raznovrsne populacije u više zemalja. Dve uključene studije imale su presečni dizajn i korišćene su za kontekstualizaciju povezanosti između motoričke kompetencije, fizičke aktivnosti i zdravstveno relevantnih ishoda, a ne za izvođenje zaključaka o efektima intervencija.

3.1. Karakteristike studija

Karakteristike uključenih studija prikazana je u Tabeli 3. Za svaku uključenu studiju izdvojene su i sumirane relevantne informacije, uključujući: autore i godinu objavljivanja; zemlju u kojoj je studija sprovedena; dizajn studije; karakteristike uzorka (raspon uzrasta i veličinu uzorka); vrstu i trajanje intervencije; instrumente procene korišćene za merenje motoričke kompetencije; kao i glavne nalaze vezane za motoričku kompetenciju i zdravstveno relevantne ishode. Ekstrakcija podataka bila je usmerena na identifikovanje obrazaca i doslednosti među studijama, a ne na izračunavanje objedinjenih veličina efekta.

Tabela 3. *Karakteristike uključenih studija*

Autor (godina)	**Zemlja**	**Starosna grupa**	**Veličina uzorka**	**Dizajn studije**	**Tip i trajanje intervencije**	**Procena motoričke kompetencije**	**Glavni ishodi**
Verstraete i sar. (2007)	Belgija	10-11 god	764	Klaster RCT	Školski program FA; 1 školska god	Motorički koordinacioni zadaci	Nivoi FA, motorička kompetencija
Fotrousi i sar. (2012)	Iran	6-7 god	36	Kvazi-eksperimentalna	Strukturisani FV program; 12 nedelja	TGMD-2	Fundamentalne motoričke veštine
Sacchetti i sar. (2013)	Italija	8-11 god	~500	Klaster intervencija	Unapređeni FV kurikulum, 2 god	Baterija motoričkih veština	Motoričke veštine, kondicija

Vernadakis i sar. (2015)	Grčka	4-6 god	66	Kvazi-eksperimentalna	FA zasnovana na eksergamingu; 8 nedelja	Testovi motoričkih veština	Ravnoteža, koordinacija
Bremer i sar. (2015)	Kanada	4-6 god	9	Pilot RCT	FA zasnovana na igri, 6 nedelja	TGMD	Sticanje motoričkih veština
Senturk i sar. (2015)	Turska	5 god	100	Kvazi-eksperimentalna	Pokretno obrazovanje, 8 nedelja	Testovi motoričkih veština	Fundamentalne motoričke veštine
Lämmle i sar. (2016)	Nemačka	6-10 god	>1500	Longitudinalna	Unapređenje kvaliteta FV, 2 godina	Baterija motoričke kompetencije	Motorička kompetencija
Lopes i sar. (2017)	Portugal	6-10 god	60	Kvazi-eksperimentalna	Strukturisane FA sesije, 24 nedelja	Testovi motoričke koordinacije	Motorička kompetencija
Lo i sar. (2017)	Tajland	6-11 god	649,442	Presečna	---	Proksi motorički indikatori	FA, rizik gojaznosti
Chen i sar. (2018)	SAD	11 god	265	Presečna	---	Procena motoričkih veština	FA, kondicija
Ye i sar. (2018)	Kina	6-9 god	261	Kvazi-eksperimentalna	Školska FA; 9 meseci	Testovi motoričke kompetencije	Motorička kompetencija
Navarro-Patón i sar. (2021)	Španija	4-5 god	28	Kvazi-eksperimentalna	Psihomotorni program; 6 nedelja	MABC-2	Motorička kompetencija
Kliziene i sar. (2021)	Litvanija	6-9 god	186	Kvazi-eksperimentalna	Intervencija zasnovana na FV; 8 meseci	Baterija motoričkih veština	Motoričke veštine
Zhang i sar. (2022)	Kina	6-7 god	4 odeljenja	Kvazi-eksperimentalna	FV intervencija; 12 nedelja	MABC-2	Motorička kompetencija
Guo i sar. (2024)	Kina	3-5 god	88	RCT	Strukturisana FA; 8 nedelja	MCA	Motorička kompetencija
Nicolosi i sar. (2024)	Italija	8-10 god	76	Kvazi-eksperimentalna	Unapređenje FV, 12 nedelja	TGMD	Motorička kompetencija
Costa i sar. (2024)	Portugal	9-10 god	38	RCT	FA + FV intervencija, 12 nedelja	MCA	Motorička kompetencija, FA
Rodrigues i sar. (2025)	Portugal	6-12 god	1034	Kontrolisana intervencija	Školska FA; 12 nedelja	MCA	Motorička kompetencija, zdravlje

Legenda: *FA = Fizička aktivnost; FV = Fizičko vaspitanje; RCT = Randomizovano kontrolisano ispitivanje; TGMD = Test razvoja krupne motorike (Test of Gross Motor Development); MABC-2 = Baterija za procenu kretanja kod dece-2 (Movement Assessment Battery for Children-2); MCA = Procena motoričke kompetencije (Motor Competence Assessment)*

3.2. Efekti na motoričku kompetenciju

Motorička kompetencija bila je primarni ishod u većini studija, pri čemu su procene bile usmerene na osnovne motoričke veštine, uključujući lokomotorne veštine, veštine kontrole objekta i stabilizacione veštine. Korišćeni su različiti instrumenti procene, među kojima su Test razvoja krupne motorike (TGMD i TGMD-2), Baterija za procenu kretanja kod dece (MABC-2) i Procena motoričke kompetencije (MCA). Tradicionalne intervencije u okviru fizičkog vaspitanja pokazale su značajna poboljšanja motoričke kompetencije. Rodrigues i sar. (2025) su izvestili o značajnim naprecima u motoričkoj kompetenciji kroz program „Super Quinas“, koji je obuhvatio 1.034 dece, pri čemu su poboljšanja uočena u svim domenima motoričkih veština. Slično tome, Lopes i sar. (2017) su utvrdili da strukturisani programi fizičkog vaspitanja efikasno unapređuju motoričku kompetenciju kod dece osnovnoškolskog uzrasta, naglašavajući značaj adekvatnih prilika za vežbanje i razvojno primerenih aktivnosti. Nicolosi i sar. (2024) su pokazali da interdisciplinarni program fizičkog vaspitanja dovodi do značajno većih poboljšanja u veštinama kontrole objekta i lokomotornim veštinama u poređenju sa tradicionalnim pristupima zasnovanim na vežbama. Eksperimentalna grupa je pokazala velike veličine efekta za veštine kontrole objekta kod oba pola, kao i značajna poboljšanja lokomotornih veština, naročito kod devojčica. Ovi nalazi ukazuju na to da integrativni nastavni pristupi koji povezuju fizičko vaspitanje sa drugim nastavnim oblastima mogu biti efikasniji od konvencionalnih metoda. Značaj tipa i kvaliteta intervencije dodatno su istakli Guo i sar. (2024), koji su upoređivali strukturisane sportske igre sa psihomotornim aktivnostima kod dece predškolskog uzrasta. Rezultati su pokazali da su strukturisane sportske igre dovele do značajno boljih ishoda u lokomotornom i manipulativnom domenu u poređenju sa psihomotornim aktivnostima i kontrolnim uslovima, uz veličine efekta koje su se kretale od srednjih do velikih (d = 0,783 do 0,998). Autori su ove povoljnije ishode pripisali takmičarskoj, socijalnoj i motivišućoj prirodi strukturisanih igara. Intervencije koje uključuju tehnologiju takođe su pokazale potencijal. Vernadakis i sar. (2015) su ispitivali egzergaming kao dopunsku intervenciju i utvrdili umerene pozitivne efekte na osnovne motoričke veštine kada se primenjuje u kombinaciji sa tradicionalnim fizičkim vaspitanjem. Međutim, Ye i sar. (2018) su izvestili o mešovitim rezultatima kod intervencija zasnovanih na egzergamingu, uz značajna poboljšanja mišićno-koštane kondicije i indeksa telesne mase (BMI), ali ograničene efekte na kardiorespiratornu kondiciju i veštine kontrole objekta u poređenju sa tradicionalnim pristupima fizičkog vaspitanja. Trajanje intervencije pokazalo se kao važan faktor. Lämmle i sar. (2016) su pokazali da duže intervencije (dve godine) dovode do trajnih poboljšanja motoričkih veština, pri čemu su deca iz interventne grupe zadržala značajno viši nivo motoričke kompetencije u poređenju sa kontrolnom grupom. Slično tome, Zhang i sar. (2022) su utvrdili da čak i 12-nedeljna intervencija može rezultirati značajnim poboljšanjima manuelne spretnosti, gađanja i hvatanja, kao i ukupne motoričke kompetencije, naročito kada su aktivnosti bile specifično osmišljene da ciljaju ove veštine. Specifične populacije takođe su imale koristi od ciljanih intervencija. Bremer i sar. (2015) su pokazali da su deca sa poremećajem iz spektra autizma ostvarila poboljšanja u osnovnim motoričkim veštinama nakon ciljane intervencije, iako mala veličina uzorka (n = 9) ograničava mogućnost generalizacije nalaza. Fotrousi i sar. (2012) su izvestili o poboljšanjima kod dece sa razvojnim poremećajem koordinacije kroz kompenzatorne programe kretanja, ističući potencijal adaptiranih programa fizičke aktivnosti u odgovoru na specifične razvojne potrebe.

3.3. Efekti na nivo fizičke aktivnosti

Više studija ispitivalo je uticaj intervencija na ukupne nivoe fizičke aktivnosti, pri čemu su uglavnom zabeleženi pozitivni nalazi. Verstraete i sar. (2007) su izvestili o značajnom povećanju nivoa fizičke aktivnosti, merenih akcelerometrijom, u interventnoj grupi u poređenju sa kontrolnom grupom, pri čemu su deca ostvarivala znatno više umerene do intenzivne fizičke aktivnosti (MVPA) tokom časova fizičkog vaspitanja, ali i tokom celokupnog školskog dana. Costa i sar. (2024) su utvrdili da sveobuhvatna školska intervencija koja je obuhvatala časove fizičkog vaspitanja, aktivnosti tokom odmora i aktivne pauze dovodi do značajnih poboljšanja u dnevnim nivoima fizičke aktivnosti, kvalitetu sna, aerobnoj kondiciji i motoričkoj kompetenciji. Ova studija je istakla značaj višekomponentnih intervencija koje prevazilaze okvire tradicionalne nastave fizičkog vaspitanja i doprinose stvaranju školskog okruženja koje podstiče kretanje. Međutim, nisu sve studije zabeležile ujednačeno povećanje fizičke aktivnosti. Lo i sar. (2017), u velikoj presečnoj studiji koja je obuhvatila 649.442 dece, utvrdili su složene odnose između učešća u nastavi fizičkog vaspitanja i nivoa fizičke aktivnosti, ukazujući na to da samo fizičko vaspitanje možda nije dovoljno

za postizanje preporučenih dnevnih nivoa fizičke aktivnosti bez dodatnih podržavajućih komponenti i izmena u okruženju.

3.4. Efekti na zdravstveno povezanu fizičku kondiciju

Ishodi vezani za zdravstveno povezanu fizičku kondiciju, uključujući kardiorespiratornu kondiciju, mišićnu snagu i fleksibilnost, pokazali su dosledna poboljšanja u više studija. Cohen i sar. (2015) su izvestili o značajnim poboljšanjima kardiorespiratorne kondicije i mišićne snage nakon klasterske intervencije koja je obuhvatila približno 460 dece. Intervencija je kombinovala strukturisane kondicione aktivnosti sa komponentama razvoja motoričkih veština. Lämmle i sar. (2016) su pokazali trajna poboljšanja komponenti fizičke kondicije tokom dvogodišnjeg interventnog perioda, sa naročito izraženim naprecima u aerobnoj sposobnosti i mišićnoj izdržljivosti. Ovi nalazi ukazuju na to da dugotrajne intervencije mogu dovesti do stabilnih adaptacija u zdravstveno povezanoj fizičkoj kondiciji koje mogu doprineti dugoročnim zdravstvenim koristima. Costa i sar. (2024) su zabeležili značajna poboljšanja aerobne kondicije merene testom trčanja sa progresivnim opterećenjem na 20 metara, pri čemu je interventna grupa nakon intervencije imala znatno više procenjene vrednosti VO_2max u poređenju sa kontrolnom grupom. Ova poboljšanja kardiorespiratorne kondicije posebno su značajna imajući u vidu njihovu povezanost sa smanjenim faktorima rizika za kardiovaskularne bolesti i unapređenim metaboličkim zdravljem.

3.5. Kognitivni i akademski ishodi

Nastajuća oblast istraživanja odnosi se na veze između intervencija fizičke aktivnosti i kognitivnog funkcionisanja. Zhang i sar. (2022) su utvrdili da 12 nedelja posebno osmišljene intervencije fizičke aktivnosti dovodi do značajnog poboljšanja efikasnosti radne memorije kod dece predškolskog uzrasta, merenog 1-back zadatkom. Značajno je da je studija identifikovala pozitivne korelacije između poboljšanja radne memorije i unapređenja ravnoteže i globalne motoričke kompetencije, što ukazuje na moguće recipročne odnose između motoričkog i kognitivnog razvoja. Chen i sar. (2018) su u presečnoj studiji ispitivali odnos između motoričke kompetencije i školskog uspeha i utvrdili pozitivne povezanosti između osnovnih motoričkih veština i pokazatelja akademskog postignuća. Iako se iz presečnih podataka ne može utvrditi uzročnost, ovi nalazi podržavaju hipotezu da razvoj motoričke kompetencije može doprineti širim obrazovnim ishodima kroz unapređeno kognitivno funkcionisanje i veću uključenost u školske aktivnosti.

3.6. Psihosocijalni ishodi

Nekoliko studija ispitivalo je psihosocijalne ishode, uključujući percipiranu motoričku kompetenciju, samoefikasnost i uživanje u fizičkoj aktivnosti. Nicolosi i sar. (2024) su procenjivali percipiranu motoričku kompetenciju uporedo sa stvarnim izvođenjem motoričkih veština, ali su rezultati u vezi sa promenama u percepciji bili nejednoznačni. Ovo ukazuje na složenost odnosa između stvarne i percipirane kompetencije, koje se mogu razvijati različitim razvojnim putanjama. Gu i sar. (2016) su ispitivali motivacione aspekte intervencija fizičke aktivnosti i utvrdili da programi koji uključuju nastavne strategije koje podržavaju autonomiju i pružaju pozitivnu povratnu informaciju unapređuju intrinzičnu motivaciju dece za fizičku aktivnost. Ovi nalazi naglašavaju značaj dizajna intervencija koji, pored razvoja veština, obuhvata i motivacione i afektivne dimenzije učešća. Sgrò i sar. (2019) su ispitivali kako različiti pristupi proceni mogu uticati na motivaciju i angažovanje dece u nastavi fizičkog vaspitanja, sugerišući da autentične, izvođenjem zasnovane procene mogu biti efikasnije od tradicionalnih testova fizičke kondicije u podsticanju pozitivnih stavova prema fizičkoj aktivnosti.

3.7. Komponente i karakteristike intervencija

Uspešne intervencije imale su nekoliko zajedničkih karakteristika. Prvo, obezbeđivale su adekvatne prilike za vežbanje uz razvojno primerene aktivnosti prilagođene nivou veština dece. Drugo, uključivale su raznovrsne aktivnosti koje su održavale interesovanje i angažovanost dece. Treće, sprovodili su ih kvalifikovani nastavnici ili su bile obezbeđene opsežne obuke nastavnika kako bi se osigurala visoka kvalitetna realizacija. Četvrto, intervencije su često prevazilazile okvire tradicionalnih časova fizičkog vaspitanja kroz dodatne prilike za kretanje tokom odmora, pre i posle škole ili kroz uključivanje porodice. Kliziene i sar. (2021) su naglasili značaj doslednosti sprovođenja intervencije i pripreme nastavnika, utvrdivši da su intervencije koje su realizovali dobro obučeni instruktori

dovele do značajno boljih ishoda u poređenju sa onima uz minimalnu stručnu podršku. Slično tome, Senturk i sar. (2015) su istakli ulogu stručnosti instruktora u podsticanju motoričkog razvoja, naročito kod mlađe dece kojoj je potrebna individualizovanija pažnja i povratna informacija. Navarro-Patón i sar. (2021) su pokazali da čak i relativno kratke intervencije (šest nedelja) mogu dovesti do značajnih poboljšanja kada su specifično usmerene na decu sa identifikovanim razvojnim potrebama, što ukazuje na to da intenzivne i fokusirane intervencije mogu biti posebno vredne u rešavanju razvojnih kašnjenja ili poremećaja.

4. DISKUSIJA

Ovaj pregled pruža sveobuhvatne dokaze da školske intervencije fizičke aktivnosti mogu efikasno unaprediti motoričku kompetenciju i podstaći zdravstveno relevantne ishode kod dece. Sinteza 18 studija sprovedenih tokom gotovo dve decenije ukazuje na dosledne pozitivne efekte u različitim populacijama, okruženjima i pristupima intervencijama, ali istovremeno naglašava važne nijanse u pogledu optimalnih strategija implementacije. Iako je većina uključenih studija ocenjena kao metodološki jaka ili umerena, dominacija kvazieksperimentalnih dizajna treba da se uzme u obzir prilikom tumačenja uzročno-posledičnih odnosa.

4.1. Razvoj motoričke kompetencije kao osnova

Snažni i dosledni dokazi o unapređenju motoričke kompetencije u svim studijama podržavaju teorijske okvire koji motoričku kompetenciju posmatraju kao osnovni element za uključivanje u fizičku aktivnost i zdravlje tokom celog životnog veka (Stodden et al., 2008). Razvoj osnovnih motoričkih veština u detinjstvu obezbeđuje „rečnik pokreta“ neophodan za učešće u različitim fizičkim aktivnostima, sportovima i igrama, čime se potencijalno uspostavljaju pozitivne putanje fizičke aktivnosti koje se nastavljaju u adolescenciji i odraslom dobu (Kriemler et al., 2011). Nalazi Guo i sar. (2024) i Nicolosi i sar. (2024) ukazuju na to da nisu sve aktivnosti razvoja motoričkih veština podjednako efikasne. Strukturisane i ciljano osmišljene aktivnosti koje uključuju elemente izazova, progresije i angažovanosti pokazuju bolje ishode u poređenju sa manje strukturisanim pristupima. Ovo je u skladu sa savremenim pedagoškim okvirima koji naglašavaju značaj dizajna zadataka, jasnoće instrukcija i primerene progresije u razvoju motoričkih veština (Lubans et al., 2010). Dokazi da interdisciplinarni pristupi Nicolosi i sar. (2024) mogu unaprediti razvoj motoričkih veština u odnosu na tradicionalne metode ukazuju na mogućnosti kurikularnih inovacija. Integrisanje razvoja motoričkih veština sa akademskim sadržajima može doprineti prevazilaženju vremenskih ograničenja i istovremeno podržati više obrazovnih ciljeva, što je posebno relevantno u kontekstu sve veće konkurencije za nastavno vreme u školama.

4.2. Promocija fizičke aktivnosti izvan fizičkog vaspitanja

Iako časovi fizičkog vaspitanja predstavljaju važno okruženje za razvoj motoričkih veština, nalazi Costa i sar. (2024) i drugih studija ukazuju na to da sveobuhvatni pristupi koji obuhvataju više prilika za kretanje tokom školskog dana ostvaruju snažnije efekte u poređenju sa samim časovima fizičkog vaspitanja. Ovaj nalaz je u skladu sa okvirima Sveobuhvatnog školskog programa fizičke aktivnosti (CSPAP), koji zagovaraju integrisane, celokupne školske pristupe promociji fizičke aktivnosti. Velika studija Lo i sar. (2017) pruža važan kontekst za tumačenje doprinosa fizičkog vaspitanja ukupnom nivou fizičke aktivnosti. Iako učešće u nastavi fizičkog vaspitanja pokazuje pozitivne veze sa nivoima aktivnosti, jačina tih veza sugeriše da samo fizičko vaspitanje ne može obezbediti ispunjavanje preporučenih dnevnih smernica fizičke aktivnosti. Ovo naglašava potrebu za komplementarnim strategijama, uključujući aktivne odmore, aktivan odlazak u školu i inicijative koje uključuju porodicu i zajednicu. Izazov pretvaranja unapređene motoričke kompetencije u dugoročno učešće u fizičkoj aktivnosti ostaje važno pitanje. Iako unapređene motoričke veštine teorijski olakšavaju uključivanje u fizičku aktivnost, ovaj proces nije automatski i može zavisiti od brojnih faktora, uključujući socijalnu podršku, mogućnosti u okruženju i motivacione orijentacije. Buduće intervencije trebalo bi eksplicitno da adresiraju ove kontekstualne faktore kako bi se maksimalno iskoristio potencijal motoričke kompetencije za uspostavljanje doživotnih obrazaca fizičke aktivnosti.

4.3. Ishodi zdravstveno povezane fizičke kondicije

Dosledna poboljšanja komponenti zdravstveno povezane fizičke kondicije u različitim studijama pružaju ohrabrujuće dokaze da školske intervencije mogu pozitivno uticati na fiziološke pokazatelje zdravlja dece. Poboljšanja kardiorespiratorne kondicije su posebno značajna imajući u vidu snažnu obrnutu povezanost između nivoa kondicije i faktora rizika za kardiovaskularne bolesti, metabolički sindrom i ukupnu smrtnost (Lee et al., 1999). Nalazi Lämmle i sar. (2016) o trajnim poboljšanjima tokom dugoročnih intervencija posebno su vredni, jer ukazuju na to da školski programi mogu dovesti do dugotrajnih adaptacija, a ne samo prolaznih efekata. Ovo ima važne implikacije za dizajn intervencija i alokaciju resursa, podržavajući ulaganje u dugoročne, sveobuhvatne programe umesto kratkoročnih inicijativa. Međutim, heterogenost metoda procene kondicije među studijama otežava direktna poređenja i sprovođenje metaanaliza. Standardizacija protokola procene unapredila bi mogućnost sinteze nalaza i utvrđivanja odnosa doza-odgovor između karakteristika intervencija i ishoda kondicije. Takođe, buduća istraživanja trebalo bi da ispitaju da li se poboljšanja kondicije prevode u klinički značajne promene zdravstvenih pokazatelja, poput krvnog pritiska, lipidnog profila i metabolizma glukoze.

4.4. Nastajući dokazi o kognitivnim koristima

Preliminarni dokazi Zhang i sar. (2022) i Donnelly i sar. (2016) o poboljšanju radne memorije posebno su intrigantni i u skladu su sa rastućim brojem istraživanja koja ukazuju na to da fizička aktivnost unapređuje kognitivno funkcionisanje kroz različite mehanizme, uključujući povećan protok krvi u mozgu, neuroplastičnost i neurohemijske adaptacije. Uočene korelacije između napretka u motoričkoj kompetenciji i kognitivnih poboljšanja ukazuju na potencijalno sinergijske odnose koji zaslužuju dalja istraživanja. Presečne povezanosti između motoričke kompetencije i školskog uspeha koje su prijavili Chen i sar. (2018) dodatno podržavaju integrisane pristupe koji fizički i kognitivni razvoj posmatraju kao međusobno povezane, a ne konkurentne prioritete. Ipak, potrebne su longitudinalne studije sa robusnim dizajnom kako bi se utvrdili uzročni odnosi i identifikovali specifični mehanizmi koji stoje u osnovi uočenih veza. Ovi nalazi imaju važne implikacije za obrazovnu politiku i praksu. Dokazi da intervencije fizičke aktivnosti mogu podržati kognitivne i akademske ishode mogu ojačati argumente za očuvanje ili proširenje nastave fizičkog vaspitanja i prilika za fizičku aktivnost u školama, naročito u kontekstima u kojima se takvi programi suočavaju sa budžetskim ili kurikularnim pritiscima. Posmatranje fizičke aktivnosti kao podrške, a ne konkurencije akademskim ciljevima, može doprineti obezbeđivanju institucionalne podrške i resursa.

4.5. Intervencije potpomognute tehnologijom

Nedosledni rezultati u studijama koje su ispitivale egzergaming i druge tehnološki podržane intervencije ukazuju na to da se ovakvi pristupi najbolje posmatraju kao dopuna, a ne zamena za konvencionalnu nastavu fizičkog vaspitanja (Verstraete et al., 2007; Ye et al., 2018). Iako egzergaming može ponuditi prednosti poput veće angažovanosti i dostupnosti, dostupni dokazi ne podržavaju njegovu nadmoć u odnosu na dobro osmišljene tradicionalne intervencije u razvoju motoričkih veština. Ipak, tehnološki potpomognuti pristupi mogu imati posebnu vrednost za određene populacije ili kontekste. Za decu sa ograničenim pristupom sportskim objektima, decu sa invaliditetom koja otežano učestvuju u tradicionalnim aktivnostima ili u sredinama sa nepovoljnim klimatskim uslovima, egzergaming i slične tehnologije mogu predstavljati vredne alternativne mogućnosti za kretanje. Buduća istraživanja trebalo bi da identifikuju specifične kontekste i populacije u kojima tehnološki potpomognute intervencije imaju najveću relativnu prednost.

4.6. Perspektive nauke o implementaciji

Nalazi Kliziene i sar. (2021) i Senturk i sar. (2015), koji naglašavaju kvalitet implementacije i pripremljenost nastavnika, ukazuju na kritične, ali često zanemarene aspekte interventnih istraživanja. Efikasnost u idealnim istraživačkim uslovima ne garantuje i delotvornost u realnim školskim okruženjima, gde se resursi, stručnost i doslednost sprovođenja mogu značajno razlikovati. Okviri nauke o implementaciji, koji sistematski razmatraju barijere i faktore koji olakšavaju usvajanje, sprovođenje i održivost intervencija, od suštinskog su značaja za prenos istraživačkih nalaza u široku praksu. Profesionalni razvoj nastavnika nameće se kao ključna poluga uspeha intervencija. Mnogi učitelji koji su zaduženi za nastavu fizičkog vaspitanja u nižim razredima osnovne škole nemaju obimnu

obuku iz oblasti motoričkog razvoja i pedagogije fizičke aktivnosti. Ulaganje u kontinuirane programe stručnog usavršavanja, dostupne nastavne materijale i sisteme podrške u implementaciji moglo bi značajno unaprediti kvalitet i uticaj školskih intervencija. Održivost predstavlja još jedno ključno pitanje. Kratkoročne istraživačke studije, čak i kada su uspešne, ne garantuju dugoročno sprovođenje programa nakon završetka istraživačke podrške. Buduća istraživanja trebalo bi eksplicitno da ispitaju faktore koji podržavaju održivu implementaciju, uključujući administrativnu podršku, raspodelu resursa, partnerstva sa zajednicom i integraciju sa postojećim školskim prioritetima i sistemima.

4.7. Metodološka razmatranja i ograničenja

Nekoliko metodoloških ograničenja treba uzeti u obzir. Prvo, dominacija kvazieksperimentalnih dizajna ograničava uzročno-posledične zaključke, te buduća istraživanja treba da prioritetizuju RCT dizajne kada god je to izvodljivo. Drugo, heterogenost mera ishoda otežava poređenja između studija, pa bi uspostavljanje standardizovanih skupova ishoda olakšalo sintezu nalaza. Treće, pristrasnost publikovanja verovatno utiče na dostupnu bazu dokaza jer su studije sa negativnim nalazima ređe objavljene, što zahteva oprezno tumačenje pretežno pozitivnih rezultata. Četvrto, većina studija je procenjivala neposredne ishode (motoričke veštine, kondiciju) uz ograničeno ispitivanje dugoročnih efekata na trajno učešće u fizičkoj aktivnosti, zdravstveni status ili kvalitet života, što naglašava potrebu za longitudinalnim istraživanjima.

4.8. Implikacije za praksu i politiku

Akumulirani dokazi podržavaju nekoliko ključnih preporuka. Prvo, škole treba da prioritetizuju razvoj motoričke kompetencije kroz nastavne planove koji obezbeđuju dovoljno vremena za učenje osnovnih motoričkih veština uz odgovarajuću progresiju. Drugo, sveobuhvatni pristupi koji uključuju aktivne odmore, pauze u učionici, aktivno kretanje do škole i angažovanje porodice efikasniji su od izolovanih intervencija, te škole treba da usvoje celokupne školske pristupe usklađene sa CSPAP okvirima. Treće, neophodna su ulaganja u stručno usavršavanje nastavnika koje obuhvata sadržajna znanja i pedagoške pristupe uz kontinuiranu podršku. Četvrto, politike moraju osigurati adekvatnu vremensku zastupljenost-najmanje 150 minuta nedeljno za učenike osnovne škole. Peto, sistematski skrining i višeslojni sistemi intervencija mogu obezbediti da sva deca, uključujući ona sa motoričkim teškoćama, dobiju odgovarajuću podršku i prilike za razvoj.

4.9. Pravci budućih istraživanja

Nekoliko istraživačkih prioriteta zahteva pažnju. Prvo, neophodno je ispitati odnose doza-odgovor kako bi se optimizovalo trajanje, učestalost i intenzitet intervencija. Drugo, longitudinalne studije treba da razjasne mehanizme koji povezuju motoričku kompetenciju sa dugoročnim zdravstvenim ishodima, identifikujući ključne medijatore i moderatore. Treće, direktna poređenja različitih pristupa uz standardizovane protokole procene pružila bi jasne smernice za izbor najefikasnijih strategija. Ekonomske analize isplativosti, koje obuhvataju direktne troškove i dugoročne zdravstvene uštede, neophodne su za donošenje odluka na nivou politike. Konačno, istraživanja moraju ispitati varijabilnost efekata među demografskim grupama i identifikovati strategije za smanjenje nejednakosti, osiguravajući da sva deca imaju podjednaku korist od školskih programa fizičke aktivnosti.

4.10. Ograničenja studije

Ovaj scoping review ima nekoliko važnih ograničenja koja treba uzeti u obzir pri tumačenju nalaza.

Pristrasnost jezika: Pretraga je ograničena na radove objavljene na engleskom jeziku, što može isključiti relevantne studije publikovane na drugim jezicima, posebno u zemljama gde engleski nije primarni jezik naučne komunikacije. Ovo može dovesti do anglocentrične pristrasnosti u sintezi nalaza i potencijalno zanemariti intervencije razvijene i evaluirane u neanglofonim kontekstima.

Izbor baza podataka: Iako su korišćene četiri glavne elektronske baze (PubMed, Web of Science, Scopus, Google Scholar), uključivanje Google Scholar-a kao izvora "sive literature" može uvesti pristrasnost kvaliteta, s obzirom da ova platforma sadrži i radove koji nisu prošli rigorozan recenzentski postupak. Ipak, odlučili smo da uključimo Google Scholar kako bismo obuhvatili širi spektar dokaza, posebno iz manje zastupljenih geografskih oblasti.

Heterogenost mera: Značajna heterogenost u instrumentima procene motoričke kompetencije (npr. TGMD-2, MABC-2, KTK, Eurofit) i različitim definicijama konstrukta otežava direktno poređenje nalaza između studija. Ova heterogenost onemogućava kvantitativnu meta-analizu i zahteva opreznost u generalizaciji zaključaka. Različiti instrumenti procenjuju različite aspekte motoričke kompetencije (npr. produktivne vs. procesne veštine), što može dovesti do različitih zaključaka o efektivnosti intervencija.

Heterogenost intervencija: Studije su uključivale širok spektar intervencija (fizičko vaspitanje, strukturisani programi, egzergaming) sa različitim trajanjima (šest nedelja do dve godine), frekvencijom i intenzitetom. Ova varijabilnost otežava identifikaciju specifičnih komponenti intervencija koje su najefektivnije za unapređenje motoričke kompetencije.

Uprkos ovim ograničenjima, ovaj scoping review pruža sveobuhvatan pregled postojeće literature o školskim intervencijama motoričke kompetencije i identifikuje ključne pravce za buduća istraživanja.

5. ZAKLJUČAK

Ovaj pregled pruža snažne dokaze da školske intervencije fizičke aktivnosti efikasno unapređuju motoričku kompetenciju i zdravstveno relevantne ishode kod dece. Doslednost pozitivnih nalaza u različitim okruženjima i populacijama potvrđuje značaj škola kao ključnih mesta za promociju fizičke aktivnosti. Uprkos metodološkim ograničenjima, akumulirani dokazi opravdavaju nastavak ulaganja u visokokvalitetne školske programe. Razvoj motoričke kompetencije u detinjstvu predstavlja ulaganje u doživotno zdravlje. Omogućavanjem svim učenicima prilike da razviju osnovne motoričke veštine, škole doprinose pozitivnim zdravstvenim putanjama koje nadilaze detinjstvo. Kako stope gojaznosti rastu, a nivoi fizičke aktivnosti opadaju, školski programi nude skalabilan i pravičan pristup zasnovan na dokazima. Iz perspektive javnog zdravlja, intervencije usmerene na motoričku kompetenciju nisu opcione aktivnosti za obogaćivanje, već neophodne komponente strategija promocije zdravlja dece.

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SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTIONS: EFFECTS ON MOTOR COMPETENCE AND HEALTH-RELATED OUTCOMES IN CHILDREN – A SCOPING REVIEW [1]

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Abstract: Insufficient physical activity and declining levels of motor competence among children represent a significant public health concern. Accordingly, the aim of this scoping review was to map and synthesize the existing evidence on the effects of school-based physical activity and physical education interventions on children's motor competence, while considering their potential role within a public health framework. This scoping review was conducted in accordance with the PRISMA-ScR guidelines. A systematic literature search was carried out across four electronic databases (PubMed, Web of Science, Scopus, and Google Scholar). Two independent reviewers assessed the studies based on predefined eligibility criteria, and disagreements were resolved by consensus. A total of eighteen studies were included in the final review. The methodological quality of the included studies was assessed using the Effective Public Health Practice Project (EPHPP) quality assessment tool. The majority of the included studies demonstrated positive effects of school-based interventions on motor competence, particularly in the domains of locomotor and manipulative skills. Interventions of longer duration, as well as those characterized by structured and developmentally appropriate activities, also showed positive and more pronounced effects. School-based physical activity and physical education interventions represent an effective public health strategy for improving motor competence and supporting healthy development in childhood. Strengthening the quality and consistency of school-based movement programs may contribute to long-term health benefits and disease prevention at the population level. This scoping review identifies gaps in the existing literature and proposes directions for future research in the field of school-based motor competence interventions.

Keywords: *motor competence, physical activity, school-based intervention, health, children*

1. INTRODUCTION

The lack of physical activity among the younger population represents a significant public health issue at the global level (World Medical Association Declaration of Helsinki, 2013; Xi et al., 2020). The World Health Organization (WHO) estimates that over 80% of adolescents globally do not meet the recommended level of physical activity of

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at least 60 minutes daily of moderate to vigorous activity (World Medical Association Declaration of Helsinki, 2013). Research conducted over the past few decades has observed a drastic decline in daily physical activities alongside an increase in sedentary lifestyles among the child population (Jebeile et al., 2022; Ogden et al., 2018). This lifestyle leads to adverse health outcomes at later stages of life. Low levels of physical activity in childhood are associated with increased risk of excess weight and obesity, reduced physical fitness, poor cardiometabolic health, and adverse psychosocial outcomes (Ogden et al., 2018; Phelps et al., 2024). For this reason, the promotion of physical activity in early life is considered the foundation of disease prevention as well as health improvement within the public health approach.

Motor competence is defined as the degree of mastery of fundamental motor skills such as locomotor, manipulative, and stabilization skills (Stodden et al., 2008). It plays a key role in children's engagement in physical activity and their overall healthy development (Lopes et al., 2017). Adequate motor competence in childhood is associated with higher levels of physical activity, better physical fitness, and more positive perception of one's own physical abilities (Lopes et al., 2020). Conversely, children with low motor competence are more prone to avoiding physical activity, adopting sedentary behaviors, and developing negative health outcomes (De Meester et al., 2020). From a life course perspective, motor competence is not only a consequence of physical activity, but also its determinant in terms of long-term participation in movement, which further emphasizes its importance as an early public health target (Lorås, 2020).

Schools are considered one of the most effective and equitable settings for implementing physical activity interventions aimed at improving motor competence and children's health (Verstraete et al., 2007). As nearly all children attend school regardless of their socioeconomic status, school-based interventions have the potential to reach large and diverse populations, reduce health inequalities, and achieve health benefits at the overall population level (Yuksel et al., 2020). Physical education classes, structured physical activity programs, and extracurricular movement activities in school environment provide regular opportunities for children to practice and develop motor skills in a supervised and developmentally appropriate context (Neil-Sztramko et al., 2021). From a public health perspective, such interventions represent scalable and sustainable primary prevention strategies.

An increasing number of studies have examined the effects of school-based physical activity and physical education interventions on children's motor competence (Costa et al., 2024; Lämmle et al., 2016; Navarro-Patón et al., 2021). These interventions vary considerably in terms of content, duration, intensity, pedagogical approach, and target population. Some programs focus on increasing the frequency or quality of physical education classes, while others introduce additional structured activities, sports programs, or innovative approaches such as exergaming and interdisciplinary physical education models. In addition to motor competence, numerous studies have addressed broader health-relevant outcomes, including physical activity levels, physical fitness, sedentary behaviors, psychosocial well-being, and cognitive functioning, indicating the multidimensional impact of school-based movement interventions (Andermo et al., 2020; Pulling Kuhn et al., 2021). Despite the growing number of intervention studies, existing evidence remains fragmented due to the heterogeneity of research designs, assessment instruments, and outcome measures (Guo et al., 2024; Vernadakis et al., 2015; Ye et al., 2018). Therefore, there is a need for an integrated synthesis of the existing literature that not only summarizes the effects of school-based physical activity interventions on motor competence, but also places these findings in a broader public health context. Such a synthesis can provide valuable insights into which types of interventions are most effective, which domains of motor competence are most sensitive to change, and how improvements in motor competence can contribute to broader health outcomes in childhood.

Therefore, the aim of this scoping review is to map and synthesize the existing evidence on the effects of school-based physical activity and physical education interventions on children's motor competence and to consider their significance as a public health strategy. Specifically, this review aims to:

- Identify and map types of school-based interventions aimed at improving motor competence;
- Synthesize findings on the effects of these interventions on different domains of motor competence;
- Identify gaps in the literature and areas requiring further research attention;
- Consider implications for public health practice and policy.

2. METHOD

This study was conducted as a scoping review in accordance with the PRISMA-ScR guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews), which represent a standardized methodological framework for this type of literature review. The scoping review methodology enables

mapping of the scope and nature of available literature on school-based physical activity and physical education interventions aimed at improving motor competence in children, and identifying key concepts, knowledge gaps, and directions for future research. The implementation of these guidelines ensured a systematic and transparent approach in the process of identifying, selecting, and synthesizing relevant scientific publications (Page et al., 2021).

2.1. Search Strategy

The identification of relevant publications was carried out through a systematic search of selected electronic databases. The search strategy encompassed four scientific databases: PubMed, Web of Science, Scopus, and Google Scholar. A detailed specification of keyword combinations and search terms in English is presented in the following tabular format (Table 1).

Table 1. *Search Strategy*

Database	Search Strategy
PubMed	("Schools" OR "Physical Education and Training" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence" OR "fundamental movement skills") AND ("Exercise" OR "Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent" OR „children“ OR „adolescents“)
Web of Science	("Schools" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence") AND ("Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent")
Scopus	("Schools" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence") AND ("Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent")
Google Scholar	("Schools" OR "Physical Education and Training" OR school-based) AND ("Motor Skills" OR "Motor Activity" OR "motor competence" OR "fundamental movement skills") AND ("Exercise" OR "Physical Fitness" OR "physical activity") AND ("Child" OR "Adolescent" OR „children“ OR „adolescents“)

2.2. Inclusion Criteria

Studies were included in the review if they met the following criteria: (1) they involved preschool or primary school-aged children; (2) they examined school-based physical activity or physical education interventions conducted during regular classes or within extracurricular school programs; (3) they assessed motor competence or motor skills as a primary or secondary outcome, using standardized or validated instruments; (4) they applied an experimental, quasi-experimental, or longitudinal intervention design; and (5) they were published in peer-reviewed scientific journals in English within the defined publication period (2007-2025).

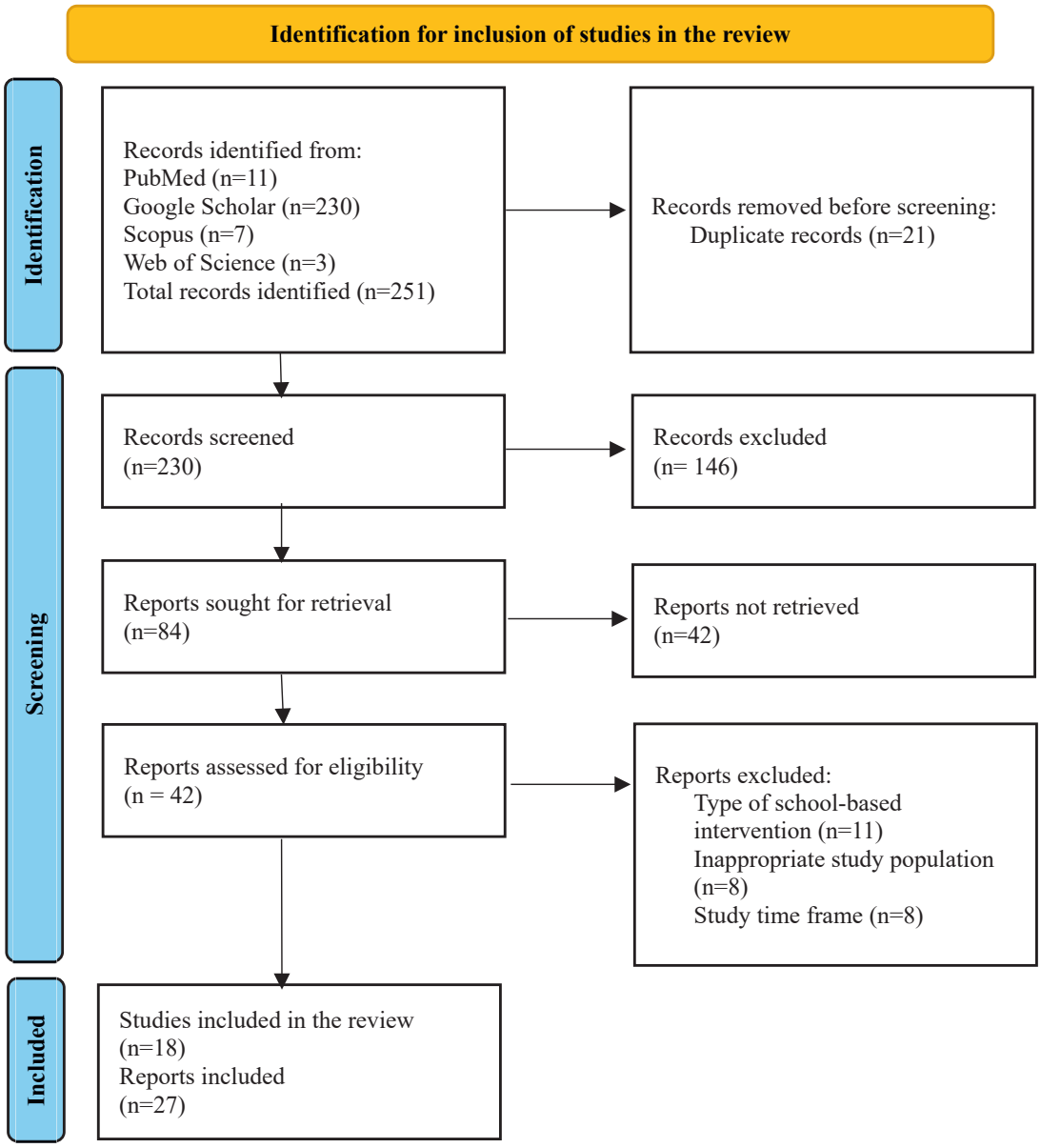
Studies were excluded if they: (1) were focused exclusively on adolescent or adult populations; (2) were conducted outside the school environment; (3) did not include an intervention component; (4) assessed exclusively physical activity levels or physical fitness without measures of motor competence; or (5) were review articles, conference abstracts, doctoral dissertations, or publications that had not undergone peer review.

2.3. Study Selection

The study selection process was conducted in accordance with the PRISMA-ScR methodology through the following phases (Diagram 1):

- Identification: Systematic search of four electronic databases.
- Screening of titles and abstracts: Two independent reviewers (SD and MD) assessed the titles and abstracts of all identified articles according to the inclusion criteria.
- Eligibility assessment: Full texts of potentially relevant studies were analyzed in detail by both reviewers to confirm fulfillment of all inclusion criteria.
- Resolution of disagreements: All disagreements between reviewers were resolved through discussion and consensus.
- Inclusion: Studies that clearly met all criteria were retained for data extraction and synthesis of findings.

Diagram 1. *PRISMA-ScR Flow diagram of the study selection process*



2.4. Data Extraction

The data from included studies were extracted using a standardized form that was pilot-tested on a sample of five studies. Two reviewers independently extracted the following data from each study:

- Study characteristics - Author and year of publication; Country and study setting; Research design; Follow-up duration/intervention duration.
- Participant characteristics - Sample size (experimental and control groups); Age of participants.
- Intervention characteristics - Type of intervention (e.g., physical education, structured programs, exergaming); Duration and frequency of intervention; Program content and structure.
- Outcome measures - Primary outcome: motor competence (instrument, domains assessed); Secondary outcomes: physical activity level, physical fitness, health parameters, psychosocial outcomes.
- Findings - Main results related to motor competence; Effects on secondary outcomes.

Disagreements in data extraction were resolved through discussion between reviewers. All extracted data were organized in tabular format (Table 3) and used for narrative synthesis of findings.

2.5. Quality Assessment of Included Studies

Although methodological quality assessment is not a mandatory component of scoping reviews according to PRISMA-ScR guidelines (Tricco et al., 2018), the quality of the included studies was assessed using the EPHPP tool (Effective Public Health Practice Project Quality Assessment Tool) for the following reasons:

- Enabling contextualization of findings and identification of methodological strengths and limitations of the existing evidence base;
- Informing the interpretation of results;
- Providing guidance for methodological improvements in future research in this area.

The EPHPP tool assesses six key domains: selection bias, study design, confounders, blinding, data collection methods, and withdrawals and dropouts. Each study was classified as strong, moderate, or weak (Table 2). Quality assessment was conducted by one reviewer (MD) and verified by another reviewer (SD). This assessment was not used to exclude studies, but solely to inform the synthesis of results and identify gaps in methodological rigor.

Table 2. *Methodological quality assessment of included studies using EPHPP tool*

Author (year)	Study design	Sample size	Selection bias	Confounders	Data collection methods	Withdrawals	Global rating
Verstraete i sar. (2007)	Cluster RCT	764	Strong	Strong	Strong	Moderate	Strong
Fotrousi i sar. (2012)	Quasi-experimental	36	Moderate	Moderate	Moderate (TGMD-2)	Strong	Moderate
Sacchetti i sar. (2014)	Cluster intervention	~500	Strong	Moderate	Strong	Moderate	Strong
Vernadakis i sar. (2015)	Quasi-experimental	66	Moderate	Moderate	Strong	Moderate	Moderate
Bremer i sar. (2015)	Pilot RCT	9	Weak	Weak	Moderate	Moderate	Weak
Senturk i sar. (2015a)	Quasi-experimental	100	Moderate	Moderate	Moderate	Moderate	Moderate
Lämmle i sar. (2016)	Longitudinal intervention	>1500	Strong	Strong	Strong	Moderate	Moderate-Strong
Lopes i sar. (2020)	Quasi-experimental	60	Moderate	Moderate	Strong	Moderate	Moderate
Lo i sar. (2017)	Cross-sectional	649.442	Moderate	Moderate	Moderate	N/A	Moderate
Ye i sar. (2018)	Quasi-experimental	261	Moderate	Moderate	Strong	Moderate	Moderate
Chen i sar. (2018)	Cross-sectional	265	Moderate	Moderate	Moderate	N/A	Moderate
Navarro-Patón i sar. (2021)	Quasi-experimental	28	Moderate	Moderate	Strong (MABC-2)	Strong	Moderate
Kliziene i sar. (2021)	Quasi-experimental	186	Moderate	Moderate	Moderate	Moderate	Moderate

Zhang i sar. (2022)	Quasi-experimental	4 clasess	Moderate	Moderate	Strong (MABC-2)	Moderate	Moderate
Guo i sar. (2024a)	RCT	88	Moderate	Moderate	Strong (MCA)	Strong	Moderate
Nicolosi i sar. (2024)	Quasi-experimental	76	Moderate	Moderate	Strong (TGMD)	Moderate	Moderate
Costa i sar. (2024)	RCT	38	Moderate	Strong	Strong (MCA)	Moderate	Strong
Rodrigues i sar. (2025)	Controlled intervention	1034	Strong	Strong	Strong (MCA)	Moderate	Strong

Legend: *RCT = Randomized Controlled Trial; TGMD = Test of Gross Motor Development; MABC-2 = Movement Assessment Battery for Children, Second Edition; MCA = Motor Competence Assessment; N/A = Not Applicable; TGMD-2 = Test of Gross Motor Development, Second Edition*

3. RESULTS

This review synthesized findings from 18 studies that examined the effects of school-based physical activity interventions on motor competence and health-relevant outcomes in children. The studies were conducted between 2007 and 2025 and encompassed different intervention designs, their duration, and diverse populations across multiple countries. Two included studies had a cross-sectional design and were used to contextualize the associations between motor competence, physical activity, and health-relevant outcomes, rather than to conclude the effects of the interventions.

3.1. Study Characteristics

The characteristics of the included studies are presented in Table 3. For each included study, relevant information was extracted and summarized, including: authors and year of publication; country where the study was conducted; study design; sample characteristics (age range and sample size); type and duration of intervention; assessment instruments used to measure motor competence; as well as main findings related to motor competence and health-relevant outcomes. Data extraction was focused on identifying patterns and consistency among studies, rather than calculating pooled effect sizes.

Table 3. *Characteristics of included studies*

Author (year)	Country	Age group	Sample size	Study design	Intervention type and duration	Motor competence assessment	Main outcomes
Verstraete et al. (2007)	Belgium	10-11 years	764	Cluster RCT	School PA program; 1 school year	Motor coordination tasks	PA levels, motor competence
Fotrousi et al. (2012)	Iran	6-7 years	36	Quasi-experimental	Structured PE program; 12 weeks	TGMD-2	Fundamental motor skills
Sacchetti et al. (2013)	Italy	8-11 years	~500	Cluster intervention	Enhanced PE curriculum, 2 years	Motor skills battery	Motor skills, fitness

Vernadakis et al. (2015)	Greece	4-6 years	66	Quasi-experimental	Exergaming-based PA; 8 weeks	Motor skills tests	Balance, coordination
Bremer et al. (2015)	Canada	4-6 years	9	Pilot RCT	Play-based PA, 6 weeks	TGMD	Motor skill acquisition
Senturk et al. (2015)	Turkey	5 years	100	Quasi-experimental	Movement education, 8 weeks	Motor skills tests	Fundamental motor skills
Lämmle et al. (2016)	Germany	6-10 years	>1500	Longitudinal	PE quality enhancement, 2 years	Motor competence battery	Motor competence
Lopes et al. (2017)	Portugal	6-10 years	60	Quasi-experimental	Structured PA sessions, 24 weeks	Motor coordination tests	Motor competence
Lo et al. (2017)	Thailand	6-11 years	649,442	Cross-sectional	---	Proxy motor indicators	PA, obesity risk
Chen et al. (2018)	SAD	11 years	265	Cross-sectional	---	Motor skills assessment	PA, fitness
Ye et al. (2018)	China	6-9 years	261	Quasi-experimental	School-based PA; 9 months	Motor competence tests	Motor competence
Navarro-Patón et al. (2021)	Spain	4-5 years	28	Quasi-experimental	Psychomotor program; 6 weeks	MABC-2	Motor competence
Kliziene et al. (2021)	Lithuania	6-9 years	186	Quasi-experimental	PE-based intervention; 8 months	Motor skills battery	Motor skills
Zhang et al. (2022)	China	6-7 years	4 classes	Quasi-experimental	PE intervention; 12 weeks	MABC-2	Motor competence
Guo et al. (2024)	China	3-5 years	88	RCT	Structured PA; 8 weeks	MCA	Motor competence
Nicolosi et al. (2024)	Italy	8-10 years	76	Quasi-experimental	PE enhancement, 12 weeks	TGMD	Motor competence
Costa et al. (2024)	Portugal	9-10 years	38	RCT	FA + PE intervention, 12 weeks	MCA	Motor competence, PA
Rodrigues et al. (2025)	Portugal	6-12 years	1034	Controlled intervention	School-based PA; 12 weeks	MCA	Motor competence, health

Legend: *PA = Physical Activity; PE = Physical Education; RCT = Randomized Controlled Trial; TGMD = Test of Gross Motor Development; MABC-2 = Movement Assessment Battery for Children, Second Edition; MCA = Motor Competence Assessment*

3.2. Effects on Motor Competence

Motor competence was the primary outcome in the majority of studies, with assessments focused on fundamental motor skills, including locomotor skills, object control skills, and stabilization skills. Various assessment instruments were used, including the Test of Gross Motor Development (TGMD and TGMD-2), the Movement Assessment Battery for Children (MABC-2), and the Motor Competence Assessment (MCA). Traditional physical education interventions showed significant improvements in motor competence. Rodrigues et al. (2025) reported significant advances in motor competence through the "Super Quinas" program, which included 1,034 children, with improvements observed across all domains of motor skills. Similarly, Lopes et al. (2017) found that structured physical education programs effectively enhance motor competence in primary school-aged children, emphasizing the importance of adequate practice opportunities and developmentally appropriate activities. Nicolosi et al. (2024) demonstrated that an interdisciplinary physical education program leads to significantly greater improvements in object control skills and locomotor skills compared to traditional exercise-based approaches. The experimental group showed large effect sizes for object control skills in both sexes, as well as significant improvements in locomotor skills, particularly among girls. These findings indicate that integrative teaching approaches that connect physical education with other curricular areas may be more effective than conventional methods. The importance of intervention type and quality was further highlighted by Guo et al. (2024), who compared structured sports games with psychomotor activities in preschool children. The results showed that structured sports games led to significantly better outcomes in the locomotor and manipulative domains compared to psychomotor activities and control conditions, with effect sizes ranging from medium to large ($d = 0.783$ to 0.998). The authors attributed these more favorable outcomes to the competitive, social, and motivating nature of structured games. Technology-based interventions also showed potential. Vernadakis et al. (2015) examined exergaming as a supplementary intervention and found moderate positive effects on fundamental motor skills when applied in combination with traditional physical education. However, Ye et al. (2018) reported mixed results for exergaming-based interventions, with significant improvements in musculoskeletal fitness and body mass index (BMI), but limited effects on cardiorespiratory fitness and object control skills compared to traditional physical education approaches. Intervention duration proved to be an important factor. Lämmle et al. (2016) showed that longer interventions (2 years) lead to sustained improvements in motor skills, with children from the intervention group maintaining significantly higher levels of motor competence compared to the control group. Similarly, Zhang et al. (2022) found that even a 12-week intervention can result in significant improvements in manual dexterity, aiming and catching, as well as overall motor competence, particularly when activities were specifically designed to target these skills. Specific populations also benefited from targeted interventions. Bremer et al. (2015) showed that children with autism spectrum disorder achieved improvements in fundamental motor skills following a targeted intervention, although the small sample size ($n = 9$) limits the generalizability of the findings. Fotrousi et al. (2012) reported improvements in children with developmental coordination disorder through compensatory movement programs, highlighting the potential of adapted physical activity programs in responding to specific developmental needs.

3.3. Effects on Physical Activity Levels

Multiple studies examined the impact of interventions on overall physical activity levels, with predominantly positive findings reported. Verstraete et al. (2007) reported a significant increase in physical activity levels, measured by accelerometry, in the intervention group compared to the control group, with children achieving considerably more moderate to vigorous physical activity (MVPA) during physical education classes, as well as throughout the entire school day. Costa et al. (2024) found that a comprehensive school intervention that included physical education classes, recess activities, and active breaks led to significant improvements in daily physical activity levels, sleep quality, aerobic fitness, and motor competence. This study highlighted the importance of multicomponent interventions that extend beyond the framework of traditional physical education classes and contribute to creating a school environment that promotes movement. However, not all studies recorded consistent increases in physical activity. Lo et al. (2017), in a large cross-sectional study that included 649,442 children, found complex relationships between participation in physical education classes and physical activity levels, indicating that physical education alone may not be sufficient to achieve recommended daily physical activity levels without additional supporting components and environmental modifications.

3.4. Effects on Health-Related Physical Fitness

Outcomes related to health-related physical fitness, including cardiorespiratory fitness, muscular strength, and flexibility, showed consistent improvements across multiple studies. Cohen et al. (2015) reported significant improvements in cardiorespiratory fitness and muscular strength following a cluster intervention that included approximately 460 children. The intervention combined structured conditioning activities with motor skill development components. Lämmle et al. (2016) demonstrated sustained improvements in physical fitness components over a two-year intervention period, with particularly pronounced advances in aerobic capacity and muscular endurance. These findings indicate that long-term interventions can lead to stable adaptations in health-related physical fitness that may contribute to long-term health benefits. Costa et al. (2024) recorded significant improvements in aerobic fitness measured by the 20-meter progressive shuttle run test, with the intervention group having considerably higher estimated VO_2max values compared to the control group after the intervention. These improvements in cardiorespiratory fitness are particularly significant given their association with reduced risk factors for cardiovascular disease and improved metabolic health.

3.5. Cognitive and Academic Outcomes

An emerging area of research concerns the links between physical activity interventions and cognitive functioning. Zhang et al. (2022) found that 12 weeks of a specially designed physical activity intervention leads to significant improvement in working memory efficiency in preschool children, measured by the 1-back task. Importantly, the study identified positive correlations between working memory improvements and enhancements in balance and global motor competence, suggesting possible reciprocal relationships between motor and cognitive development. Chen et al. (2018), in a cross-sectional study, examined the relationship between motor competence and academic achievement and found positive associations between fundamental motor skills and indicators of academic performance. Although causality cannot be established from cross-sectional data, these findings support the hypothesis that motor competence development may contribute to broader educational outcomes through improved cognitive functioning and greater engagement in school activities.

3.6. Psychosocial Outcomes

Several studies examined psychosocial outcomes, including perceived motor competence, self-efficacy, and enjoyment in physical activity. Nicolosi et al. (2024) assessed perceived motor competence alongside actual motor skill performance, but the results regarding changes in perception were equivocal. This indicates the complexity of the relationship between actual and perceived competence, which may develop along different developmental trajectories. Gu et al. (2016) examined motivational aspects of physical activity interventions and found that programs incorporating teaching strategies that support autonomy and provide positive feedback enhance children's intrinsic motivation for physical activity. These findings emphasize the importance of intervention design that, in addition to skill development, encompasses motivational and affective dimensions of participation. Sgrò et al. (2019) investigated how different assessment approaches can influence children's motivation and engagement in physical education classes, suggesting that authentic, performance-based assessments may be more effective than traditional physical fitness tests in promoting positive attitudes toward physical activity.

3.7. Intervention Components and Characteristics

Successful interventions had several common characteristics. First, they provided adequate practice opportunities with developmentally appropriate activities tailored to children's skill levels. Second, they included diverse activities that maintained children's interest and engagement. Third, they were implemented by qualified teachers or extensive teacher training was provided to ensure high-quality delivery. Fourth, interventions often extended beyond the framework of traditional physical education classes through additional movement opportunities during recess, before and after school, or through family involvement. Kliziene et al. (2021) emphasized the importance of intervention implementation consistency and teacher preparation, finding that interventions delivered by well-trained instructors led to significantly better outcomes compared to those with minimal professional support. Similarly, Senturk et al. (2015) highlighted the role of instructor expertise in promoting motor development, particularly among younger children who require more individualized attention and feedback. Navarro-Patón et al. (2021)

showed that even relatively short interventions (6 weeks) can lead to significant improvements when specifically targeted at children with identified developmental needs, indicating that intensive and focused interventions may be particularly valuable in addressing developmental delays or disorders.

4. DISCUSSION

This review provides comprehensive evidence that school-based physical activity interventions can effectively enhance motor competence and promote health-relevant outcomes in children. The synthesis of 18 studies conducted over nearly two decades indicates consistent positive effects across different populations, settings, and intervention approaches, while simultaneously highlighting important nuances regarding optimal implementation strategies. Although the majority of included studies were rated as methodologically strong or moderate, the dominance of quasi-experimental designs should be taken into account when interpreting causal relationships.

4.1. Motor Competence Development as Foundation

Strong and consistent evidence of motor competence improvement across all studies supports theoretical frameworks that view motor competence as a fundamental element for engagement in physical activity and health throughout the lifespan (Stodden et al., 2008). The development of fundamental motor skills in childhood provides the "movement vocabulary" necessary for participation in various physical activities, sports, and games, potentially establishing positive physical activity trajectories that continue into adolescence and adulthood (Kriemler et al., 2011). The findings of Guo et al. (2024) and Nicolosi et al. (2024) indicate that not all motor skill development activities are equally effective. Structured and purposefully designed activities that incorporate elements of challenge, progression, and engagement show better outcomes compared to less structured approaches. This is consistent with contemporary pedagogical frameworks that emphasize the importance of task design, clarity of instruction, and appropriate progression in motor skill development (Lubans et al., 2010). The evidence that interdisciplinary approaches by Nicolosi et al. (2024) can enhance motor skill development compared to traditional methods points to possibilities for curricular innovations. Integrating motor skill development with academic content can help overcome time constraints while simultaneously supporting multiple educational objectives, which is particularly relevant in the context of increasing competition for instructional time in schools.

4.2. Physical Activity Promotion Beyond Physical Education

Although physical education classes represent an important setting for motor skill development, the findings of Costa et al. (2024) and other studies indicate that comprehensive approaches that encompass multiple movement opportunities throughout the school day achieve stronger effects compared to physical education classes alone. This finding is consistent with the Comprehensive School Physical Activity Program (CSPAP) frameworks, which advocate for integrated, whole-school approaches to physical activity promotion. The large study by Lo et al. (2017) provides important context for interpreting the contribution of physical education to overall physical activity levels. Although participation in physical education classes shows positive associations with activity levels, the strength of these associations suggests that physical education alone cannot ensure compliance with recommended daily physical activity guidelines. This emphasizes the need for complementary strategies, including active recess, active transportation to school, and initiatives involving family and community. The challenge of converting improved motor competence into long-term physical activity participation remains an important issue. Although improved motor skills theoretically facilitate engagement in physical activity, this process is not automatic and may depend on numerous factors, including social support, environmental opportunities, and motivational orientations. Future interventions should explicitly address these contextual factors to maximize the potential of motor competence for establishing lifelong physical activity patterns.

4.3. Health-Related Physical Fitness Outcomes

Consistent improvements in health-related physical fitness components across various studies provide encouraging evidence that school-based interventions can positively influence physiological indicators of children's

health. Improvements in cardiorespiratory fitness are particularly significant given the strong inverse association between fitness levels and risk factors for cardiovascular disease, metabolic syndrome, and overall mortality (Lee et al., 1999). The findings of Lämmle et al. (2016) regarding sustained improvements during long-term interventions are especially valuable, as they indicate that school programs can lead to lasting adaptations rather than merely transient effects. This has important implications for intervention design and resource allocation, supporting investment in long-term, comprehensive programs instead of short-term initiatives. However, the heterogeneity of fitness assessment methods among studies makes direct comparisons and meta-analyses difficult. Standardization of assessment protocols would enhance the ability to synthesize findings and establish dose-response relationships between intervention characteristics and fitness outcomes. Additionally, future research should examine whether fitness improvements translate into clinically significant changes in health indicators, such as blood pressure, lipid profile, and glucose metabolism.

4.4. Emerging Evidence on Cognitive Benefits

The preliminary evidence from Zhang et al. (2022) and Donnelly et al. (2016) regarding working memory improvement is particularly intriguing and consistent with a growing body of research indicating that physical activity enhances cognitive functioning through various mechanisms, including increased cerebral blood flow, neuroplasticity, and neurochemical adaptations. The observed correlations between motor competence improvements and cognitive enhancements suggest potentially synergistic relationships that merit further investigation. The cross-sectional associations between motor competence and academic achievement reported by Chen et al. (2018) further support integrated approaches that view physical and cognitive development as interconnected rather than competing priorities. However, longitudinal studies with robust designs are needed to establish causal relationships and identify the specific mechanisms underlying the observed associations. These findings have important implications for educational policy and practice. Evidence that physical activity interventions can support cognitive and academic outcomes may strengthen arguments for preserving or expanding physical education classes and physical activity opportunities in schools, particularly in contexts where such programs face budgetary or curricular pressures. Viewing physical activity as supporting rather than competing with academic goals may help secure institutional support and resources.

4.5. Technology-Assisted Interventions

The inconsistent results in studies examining exergaming and other technology-supported interventions indicate that such approaches are best viewed as supplements rather than replacements for conventional physical education instruction (Verstraete et al., 2007; Ye et al., 2018). Although exergaming may offer advantages such as greater engagement and accessibility, the available evidence does not support its superiority over well-designed traditional interventions in motor skill development. Nevertheless, technology-assisted approaches may have particular value for certain populations or contexts. For children with limited access to sports facilities, children with disabilities who have difficulty participating in traditional activities, or in environments with adverse climatic conditions, exergaming and similar technologies may represent valuable alternative movement opportunities. Future research should identify specific contexts and populations in which technology-assisted interventions have the greatest relative advantage.

4.6. Implementation Science Perspectives

The findings of Kliziene et al. (2021) and Senturk et al. (2015), which emphasize implementation quality and teacher preparedness, point to critical yet often overlooked aspects of intervention research. Efficacy under ideal research conditions does not guarantee effectiveness in real school environments, where resources, expertise, and implementation consistency may differ significantly. Implementation science frameworks, which systematically consider barriers and facilitating factors for intervention adoption, delivery, and sustainability, are essential for translating research findings into widespread practice. Teacher professional development emerges as a key lever for intervention success. Many teachers responsible for physical education instruction in lower elementary grades lack extensive training in motor development and physical activity pedagogy. Investment in continuous professional development programs, accessible teaching materials, and implementation support systems could significantly en-

hance the quality and impact of school-based interventions. Sustainability represents another crucial issue. Short-term research studies, even when successful, do not guarantee long-term program implementation after research support concludes. Future research should explicitly examine factors that support sustainable implementation, including administrative support, resource allocation, community partnerships, and integration with existing school priorities and systems.

4.7. Methodological Considerations and Limitations

Several methodological limitations should be taken into account. First, the dominance of quasi-experimental designs limits causal inferences, and future research should prioritize RCT designs whenever feasible. Second, the heterogeneity of outcome measures makes comparisons across studies difficult, and establishing standardized outcome sets would facilitate the synthesis of findings. Third, publication bias likely affects the available evidence base as studies with negative findings are published less frequently, requiring cautious interpretation of predominantly positive results. Fourth, most studies assessed immediate outcomes (motor skills, fitness) with limited examination of long-term effects on sustained physical activity participation, health status, or quality of life, which emphasizes the need for longitudinal research.

4.8. Implications for Practice and Policy

The accumulated evidence supports several key recommendations. First, schools should prioritize motor competence development through curricula that provide sufficient time for learning fundamental motor skills with appropriate progression. Second, comprehensive approaches that include active recess, classroom breaks, active transportation to school, and family engagement are more effective than isolated interventions, and schools should adopt whole-school approaches aligned with CSPAP frameworks. Third, investments in teacher professional development are essential, encompassing content knowledge and pedagogical approaches with ongoing support. Fourth, policies must ensure adequate time allocation—at least 150 minutes weekly for elementary school students. Fifth, systematic screening and multi-tiered intervention systems can ensure that all children, including those with motor difficulties, receive appropriate support and developmental opportunities.

4.9. Future Research Directions

Several research priorities require attention. First, it is necessary to examine dose-response relationships to optimize intervention duration, frequency, and intensity. Second, longitudinal studies should clarify the mechanisms linking motor competence with long-term health outcomes, identifying key mediators and moderators. Third, direct comparisons of different approaches using standardized assessment protocols would provide clear guidance for selecting the most effective strategies. Economic cost-effectiveness analyses, encompassing direct costs and long-term health savings, are essential for policy-level decision-making. Finally, research must examine effect variability among demographic groups and identify strategies for reducing inequalities, ensuring that all children benefit equally from school-based physical activity programs.

4.10. Study Limitations

This scoping review has several important limitations that should be considered when interpreting the findings.

Language bias: The search was limited to articles published in English, which may exclude relevant studies published in other languages, particularly in countries where English is not the primary language of scientific communication. This may lead to Anglocentric bias in the synthesis of findings and potentially overlook interventions developed and evaluated in non-Anglophone contexts.

Database selection: Although four major electronic databases were used (PubMed, Web of Science, Scopus, Google Scholar), the inclusion of Google Scholar as a source of "grey literature" may introduce quality bias, given that this platform contains articles that have not undergone rigorous peer review. Nevertheless, we decided to include Google Scholar to encompass a broader spectrum of evidence, particularly from underrepresented geographical areas.

Measurement heterogeneity: Significant heterogeneity in motor competence assessment instruments (e.g., TGMD-2, MABC-2, KTK, Eurofit) and different construct definitions makes direct comparison of findings across studies difficult. This heterogeneity precludes quantitative meta-analysis and requires caution in generalizing conclusions. Different instruments assess different aspects of motor competence (e.g., product vs. process skills), which may lead to different conclusions about intervention effectiveness.

Intervention heterogeneity: Studies included a broad spectrum of interventions (physical education, structured programs, exergaming) with varying durations (6 weeks to 2 years), frequency, and intensity. This variability makes it difficult to identify specific intervention components that are most effective for improving motor competence.

Despite these limitations, this scoping review provides a comprehensive overview of existing literature on school-based motor competence interventions and identifies key directions for future research.

5. CONCLUSION

This review provides strong evidence that school-based physical activity interventions effectively enhance motor competence and health-relevant outcomes in children. The consistency of positive findings across different settings and populations confirms the importance of schools as key sites for physical activity promotion. Despite methodological limitations, the accumulated evidence justifies continued investment in high-quality school programs. Motor competence development in childhood represents an investment in lifelong health. By providing all students with opportunities to develop fundamental motor skills, schools contribute to positive health trajectories that extend beyond childhood. As obesity rates rise and physical activity levels decline, school programs offer a scalable and equitable evidence-based approach. From a public health perspective, interventions focused on motor competence are not optional enrichment activities, but essential components of children's health promotion strategies.

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