Refining a College Student-Led Implementation Strategy Using Implementation Mapping in a Rural School

McKenna G. Major, BS
Julianna F. King, BS
Skyler T. Taaffe
Luke E. Troyer
Zack Waggoner, BA
Derek W. Craig, PhD
Richard J. Holden, PhD
Vanessa M. Martinez Kercher, PhD
Kyle A. Kercher, PhD*

Abstract

Many physical activity (PA) interventions have been designed, yet few are scaled up or sustained. Additional refinement of implementation strategies may improve adoption, implementation, and maintenance of PA interventions. One such intervention is Hoosier Sport, a sport-based program partnering with middle schools to increase youth PA engagement. The objective of the present study was to (1) retrospectively use an implementation mapping approach to identify determinants, compile methods of change, and evaluate outcomes, and (2) to synthesize results of implementation mapping within the context of a pilot study of the Hoosier Sport implementation strategy. We conducted a retrospective study of Hoosier Sport using implementation mapping to iteratively develop a comprehensive implementation strategy. Implementation mapping occurred with a campus-community team composed of researchers, college students, and community partners. A pilot study of Hoosier Sport served as the input and exemplified retrospective use of implementation mapping in context. The process identified key strengths (e.g., high fidelity and program interest) and weaknesses (e.g., reproducibility of evaluation and training materials, limited theoretical rationale), and used them to pinpoint opportunities for refinement (e.g., integration of positive youth development into sport lessons, connecting theoretical constructs to performance objectives). Our findings demonstrate a pragmatic example of the utility of implementation mapping while also contributing to the literature by providing a unique assessment of past research combined with future implementation planning.

Keywords: implementation science, sport-based youth development, implementation mapping, school, physical activity.

*Corresponding author may be reached at kylkerch@iu.edu

Introduction

According to the Centers for Disease Control and Prevention (CDC), the leading cause of death in the U.S. is cardiovascular disease (CVD) (Heron & Anderson, 2016). A major risk factor for CVD is a sedentary lifestyle, and physical inactivity is increasingly prevalent in the U.S. (Heron & Anderson, 2016). Furthermore, physical inactivity during childhood increases the chance of developing CVD later in life (U.S.

Department of Health and Human Services [USDHHS], 2018). Conversely, higher cardiorespiratory fitness during childhood and adolescence is associated with lower BMI, lower waist circumference, and a lower prevalence of metabolic syndrome later in life (Mintjens et al., 2018). Despite this information, only about 20% of children aged 6-17 years meet the U.S. guidelines of 60 minutes of moderate to vigorous intensity aerobic physical activity (PA) each day (USDHHS, 2018). Due to more than half of children engaging in a sedentary lifestyle, PA interventions are necessary public health initiatives for increasing movement, encouraging healthy lifestyles, and decreasing CVD lifetime risk.

PA interventions target sedentary behavior and promote activity in children; however, Lai and colleagues (2020) found that beyond the duration of the study, most programs and implementation remain limited (Cassar et al., 2019). To be most effective, practical PA interventions should consider the context in which they are being delivered and ensure that they address the specific needs of the population they serve (Brandes et al., 2022; Hasson et al., 2023). An effective intervention also continually assesses feasibility to improve sustainability and ability to scale up (Pfledderer et al., 2023). Many interventions may be inappropriately scaled or lack a structured operation for design, implementation, and evaluation. Although many PA interventions effectively improve health outcomes, they are less likely to be sustainable without a systematic process for program development and implementation that incorporates theory and existing evidence (Czajkowski et al., 2015; Fernandez et al., 2019).

The incorporation of theory into the process helps to provide a framework for building interventions and creating program goals. As the goal of many youth PA interventions is to increase PA levels through individual changes in behavior and motivation, many of these programs utilize psychological theories. Several youth PA interventions have incorporated self-determination theory (SDT) and social cognitive theory (SCT) into the development of program outcomes and curricula, both of which have shown to be significant in increasing children's PA (Bagherniya et al., 2018; Sebire et al., 2013). Within SDT is the basic psychological needs mini theory which posits that the basic psychological needs of autonomy, competence, and relatedness must be met to achieve optimal health and motivation (Ryan & Deci, 2017). Autonomy refers to an individual's ability to act/make choices independently from external motives. Competence refers to an individual's ability to carry out an action successfully, while relatedness refers to the connectedness of an individual to their surrounding peers/community. SCT explains how an individual learns behavior through their personal and environmental factors (Bandura, 1976). One key factor is self-efficacy, which impacts whether we are motivated to adopt or resist a specific behavior (Ramirez et al., 2012). Environmental factors include the degree of social support one receives and the barriers impeding on their ability to engage in a behavior.

Currently, there are some studies that have used a systematic and reproducible intervention process to execute their PA intervention in children; however, none have done so in a rural community middle school population (Fernandez et al., 2019; Walker et al., 2022). Intervention mapping is a systematic approach to intervention development in which researchers collaborate with stakeholders and community partners through a six-step process to identify a health problem and potential targets of change (Kay Bartholomew Eldredge et al., 2016). The intervention process integrates

theory and empirical evidence to guide program development. Intervention mapping generates a clear path for establishing the goals of the intervention and achieving those goals via a step-by-step approach.

Within intervention mapping is the process of implementation mapping, which is made up of five tasks, listed in Figure 1 (Fernandez et al., 2019).

These tasks provide a framework to ensure that the intervention addresses all barriers and facilitators within a population to align with the needs of the stakeholders. Implementation mapping enables researchers to develop clear, targeted intervention implementation strategies. This method serves as a more comprehensible, step-by-step guide for researchers to use. Several different topic areas have adopted this process (Fritz et al., 2024; Hoskins et al., 2022; Kang & Foster, 2022; Perkison et al., 2023); however, there is currently no study to retrospectively incorporate the implementation mapping process into a youth PA intervention.

The primary objective of the present study was to retrospectively use an implementation mapping approach to identify determinants, compile methods of change, and evaluate outcomes. The secondary objective was to synthesize the results of implementation mapping within the context of a pilot study of the Hoosier Sport implementation strategy. The results of the present study will provide a refined and testable implementation protocol, including matrices of change for adoption and implementation and an evaluation strategy. Further, results will retrospectively identify strengths, weaknesses, and future research directions from the pilot study of the Hoosier Sport implementation strategy.

Methods

Overall Study Design

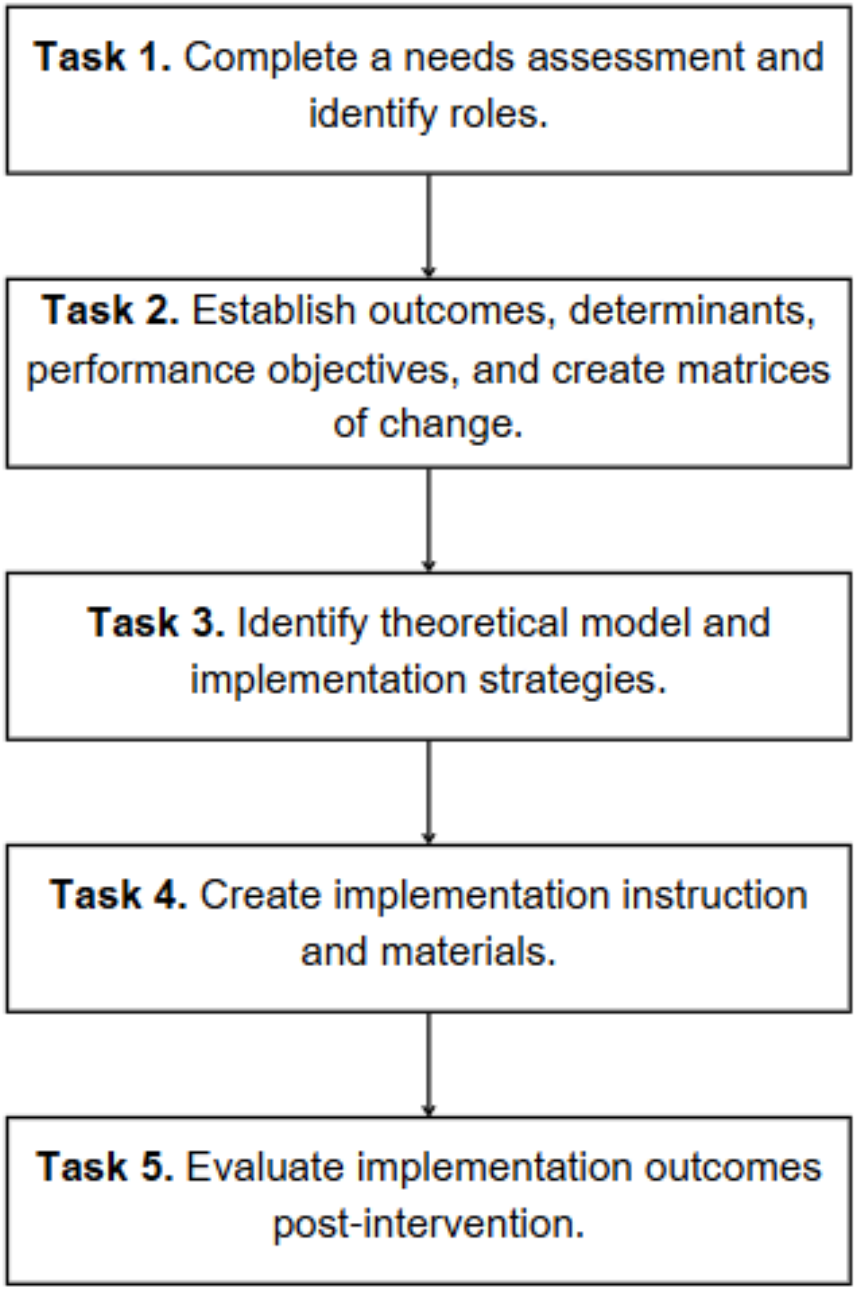
This study describes the completion of Tasks 1-5 of implementation mapping (Fernandez et al., 2019). These tasks were completed after executing Steps 1-4 of Intervention Mapping (Major et al., 2024). This process functions to refine current and future implementation of the Hoosier Sport program. See Figure 1 for a framework of Tasks 1-5. As the study is designed as a retrospective application of implementation mapping, all data presented are reflective of the refined version of program objectives, materials, and curricula.

Research Context and Implementation Mapping Team

Hoosier Sport

Hoosier Sport is a sport-based youth development program within a Midwestern university that establishes campus-community partnerships with surrounding school districts to increase youth PA. The broader Hoosier Sport team includes over 25 people (ranging from undergraduate students to faculty) and is supported by approximately 10 service-learning students each semester. There are an additional 1-2 team members from the respective partner schools. The Hoosier Sport program first conducts a needs assessment within the school district to evaluate the unique needs of under-resourced schools. The team then leads a human-centered participatory co-design process, followed by pilot testing of the program developed from the outcomes of the needs assessment and co-design. As of now, the program has included goal setting, incentives to increase PA, and physical education classes during school hours instructed by trained college service-learning students and

Figure 1
Implementation Mapping Process



university faculty. Hoosier Sport was originally created using intervention mapping and follows best practice recommendations in behavioral science which suggest continually moving between iterative testing and refinement (Czajkowski et al., 2015; Major et al., 2024). The primary outcomes of the program are (a) PA measures (e.g., daily PA) and (b) implementation outcomes (e.g., feasibility indicators). The secondary outcomes are (a) leadership skills (e.g., teamwork, goal setting) and (b) psychological outcomes (e.g., basic psychological needs). The delivery model for Hoosier Sport consists of training college service-learning students to deliver the planned intervention through a university course curriculum. Service-learning students are trained at a one-to-two-day team event at the start of each semester, along with bi-weekly 75-minute meetings for the six weeks leading up to the start of the intervention. These service-learning students deliver the intervention alongside Hoosier Sport faculty in a physical education class setting. The service-learning students are required to meet a 20-hour minimum in time spent in the field for the class.

Implementation Mapping Team & Sessions

The implementation mapping team consisted of nine members, including two undergraduate students, two graduate students, one medical school student, two faculty members, one practitioner, and one partner school district principal. Members were selected for their prior and wide-ranging experience working with the target communities. There were four core team members from the Hoosier Sport research team (a faculty member, graduate student, medical student, and practitioner) that met to systematically work through the implementation mapping tasks (see Figure 1) and the associated implementation mapping workbook (Bartholomew Eldredge et al., 2016). Each meeting consisted of a review of progress from the previous meeting (when applicable), a discussion of meeting goals, facilitated discussion, group brainstorming, and individual ideation. The four core team members from Hoosier Sport facilitated each meeting and its dialogue. The team reached consensus by group discussion and inclusion of additional implementation team members as needed. The core team initially synthesized information after each meeting to formally complete the implementation tasks and to share back results with the middle school principal and other implementation mapping team members for review and discussion before moving onto the next task.

Theories

To guide our implementation strategy, we applied self-determination theory (SDT) and social cognitive theory (SCT) —both of which address an individual's psychosocial processes which drive engagement and adherence to PA. SDT and SCT have both been utilized in various school-based PA interventions, in which they were used to create program components and goals. The goals of these programs were often to increase motivation, competence, and social support as well as increase PA. We selected these theories in part due to their widespread use within youth PA interventions, namely those that are based at school. Furthermore, we determined the general goals and themes of our intervention and identified theories that were best aligned. The theories could then be utilized to guide our selection and review of determinants and the creation of implementation and evaluation protocols. These theories helped to retrospectively advise the implementation mapping process for both adopters and implementers.

Implementation Mapping Tasks

Task 1: Conduct needs and asset assessment; identify adopters and implementers

The first task consists of assessing needs and assets for implementing the intervention and identifying program adopters and implementers. The adopters of the program are primarily the middle school children, and secondarily, the school administrators and teachers. We administered a needs assessment to identify the needs of our adopters through questions related to the basic psychological needs satisfaction and policy-systems-environment level of influence (Greeven et al., 2023). Questions related to psychological needs were gathered from the Basic Psychological Needs in Exercise Scale which assesses the participant's self-assessed autonomy, competence, and relatedness within the context of an intervention (Costa et al., 2017). The policy-systems-environment questions are related to the adults' identification of assets such as the resources and strengths that school and community offer to the intervention. These questions also assessed the adults' perceptions of current school policy and PA programming. See Greeven et al. (2023) for a full description of needs assessment methodology and results. Our focus on children as the primary adopters of the program helped to solidify our child-centered approach, allowing us to emphasize the child participants of our intervention into program design and delivery. In the present study, school administrators and teachers were adopters secondarily, but serve an important role in maintaining the sustainability and feasibility of the program. Implementers of the program are both the college service-learning students and Hoosier Sport research team.

Task 2: Identify adoption and implementation outcomes, performance objectives, and determinants; create matrices of change

Task 2 aims to identify performance objectives and adoption and implementation outcomes. Based on the outlined task, we identified these outcomes and developed our performance objectives. The determinants were created based on theory as well as feedback from the implementation mapping team on experiences working with the students. For example, many team members highlighted that the children were more engaged when they could be physically active with their friends, so we selected a theory (SDT) that included a determinant related to social support. We chose SDT to guide our determinants: autonomy, competence, and relatedness. The performance objectives outlined explicit actions that adopters and/or implementers must perform to achieve the desired outcomes. We created the objectives by discussing the specific steps that the children must take to be physically active in this intervention, as well as the steps that the team must take to deliver the intervention. Performance objectives were crossed with determinants to create a matrix of change objectives. This process consisted of brainstorming the specific actions that adopters and/or implementers needed to take that would adjust the determinants to meet performance objectives.

Task 3: Choose theoretical change methods; select or create implementation strategies

Using what we learned from the matrices of change, Task 3 allows us to review our chosen theoretical change methods and how they align with our implementation strategies. We chose SDT and SCT as our theoretical methods due to their use in previous youth health research, as well as their alignment with pre-existing program goals and strategies. We mapped the basic

psychological needs (autonomy, competence, and relatedness) from SDT to each of the performance objectives for both the adopters (children) and the implementers (college service-learning students). These theories and their applications were chosen based on their previous use in youth development research and team members' input regarding experiences in delivering the program. From this mapping, we identified the different implementation strategies to achieve these performance objectives that align with the theoretical change method of basic psychological needs from SDT. The implementation mapping team was informed of the context of current Hoosier Sport programming and used group discussion and sharing of preliminary results with additional team members to come to consensus on the specific implementation strategies, practical applications, and alignment with selected theories. See the Implementation Mapping Team & Sessions subsection for additional information.

Task 4: Produce implementation protocols and materials

Task 4 entails creating the learning materials for training service-learning students to deliver the program. These materials consisted of the course curriculum and team training activities. In addition to the resources used to train implementers, this task also includes creating protocols for the program's delivery. Due to the study being completed retrospectively, many of these materials and protocols were already produced; thus, they were reviewed during this process.

Task 5: Evaluate implementation outcomes

We identified each component of the implementation (i.e., context, reach, dose delivered, dose received, fidelity, recruitment). This step included ensuring that our implementation goals and outcomes properly aligned with our determinants and theories. The completion of this step was concurrent to a pilot study that evaluated program outcomes (Kwaiser et al., 2024).

Previously Conducted Pilot Study

The pilot study of the previously developed implementation strategy was utilized as an input to the implementation mapping tasks. It also served as an example of what the evaluation process may look like practically. The study included children (n = 33) from a rural, primarily White Midwestern middle school as participants in the intervention, and research team members (n = 7) as implementers of the intervention. Pilot results are summarized in Task 5 at the end of the Results section to showcase how pilot study results informed the use of IM retrospectively to identify key strengths, weaknesses, and opportunities for refinement. All components were evaluated post-intervention and had an indicator of 80% < a priori threshold on their respective measures.

Results

Implementation Mapping Tasks

Task 1

To implement our intervention, the implementer group first conducted a needs assessment of each respective group of participants (e.g., parents, guardians, administrators, teachers, and children) (Greeven et al., 2023). Both children and adults were largely interested in PA programming (72% and 82%, respectively) and moderately interested in leadership programming (62% and 86%, respectively). The collective interest in both leadership and PA programming led the design and subsequent implementation of our curriculum. We used different sport activities (e.g., basketball, volleyball, pickleball, etc.)

to drive the PA programming curriculum, focusing on activities that support the students' learning of the respective activity as well as encouraging enjoyment during the exercise. Leadership curriculum was often worked into the PA skills but also structurally built into the program. For example, we implemented leadership skills (such as critical thinking and adaptability) into the PA activities to support leadership development. We also used college students to deliver the program, serving as role models for leadership. For the service-learning students, the main goals for their experience included improving their communication, critical thinking, public speaking, and leadership. An example of these skills being developed was the delegation of the lead coach role to varied students to provide each the opportunity to improve the skills they sought. Given the needs assessment results and the goal sheets, the overall goals for the program included creating a program that children want to join and supporting the service-learning students in their delivery of the intervention with fidelity and development of their leadership skills.

Task 2

With the adopters being the children involved in the program, the main adoption outcome is creating a program and implementation strategy that encourages children to participate in Hoosier Sport. To achieve this, four performance objectives must be met: (1) Gain knowledge of what Hoosier Sport is, (2) Decide to sign-up for Hoosier Sport, (3) Talk to a parent and have them provide consent, and (4) Provide assent for Hoosier Sport. With the college students, the main implementation outcome is to deliver Hoosier Sport with fidelity. Delivering Hoosier Sport as it was designed to be delivered incorporates five performance objectives: (1) Decide to join Hoosier Sport team or service-learning class, (2) Subsequently join the program/class, (3) Receive training, (4) Demonstrate competence in knowledge/application, and (5) Schedule/sign-up for intervention days. The maintenance outcome is to maintain these implementation systems, and these objectives include (1) Post-program evaluation, (2) Summarizing findings, (3) Sharing results/findings with school faculty, (4) Developing action items, and (5) Implementing these action items. From these objectives, we created matrices of change to use in Task 3, seen in Table 1.

Task 3

To achieve the performance objectives, we relied upon SDT and SCT– specifically the determinants of autonomy, competence, and relatedness along with support skills and skill development – to determine and map the implementation strategies. The implementation mapping team identified the practical applications associated with each performance objective and linked them to our chosen theories. Figures 2 and 3 exemplify other ways in which these strategies were practically applied.

Task 4

As the materials were previously created, our review largely consisted of focusing on program curriculum and implementer training. This included refining the Hoosier Sport advertising course throughout the School of Public Health with flyers and recruitment materials. Additionally, we reviewed the opportunities provided for social support and bonding throughout the semester. We also provided service-learning students an offer to officially join the research team after the semester, including fun activities in training that encourage enthusiasm for the program, and allowing students to choose which intervention days they wanted to attend. Further identification

Table 1

Refined adoption outcomes and determinants & implementation outcomes and determinants

Adoption Outcome: Children wanting to participate in Hoosier Sport				**Implementation Outcome: Deliver Hoosier Sport with fidelity (deliver how it was designed to be delivered)**			
Performance Objectives (PO)	**Personal Determinants**			**Performance Objectives (PO)**	**Personal Determinants**		
	Determinant 1: Autonomy	**Determinant 2: Competence**	**Determinant 3: Relatedness**		**Determinant 1: Autonomy**	**Determinant 2: Competence**	**Determinant 3: Relatedness**
PO.1 Gain knowledge of what Hoosier Sport is	Choosing to learn about Hoosier Sport	Understanding message about Hoosier Sport	Hearing about program from peers	PO.1 Decide to join Hoosier Sport team or service-learning class	Believing they have enough time to allocate to Hoosier Sport	Believing that joining Hoosier Sport is achievable.	Believing that peers are gaining value from Hoosier Sport
PO.2 Decide to sign-up for Hoosier Sport	Motivating self to sign-up Choosing to sign-up	Understanding the simple process to sign-up process	Sharing/learning about common interests with other people signing up	PO.2 Join the program/class	Choosing to join the program or class Having an interest in the Hoosier Sport mission and values	Knowing how to sign-up for class/program Being able to be hired/navigating registration process	Believing that peers are also joining the program/class
PO.3 Talk to parent and have them provide consent	Choosing to talk to parents	Having the skills to communicate with parents Sharing information with parents on how to fill out consent form	Communicating with parent, sharing information	PO.3 Receive training	Choosing to receive training to continue onboarding process	Completing training	Building comradery with peers

PO.4 Provide informed assent for Hoosier Sport	Choosing to provide assent	Understanding assent Navigating survey/using iPad	Hearing about peers providing assent	PO.4 Demonstrate competence in knowledge/application	Choosing to watch videos/gaining knowledge Choosing to attend class	Studying and learning content	Believing that others are completing the test
				PO. 5 Schedule/sign-up for intervention days	Choosing what days to attend Having enough time to attend	Understanding the scheduling process Knowing the schedule Having time management skills	Wanting to be involved with group

Figure 2

Refined determinants and change objectives with applications for adopters

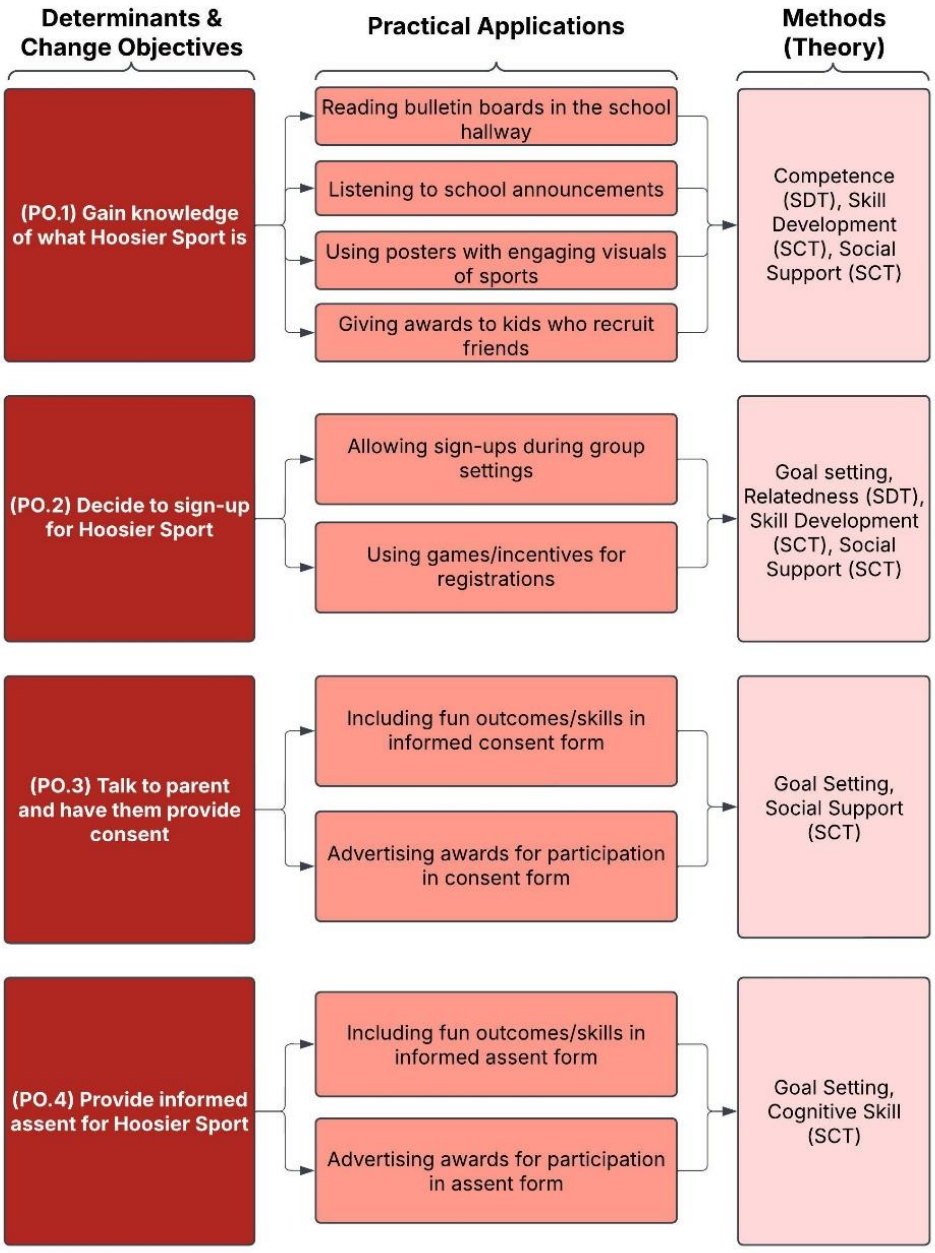
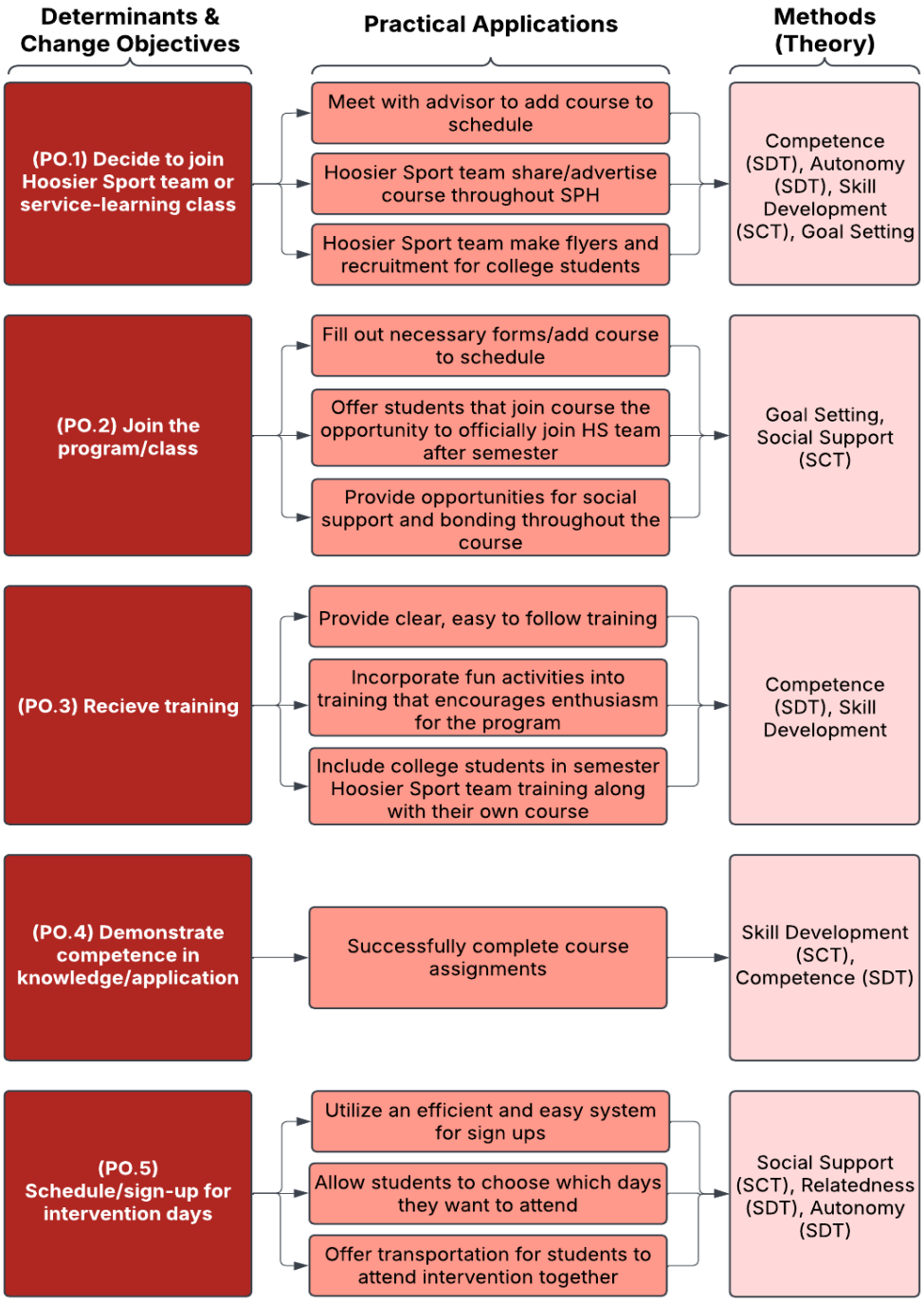


Figure 3

Refined determinants and change objectives with applications for implementers



of program materials and protocols can be seen in Figure 4.

Task 5

An evaluation strategy was created based on our program goals and desired outcomes. We produced the strategy by identifying our outcomes and matching them to our evaluation measures while refining those that did not have clear forms of assessment. We ensured that the measures were valid from previous literature, and our timing was based on evidence of change. The strategy can be visualized in Table 2.

Pilot Test

Key Pilot Study Findings that Informed Implementation Mapping

The pilot study was a longitudinal evaluation of the Hoosier Sport program, consisting of 6th and 7th graders (n=33) at a rural middle school (Kwaiser et al., 2024). The intervention was eight weeks, with data collection at weeks 0 and 9. The purpose of the study was to evaluate the Hoosier Sport intervention and its implementation. Fidelity was assessed using the System for Observation of Staff Promotion of Activity and Nutrition (SOSPAN) and the System of Observing Fitness Instruction Time (SOFIT). SOSPAN was utilized to evaluate the behaviors and interactions of college service-learning students with the children during a program session, and SOFIT helped to calculate the amount of time spent in different levels of PA. According to the SOSPAN and SOFIT measurement, fidelity was high. Staff were engaged in PA for 62.5% of the time, the schedule was followed 85% of the time, all children were moving for 32.5% of the time, and elimination games were only used for 2.5% of the time. SOFIT demonstrated that children achieved moderate-to-vigorous PA for 94-95% of each session. These fidelity results led to adding a SOSPAN training module to the onboarding process for each semester. Additionally, Hoosier Sport exhibited high feasibility and acceptability, but lacked theoretical support. The IM process aligned every newly refined performance objective with a theoretical construct. While the pilot study explored a broad range of outcomes, a more targeted approach was needed. IM led to narrowing the set of outcomes to strengthen alignment between outcomes, evaluation questions, and measures.

Integration of Pilot Study Results into Implementation Mapping

Retrospectively integrating pilot study results into the implementation mapping process allowed for identification of key strengths, weaknesses, and opportunities for refinement. Table 3 provides specific examples of refinements from original pilot study findings.

Discussion

The present study used implementation mapping to retrospectively refine a prototype implementation strategy for the Hoosier Sport program. The study used the context of results from a pilot test of the implementation strategy to inform the implementation mapping process (Kwaiser et al., 2024). Strengths and weaknesses from the pilot study were used to inform group discussion and provide rationale for selecting specific opportunities for refinement. There were four key findings. First, retrospective implementation mapping enabled a structured review of our implementation of Hoosier Sport. This allowed us to identify gaps in our previously planned implementation strategy and to greatly improve the specification of this strategy (i.e., outcomes, objectives, determinants, change matrices). Second, this study strengthened the connection of our

Figure 4

Refined implementation protocols and materials for adopters and implementers

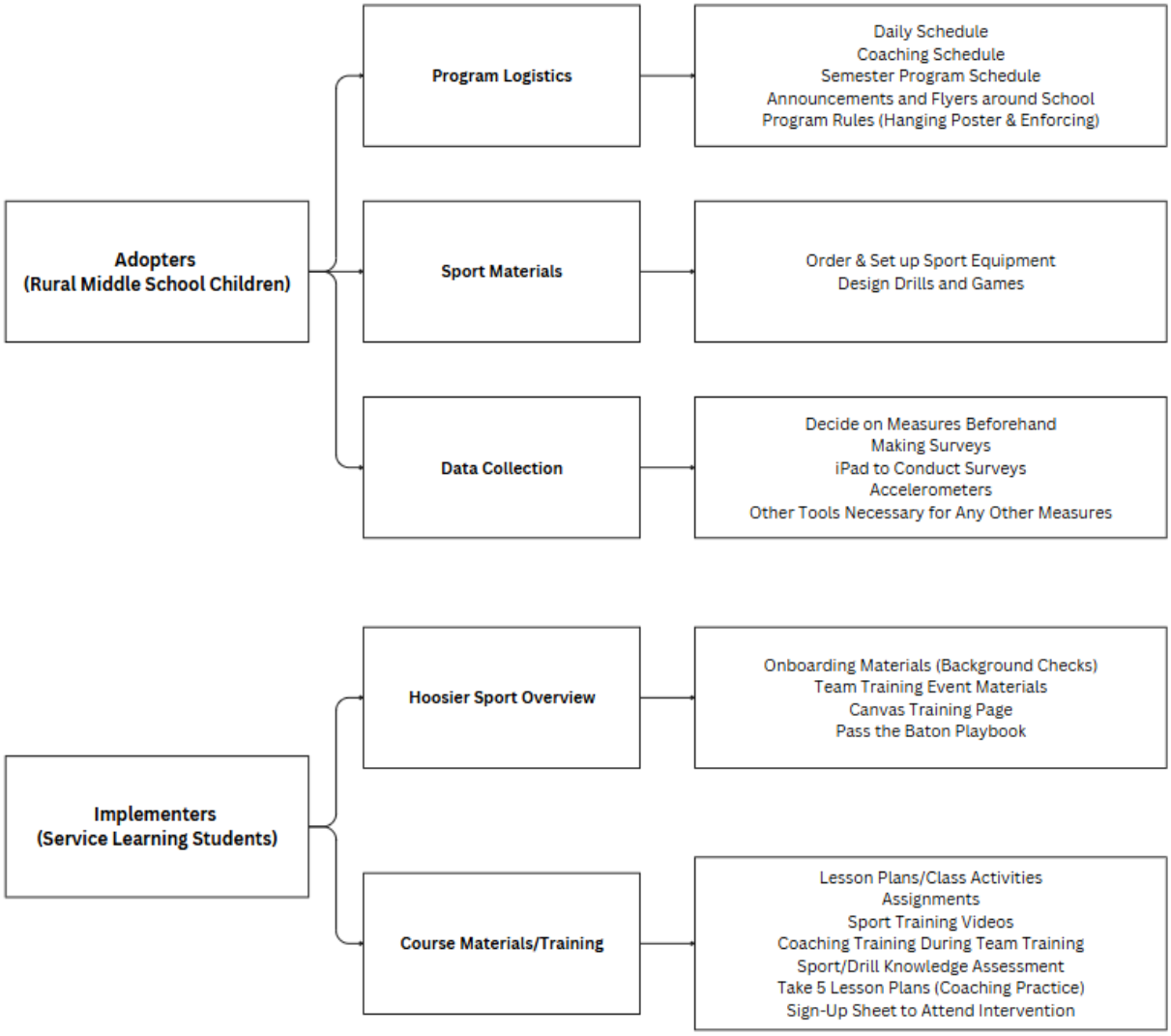


Table 2
Refined Evaluation Strategy Post-Implementation Mapping

Priority Population: Rural Middle School Children			
Outcome	**Evaluation Question**	**Measure & Source**	**Timing**
Quality of Life			
CVD risk	Does Hoosier Sport decrease children's CVD risk over time?	Accelerometer/ pedometer, self-report CAPL-2 question	Pre- and post-intervention
Health			
Resting heart rate (most sensitive/changeable compared to BP, HR)	Do the participant's resting heart lower from pre- to post-intervention?	Sphygmomanometer	Pre- and post-intervention
Behavior			
Increased PA (total PA)	How many minutes a week do children spend physically active?	Accelerometer/ pedometer	Wear consecutively for seven days
Increased daily steps	How many steps do children achieve daily?	Measured with accelerometer/pedometer	Wear consecutively for seven days
Behavioral Determinants			
Increased autonomy to choose a PA	How likely are children to independently engage in PA?	Adapted BPNES	Pre- and post-intervention
Increased relatedness to support PA	How does relatedness influence PA?	Adapted-BPNES	Pre- and post-intervention
Increased competence to perform PA	How does a greater competence in PA influence PA?	Adapted BPNES	Pre- and post-intervention
Positive role models	How do role models influence PA?	Adapted BPNES	Pre- and post-intervention
Sport equipment access	How does access to sports equipment support PA?	PSE survey	Pre- and post-intervention
Environmental Determinants			
Interpersonal: teachers, college student implementers, peers, reinforcement	How does the interpersonal environment influence PA levels?	SOSPAN Self-perception profile for children	SOSPAN: Every 2 weeks Self-perception profile for children: Pre- and post-intervention

Organizational: lack of trained staff, PE policy, free play policy, sport equipment, sport infrastructure	How does interpersonal organizational influence PA levels?	PSE survey	Pre- and post-intervention

Note. CVD = Cardiovascular disease; CAPL-2 = Canadian Assessment of Physical Literacy – Second Edition; BP = Blood pressure; HR= Heart rate; PA = Physical activity; PE = Physical education; BPNES = Basic Psychological Needs in Exercise Scale; PSE = Policy-Systems-Environment; SOSPAN= System for Observing Staff Promotion of Activity and Nutrition.

Table 3

Examples of Implementation Mapping Refinements Informed by Preliminary Findings

Preliminary Finding	IM Task	Example of Resulting Refinement
High interest among adult and child participants in leadership programming	*Task 1: Conduct needs and asset assessment and identify adopters and implementers*	Increased emphasis on recurring high-quality training of college student role models; inclusion of positive youth development into sport lessons (i.e., leadership skills)
High program fidelity demonstrated by SOSPAN & SOFIT results	*Task 2: Identify adoption and implementation outcomes, performance objectives, and determinants; create matrices of change*	Added SOSPAN training module to onboarding process for each semester (PO.3 Receive training)
Limited theoretical support for program planning and findings	*Task 3: Choose theoretical change methods; select or create implementation strategies*	Connected every performance objective with a theoretical construct(s)
Limited reproducible training or onboarding materials	*Task 4: Produce implementation protocols and materials*	Training materials were enhanced to include an e-course that housed items, such as sport/PA training videos, background check processes, and applied coaching assessments prior to intervention
Inadequate reproducibility and minimal clarity of evaluation process	*Task 5: Evaluate implementation outcomes*	Evaluation strategy was modified to simplify and clarify outcomes, evaluation questions, and measures (i.e., Table 2)
Note. SOSPAN = System for Observing Staff Promotion of Activity and Nutrition; SOFIT = System of Observing Fitness Instruction Time; PA = physical activity		

implementation strategy to evidence-based theory (i.e., SCT and SDT). Third, retrospectively applying implementation mapping may increase the likelihood of fidelity in the intervention processes. Finally, the present study may increase the scalability and sustainability of the Hoosier Sport intervention and implementation strategy. Retrospective use of implementation mapping to refine and evaluate a pilot tested implementation strategy of a youth PA intervention is a novel approach. Other health behavior researchers may be able to use a similar process to improve the implementation of their interventions.

First, the retrospective use of implementation mapping enabled a structured review and identification of gaps in our processes. Hoosier Sport has several components spanning from the training of service-learning students and supporting the fidelity of the sport curriculum to collecting/analyzing data. Each component has its own set of expectations and requirements for its success. Retrospective implementation mapping allows us to identify what may not be executed to the original strategy. For example, with the Hoosier Sport overview material, we planned on having the Playbook – a set of instructions for the entirety of the Hoosier Sport process. Upon review, we determined this document is not vital for the service-learning students and their experience. Additionally, an important determinant for Hoosier Sport is the interpersonal environment. Using SOSPAN to measure this environment, we planned to complete the measure every two weeks; however, given the availability of service-learning students, this measurement was done at less consistent time points (once at the beginning of the semester and three times near the end). Performing the retrospective implementation mapping serves as a check on the program to ensure that the program fidelity is met and further refinement occurs. The retrospective approach to implementation mapping aligns with best practices in behavioral science which recommend continual refinement and optimization (Czajkowski et al., 2015).

Second, the implementation mapping process allowed us to strengthen our use of evidence-based theory in the creation of implementation strategies. Throughout the implementation mapping tasks, we incorporated SCT and SDT to identify determinants, create matrices of change and implementation methods, and produce evaluation protocols. These theories helped to increase efficacy of the program's implementation. For example, prior to refinement, program planning had no framework or theoretical support; now, we have ensured that program objectives and curriculum are grounded in theory. The theories also supported the production of our evaluation measures. With review of the pilot study, implementers found that the SOSPAN framework could be enhanced by incorporating student feedback and SDT (Kwaiser et al., 2024). For example, implementers included non-elimination games, small group work, and verbal encouragement to increase student levels of autonomy, competence, and relatedness. By utilizing these theories throughout the retrospective implementation process, we further ensured that our intervention had a strong foundation based on evidence. As a result, we can better communicate and support our choice of determinants and strategies to our stakeholders.

Third, the retrospective implementation mapping process may increase the fidelity of program implementation and evaluation. Through the implementation mapping tasks, we identified our implementation outcomes and strategies based on the SDT and SCT determinants selected. The process allowed us to ensure fidelity between the determinants that we select from theory and

the outcomes that we create for our population. Additionally, we ensured that our evaluation strategy was also in alignment with our desired program goals. For example, a program goal was to increase daily PA, and we verified that our evaluation strategy was accurately measuring this outcome using accelerometers. Furthermore, we evaluated program fidelity through our pilot study. The SOSPAN tool demonstrated that the staff delivered the program with fidelity as they used verbal encouragement 87.5% of the time and actively engaged in PA 62.5% of the time (Kwaiser et al., 2024). SOFIT showed that children participated in vigorous PA for 59% of a total session and only stood for 5% of the time (Kwaiser et al., 2024). Utilizing the implementation process helped to strengthen the connection of our determinants to outcomes, and goals to measurement tools. By establishing that, we may improve the fidelity of program implementation.

Additionally, through this process, training of college students and the materials used for training can be improved after identifying areas of growth. Discovering the areas of improvement for our materials may help to increase likelihood of scalability and sustainability — including increasing service-learning student compliance and streamlining the learning process for curriculum implementation. Regarding student compliance, the students are required to complete 20 hours of service-learning experience over the semester. While this has been successful for the students thus far, we will also need to monitor our growth rate to ensure we can support the demand. This also allows us to anticipate and plan parameters to prevent lack of compliance by the service-learning students.

By retrospectively incorporating implementation mapping on the results from a pilot study of the Hoosier Sport program, we identified strengths and weaknesses and refined our implementation protocols. Basing our evaluation processes on evidence-based theories, such as SDT and SCT, we solidified our choice of theory to guide our implementation methodology and assessment in a manner that fulfills youth social and cognitive needs. Due to the iterative and collaborate methodology of implementation mapping, our structured approach strengthens intervention effectiveness. It also increases future likelihood of success in funding, school/stakeholder recruitment, and overall improved health outcomes. Implementation mapping enables us to identify areas of improvement for the sustainability of the program, both within and across different schools.

Limitations

This study must be interpreted within its limitations. While retrospective, implementation mapping was a relatively novel, positive, and pragmatic approach to improving our implementation strategy overall, but it had inherent challenges. For example, using existing data is limited in that the data has already been collected and may be incomplete, missing, not reported, or otherwise flawed. Despite this data interpretation limitation, we believe implementation mapping using existing data as an input to the process is ideal because the process (1) is simultaneously moving towards the next prospective iteration of the implementation strategy and (2) capitalizes on potential lessons learned from actual applications of an iteration of the approach. Another limitation is a lack of generalizability. This study includes a small sample size with limited ethnic and racial diversity that may not accurately represent students at other schools. Furthermore, the use of a convenience sample for the implementation mapping team could lead to selection bias. Another limitation of this

study is a limited ability to establish a causal relationship. While the study demonstrates strong practicality and external validity, this study has limited internal validity due to lacking a control group. Finally, the complex language of implementation mapping presents a challenge for community-based implementation mapping teams. The field of implementation science, including implementation mapping, often uses language that is targeted at other researchers, which can make it difficult to communicate results with stakeholders.

Implications for Health Behavior Research

The implications of this study offer a systematic approach for retrospectively evaluating currently implemented interventions. There is little existing research on applying implementation mapping to PA programs, and our study presents one of the first to specifically perform retrospective implementation mapping for a youth PA intervention. This study exemplifies the ability to apply implementation mapping for retrospective application and subsequent planning to improve future interventions. The implementation process allowed us to apply structure and theory to an already-existing intervention to improve sustainability and scalability. We offer this analysis as an example of how health behavior researchers can retrospectively assess their interventions to improve program implementation. Other researchers can utilize the implementation mapping process, coupled with pilot testing, to increase sustainability and scalability within their own programs.

Discussion Questions

Our study demonstrated a practical example of using implementation mapping within an iterative intervention and implementation testing process. How can other researchers continue to use implementation mapping iteratively to improve implementation on an ongoing basis?

Implementation mapping and implementation science use a great deal of academic jargon, despite their focus on delivering efficient programming in pragmatic or real-world settings (e.g., communities). How can academics, implementation scientists, and health behavior researchers continue to make their community-based/health behavior research more accessible to end users?

Ethics and Dissemination

The Indiana University Institutional Review Board approved the study protocol (#18784 and #25962). The participants provided their informed consent/assent prior to participating in the study.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Funding

This work was supported by the American Heart Association Career Development Award (award ID: 24CDA1038890; DOI: 10.58275/AHA.24CDA1038890.pc.gr.198245).

Conflicts of Interest

The authors have no conflicts of interest to declare.

References

Bagherniya, M., Mostafavi Darani, F., Sharma, M., Maracy, M. R., Allipour Birgani, R., Ranjbar, G., Taghipour, A., Safraian, M., & Keshavarz, S. A. (2018).

Assessment of the Efficacy of Physical Activity Level and Lifestyle Behavior Interventions Applying Social Cognitive Theory for Overweight and Obese Girl Adolescents. *Journal of Research in Health Sciences*, *18*(2), e00409.

Bandura, A. (1976). *Social Learning Theory* (1st ed.). Prentice-Hall. https://doi.org/10.1037/0003-066X.55.1.68

Bartholomew Eldredge, L.K., Markham, C.M., Ruiter, R.A.C., Fernández, M.E., Kok, G., & Parcel, G.S. (Eds.). (2016). *Planning health promotion programs: An Intervention Mapping approach* (4th ed.). San Francisco, CA: Jossey-Bass.

Brandes, B., Busse, H., Sell, L., Christianson, L., & Brandes, M. (2022). A scoping review on characteristics of school-based interventions to promote physical activity and cardiorespiratory fitness among 6- to 10-year-old children. *Preventive medicine*, *155*, 106920. https://doi.org/10.1016/j.ypmed.2021.106920

Cassar, S., Salmon, J., Timperio, A., Naylor, P. J., van Nassau, F., Contardo Ayala, A. M., & Koorts, H. (2019). Adoption, implementation and sustainability of school-based physical activity and sedentary behaviour interventions in real-world settings: a systematic review. *The international journal of behavioral nutrition and physical activity*, *16*(1), 120. https://doi.org/10.1186/s12966-019-0876-4

Costa, L. C. A. da, Maroco, J., & Vieira, L. F. (2017). VALIDATION OF THE BASIC PSYCHOLOGICAL NEEDS IN EXERCISE SCALE (BPNES). *Journal of Physical Education*, *28*(1). https://doi.org/10.4025/jphyseduc.v28i1.2847

Czajkowski, S. M., Powell, L. H., Adler, N., Naar-King, S., Reynolds, K. D., Hunter, C. M., Laraia, B., Olster, D. H., Perna, F. M., Peterson, J. C., Epel, E., Boyington, J. E., & Charlson, M. E. (2015). From ideas to efficacy: The ORBIT model for developing behavioral treatments for chronic diseases. *Health Psychology*, *34*(10), 971-982. https://doi.org/10.1037/hea0000161

Fernandez, M. E., ten Hoor, G. A., van Lieshout, S., Rodriguez, S. A., Beidas, R. S., Parcel, G., Ruiter, R. A. C., Markham, C. M., & Kok, G. (2019). Implementation Mapping: Using Intervention Mapping to Develop Implementation Strategies [Methods]. *Frontiers in Public Health*, *7*. https://doi.org/10.3389/fpubh.2019.00158

Fritz, J. M., Gibson, B., Wetter, D. W., del Fiol, G., Solis, V., Ford, I., Lundberg, K., & Thackeray, A. (2024). Use of implementation mapping in the planning of a hybrid type 1 pragmatic clinical trial: the BeatPain Utah study. *Implementation Science Communications*, *5*(1), 3. https://doi.org/10.1186/s43058-023-00542-z

Greeven, S. J., Medellin, A. M., Watkins, J. M., Coble, C. J., Brunnemer, J. E., Fernández Solá, P. A., Dutta, S., Hobson, J. M., Evanovich, J. M., Martinez Kercher, V. M., & Kercher, K. A. (2023). Multilevel needs assessment of physical activity, sport, psychological needs, and nutrition in rural children and adults [Original Research]. *Frontiers in Public Health*, *11*. https://doi.org/10.3389/fpubh.2023.1290567

Hasson, R. E., Beemer, L. R., Eisman, A. B., & Friday, P. (2023). Closing the Gap Between Classroom-Based Physical Activity Intervention Adoption and Fidelity in Low-Resource Schools. *Kinesiology Review*, *12*(1), 36-46. https://doi.org/10.1123/kr.2022-0041

Heron, M., & Anderson, R. N. (2016). Changes in the Leading Cause of Death: Recent Patterns in Heart Disease and

Cancer Mortality. *NCHS Data Brief* (254), 1-8. National Center for Health Statistics.

Hoskins, K., Sanchez, A. L., Hoffacker, C., Momplaisir, F., Gross, R., Brady, K. A., Pettit, A. R., Zentgraf, K., Mills, C., Coley, D., & Beidas, R. S. (2022). Implementation mapping to plan for a hybrid trial testing the effectiveness and implementation of a behavioral intervention for HIV medication adherence and care retention. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.872746

Kang, E., & Foster, E. R. (2022). Use of Implementation Mapping With Community-Based Participatory Research: Development of Implementation Strategies of a New Goal Setting and Goal Management Intervention System. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.834473

Kay Bartholomew Eldredge, L., Markham, C., Ruiter, R., Fernández, M., Kok, G., & Parcel, G. (2016). *Planning Health Promotion Programs: An Intervention Mapping Approach.* Jossey-Bass.

Kwaiser, M. M., Medellin, A. M., Watkins, J. M., Goss, J. M., Hobson, J. M., Martinez Kercher, V. M., & Kercher, K. A. (2024). Evaluation of a Pilot College Student-Based Physical Activity Implementation Strategy in a Rural Middle School. *International Journal of Environmental Research and Public Health*, *21*(12), 1645.

Lai, B., Lee, E., Wagatsuma, M., Frey, G., Stanish, H., Jung, T., & Rimmer, J. H. (2020). Research Trends and Recommendations for Physical Activity Interventions Among Children and Youth With Disabilities: A Review of Reviews. *Adapted Physical Activity Quarterly*, *37*(2), 211–234. https://doi.org/10.1123/apaq.2019-0081

Major, M. G., Watkins, J. M., Goss, J. M., Waggoner, Z., Martinez Kercher, V. M., & Kercher, K. A. (2024). Intervention Mapping for Refining a Sport-Based Public Health Intervention in Rural Schools. *International Journal of Environmental Research and Public Health*, *21*, 1557.

Mintjens, S., Menting, M. D., Daams, J. G., van Poppel, M. N. M., Roseboom, T. J., & Gemke, R. J. B. J. (2018). Cardiorespiratory Fitness in Childhood and Adolescence Affects Future Cardiovascular Risk Factors: A Systematic Review of Longitudinal Studies. *Sports Medicine*, *48*(11), 2577–2605. https://doi.org/10.1007/s40279-018-0974-5

Perkison, W. B., Rodriguez, S. A., Velasco-Huerta, F., Mathews, P. D., Pulicken, C., Beg, S. S., Heredia, N. I., Fwelo, P., White, G. E., Reininger, B. M., McWhorter, J. W., Chenier, R., & Fernandez, M. E. (2023). Application of implementation mapping to develop strategies for integrating the National Diabetes Prevention Program into primary care clinics. *Frontiers in Public Health*, *11*. https://doi.org/10.3389/fpubh.2023.933253

Pfledderer, C. D., von Klinggraeff, L., Burkart, S., Wolfenden, L., Ioannidis, J. P. A., & Beets, M. W. (2023). Feasibility indicators in obesity-related behavioral intervention preliminary studies: a historical scoping review. *Pilot and Feasibility Studies*, *9*(1), 46. https://doi.org/10.1186/s40814-023-01270-w

Ramirez, E., Kulinna, P. H., & Cothran, D. (2012). Constructs of physical activity behaviour in children: The usefulness of Social Cognitive Theory. *Psychology of*

Sport and Exercise, *13*(3), 303-310. https://doi.org/10.1016/j.psychsport.2011.11.007

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. The Guilford Press. https://doi.org/10.1521/978.14625/28806

Sebire, S. J., Jago, R., Fox, K. R., Edwards, M. J., & Thompson, J. L. (2013). Testing a self-determination theory model of children's physical activity motivation: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), 111. https://doi.org/10.1186/1479-5868-10-111

U.S. Department of Health and Human Services. (2018). Physical activity guidelines for Americans (2nd ed.). https://health.gov/sites/default/files/2019 09/Physical_Activity_Guidelines_2nd_edition.pdf

Walker, T. J., Kohl, H. W., Bartholomew, J. B., Green, C., & Fernández, M. E. (2022). Using Implementation Mapping to develop and test an implementation strategy for active learning to promote physical activity in children: a feasibility study using a hybrid type 2 design. *Implementation Science Communications*, *3*(1), 26. https://doi.org/10.1186/s43058-022-00271-9

Appendix

Abbreviations

BP	Blood pressure
BPNES	Basic Psychological Needs in Exercise Scale
CAPL-2	Canadian Assessment of Physical Literacy – Second Edition
CDC	Centers for Disease Control and Prevention
CFIR	The Consolidated Framework for Implementation Research
CVD	Cardiovascular disease
HR	Heart rate
PA	Physical activity
PE	Physical education
PSE	Policy-Systems-Environment
SCT	Social cognitive theory
SDT	Self-determination theory
SOFIT	System for Observing Fitness Instruction Time
SOSPAN	System for Observing Staff Promotion of Activity and Nutrition