Annals of Agricultural and Environmental Medicine 2024, Vol 31, No 2, 160–169
www.aaem.pl

REVIEW ARTICLE

Development and application of the integration of physical activity into health care – a scoping review

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Sun J, Ren Y, Qian G, Yue S, Szumilewicz A. Development and application of the integration of physical activity into health care – a scoping review. Ann Agric Environ Med. 2024; 31(2): 160–169. doi: 10.26444/aaem/183778

Abstract

Introduction and Objective. As globalization and modernization continue to impact people's lives, a significant shift in lifestyle has taken place, resulting in a worldwide decrease in physical activity and an increase in unhealthy eating patterns. Physical inactivity has become the fourth leading cause of death globally. The aim of this scoping review is to analyze the concept and development of integrating physical activity into healthcare (IPAHc), based on the principles of sports and exercise medicine (SEM) and exercise is medicine (EIM).

Review methods. A systematic search was conducted of relevant published studies with full text using PubMed, Scopus, Web of Science, Academic Search Ultimate, Medline, and SPORTDiscus, via the EBSCO search platform.

Brief description of the state of knowledge. Twenty-nine studies met the inclusion criteria. The integration pathway centres around physical activity consultation and/or referral, and information technology which has been extensively utilized in IPAHc, including websites, electronic medical records, social media, wearable devices, mobile software, and referral tools. SEM and EIM face numerous implementation challenges, such as time constraints, education/training, resources, and tools.

Summary. The concept of IPAHc involves the integration of Physical Activity Vital Signs (PAVS) into electronic medical records to evaluate the physical activity levels of the general population. This can assist individuals in achieving fitness goals, preventing diseases, treating existing illnesses, and undergoing rehabilitation. IPAHc has been in development for many years and is now being explored in practice. Despite the widespread use of information technology in this integration process, a number of challenges still need addressing.

Key words

physical activity, healthcare, community, tools, health

INTRODUCTION

Physical activity (PA) is globally recognized as a crucial lifestyle behaviour that yields significant health benefits[1]. Regular PA promotes and protects both mental and physical health [2] and serves as an effective means for primary and secondary prevention of almost all chronic diseases [3]. PA is particularly vital for individuals living with health conditions; benefits include reducing post-operative complications and improving rehabilitation effects [4]. Inpatient activity positively impacts physical and psychological health and the general quality of life [5]. For those with physical disabilities, PA can enhance health and well-being [6], with research indicating that exercise can treat 26 diseases [7]. Various countries and regions are increasing their emphasis on healthy lifestyles, issuing PA guidelines to encourage nationwide exercise [8].

Initiatives to increase PA face several challenges. First, more than 1.4 billion adults worldwide are at risk of diseases due to insufficient PA [2]; 81% of adolescents, and 27.5% of adults currently do not meet the WHO's recommended levels of PA [1]. Compelling evidence indicates that physical inactivity is a significant cause of most chronic diseases, while PA primarily prevents or delays these conditions [2]. The global cost of inaction on physical inactivity would reach approximately $47·6 billion per year [9].Second, opportunities for individuals to participate in PA are uneven and inequitable [2]. Third, regular participation in sports and exercise can result in sports-related injuries (SRIs), which are a primary reason for exercise cessation [8]. While the health benefits of sports are widely acknowledged, sports injuries, sudden death, and other sports risk issues are serious concerns, with youth injuries being particularly prevalent [10]. Fourth, as the global population ages, the number of people living with non-communicable diseases increases, and the consequences of injuries rise, health policy planners must prioritize rehabilitation services [11]. Recent estimates suggest that 2.4 billion people with health conditions could require rehabilitation globally; this need has increased by 63% since 1990 [12] and is expected to continue rising [13].

Although PA offers a wide range of positive effects on numerous health conditions, it is seldom practiced in routine clinical or hospital care [14]. Pre-exercise assessments by healthcare providers for patients are uncommon [15]; PA consultations at physician clinics are inadequate, and patients receive limited guidance [14]. The quality of reports on exercise intervention is poor across all areas involving sports medicine [16]. According to a WHO report, most countries

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Received: 27.09.2023; accepted: 06.02.2024; first published: 21.02.2024

lack a PA policy, and there is global consensus that resources are a crucial factor [1].

Exercise has a positive impact on human health, and there is an urgent need for intervention guidance to effectively address the challenges presented by people's health and PA needs. To address this need, two concepts, Sports and Exercise Medicine (SEM) [17] and Exercise is Medicine (EIM) [18], have been proposed and explored through practical research. Most of the literature focuses on specific disease interventions, such as preventing and treating chronic diseases [19] or assisting with in rehabilitation [20]. Therefore, there is a need for a more comprehensive analysis of the topic, a deeper study into methods for the integration of physical activity into healthcare (IPAHc), and further exploration of specific integration paths. This study aims to elucidate the development and implications of IPAHc, analyze the pathways, application tools, barriers to IPAHc, and provide a reference for the in-depth integration of PA and healthcare.

MATERIALS AND METHOD

The protocol for this scoping review follows a five-step framework outlined by Arksey and O'Malley and advanced by Levac et al. [21, 22], guided by the preferred reporting items for systematic review and meta-analysis (PRISMA) [23]. The framework includes identification of research questions and relevant studies, study selection, data extraction from the selected articles, and dissemination of the results. These steps were followed in the development of the scoping review protocol and are described in detail in subsequent sections. Ethical approval was not required for this study. The scoping review search was completed in October 2022, and the follow-up analysis of literature search results completed in March 2023.

Identifying research questions. The scoping review addressed the following research questions:
1) What are the theories and developments of SEM and EIM?
2) What are the pathways/applications for SEM and EIM?
3) What tools are used in SEM and EIM?
4) What are the barriers to SEM and EIM integration in healthcare?

Identifying relevant studies. The following bibliographic platforms and databases were searched: PubMed, Scopus, Web of Science, Academic Search Ultimate, Medline, and SPORTDiscus with Full Text via the EBSCO search platform. The time range was set for all years, using the terms ('sport and exercise medicine') or ('exercise is medicine' or 'exercise as medicine') and ('model' or 'pattern'). The following inclusion and exclusion criteria were used to identify eligible articles for review.

Inclusion criteria: (1) full-text available; (2) the research referenced SEM or EIM and addressed at least one of the research questions; (3) written in English; and (4) published in scholarly (peer-reviewed) journals.

Exclusion criteria: (1) books, book sections, dissertations, theses, or conference abstracts; (2) no review issues addressed; (3) no valid information could be extracted.

Selecting studies. The study selection process and criteria for exclusion followed PRISMA. Two investigators were involved in approving articles for inclusion in the scoping review. A video conference meeting was set up to discuss discrepancies between the investigators when deciding to include or exclude an article. If discrepancies were found and could not be resolved between the two researchers, a third researcher was engaged to finalize the assessment. Articles were included if they addressed at least one of the research questions and excluded if they were not a full study. Duplicate articles were removed if they had the same author and title. Studies deemed irrelevant were summarized with reasons for their exclusion. After the selection of studies, the authors, date, title, results, and any other necessary fields for each article were screened and listed.

Data collection. A data chart was constructed Using Microsoft Word to facilitate the information stated within each included study (Tab. 1–4). The first author charted all study details, while the second author checked the accuracy of data extraction; all researchers used the same Excel Table to avoid missing information. The information extracted from each article included: author name, publication date, title, type of study, research concept, country, subject of study, and which of the four questions were addressed. A '+' indicated the relevant question addressed by the study.

Collating, summarizing, and reporting the results. After the articles had been screened, each one was organized around a topic related to one or more of the four research questions answered in this scoping review. Further details of the findings are discussed and referenced in the Results section below.

RESULTS

Study characteristics. A total of 4,165 articles were identified in the search process (Fig. 1). After removing duplicates and papers irrelevant to the selected topic, 25 papers were included in the analysis [8, 14, 17, 19, 20, 24–43]. Based on the reference lists in these papers, an additional four studies were included [44–47], to comprise a total of 29 articles included in the analysis. The complete lists of included articles are summarized in Table 1. The publication period ranged from 2011–2022, with 62.1% of the papers published after 2019. Eight countries were involved, with most concentrated in developed regions (Fig. 1; Tab. 1).

What is the conceptualization and development of SEM and EIM? Eighteen articles addressed concept and development [17, 19, 20, 24, 25, 28, 29, 31–35, 38, 40, 42, 43, 45, 47], with four papers about SEM [17,24,32,40], including one about eSEM and teleSEM (Tab. 2). There were 14 articles about EIM, including 13 articles about the concept of EIM [19, 20, 28, 29, 31,33–35, 38, 42, 43, 45, 47], 6 articles about the principles of EIM [20, 28, 29, 31, 42, 45], 1 article about Exercise is Medicine (EIM) on Campus [25], and one article about the current business development of EIM [36] (Tab. 2).

What are the pathways/applications for SEM and EIM? The pathways for SEM or EIM applications are summarized in Table 3, with a total of 13 articles included in the analysis [8, 17, 19, 20, 25, 28, 29, 32–34, 37, 38, 43]. At the organizational

Table 1. Summary of included studies information

Author, Year	Type of Research	Research Concept	Study Location	Research Subjects	Included Questions			
					1	2	3	4
Matheson et al., 2011[17]	Review	SEM	USA	Chronic disease prevention and management	+	+		
Holtzhausen et al., 2014[24]	Review	SEM	South Africa	Whole population	+			
Lobelo et al., 2014[19]	Review	EIM	USA	Non-communicable diseases (NCDs)	+	+		
Bopp et al., 2015[25]	Intervention	EIM	USA	College campuses	+	+	+	
Thornton et al., 2016[44]	Review	SEM	Canada	Chronic disease prevention and management				+
Cowan et al., 2016[20]	Review	EIM	USA	Rehabilitation	+	+		
Pojednic et al., 2016[26]	Survey	EIM	USA	Doctors				+
Fowles et al., 2017[27]	Survey	EIM	Canada	Physicians				+
Stoutenberg et al., 2018[28]	Original Research	EIM	USA	Working group	+	+		
Jagannathan et al., 2018[29]	Pragmatic clinical trial	EIM	USA	Kidney disease	+	+	+	
Shurlock et al., 2018[30]	Survey	SEM	UK	SEM doctors			+	
Pullen et al., 2019[8]	Survey	SEM	UK	Injury treatment and health management		+		+
Bowen et al., 2019[31]	Review	EIM	USA	Whole population	+		+	+
Dijkstra et al., 2020[32]	Review	SEM	Qatar	Injury assessment	+	+	+	+
Thompson et al., 2020[33]	Review	EIM	USA	Treatment and prevention of various chronic diseases	+	+	+	+
Krops et al., 2020[34]	Survey	EIM	Netherlands	Clinicians, department managers, lifestyle coaches, patients	+	+	+	+
Smock et al., 2020[35]	Survey	EIM	USA	Healthcare providers	+			+
Lobelo et al., 2020[36]	Clinical report	EIM	USA	Children			+	
Myers et al., 2021[37]	Survey	SEM	UK	SEM consultants, staff, patients		+	+	
Linke et al., 2021[38]	Survey	EIM	USA	All patients	+	+		
Bowen et al., 2021[45]	Survey	EIM	USA	Health care providers	+			+
Steele et al., 2021[39]	Communication	SEM	UK	Dataset			+	
Ash et al., 2021[46]	Perspectives	SEM	Global	Wearable Devices			+	
Neunhaeuserer et al., 2021[40]	Review	SEM	Italy	SEM in Europe	+			
dos Santos et al., 2021[41]	Review	SEM	Brazi	Myopathies			+	+
Nauta et al., 2022[14]	Survey	EIM	Netherlands	Doctors				+
Bouma et al., 2022[42]	Survey	EIM	Netherlands	Clinicians, lifestyle coaches, hospital managers	+		+	+
Porter et al., 2022[43]	Survey	EIM	USA	Physical inactivity and/or non-communicable disease	+	+		
Davenport et al., 2022[47]	Perspective	EIM	USA	Physical therapists	+		+	+

SEM – Sport and Exercise Medicine; EIM – Exercise is Medicine. Included questions: 1 – What are theory and development of SEM and EIM? 2 – What are the paths/applications for SEM and EIM applications? 3 – What are the tools used in SEM and EIM? 4 – What are the barriers of SEM and EIM?

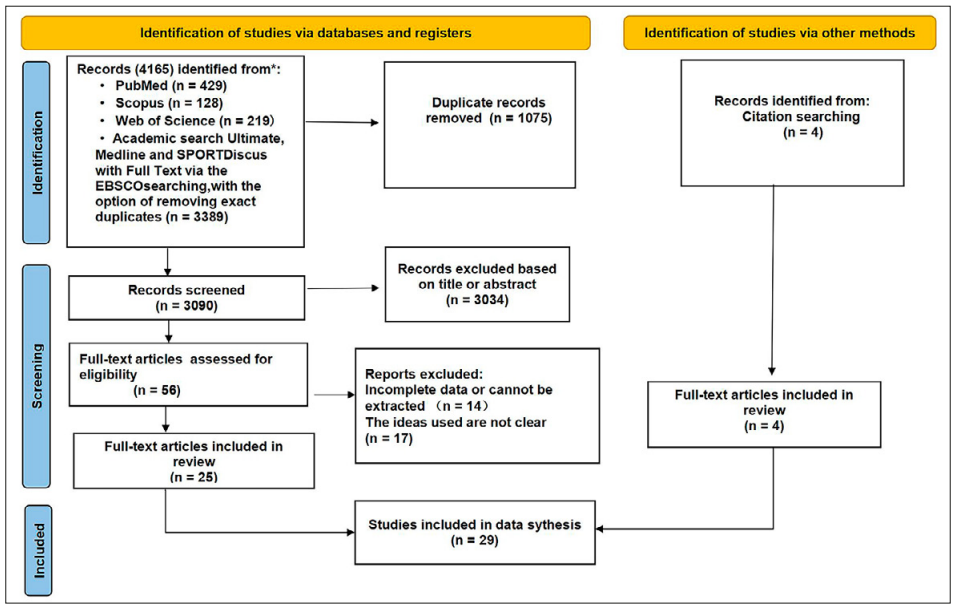

Figure 1. Flow diagram of study selection

Table 2. Theory and development of SEM and EIM

Author, Year	Research Concept	Concept/development
Matheson et al. 2011 [17]	SEM	Sport and exercise medicine's culture is multidisciplinary, integrated, and holistic, ideally suited to act in the areas of preventive and rehabilitative medicine using a multidisciplinary, holistic approach.
Holtzhausen et al. 2014 [24]	SEM	SEM is a young discipline in health sciences. Current scope of practice of SEM: prevention, diagnosis, treatment of sports injuries; prevention, diagnosis, prevention, rehabilitation of chronic medical conditions, using exercise and lifestyle intervention as therapeutic tools.
Lobelo et al 2014 [36]	EIM	In 2007, AMA and ACSM developed the EIM global initiative, aimed at making PA assessment, prescription, and patient referral the standard of care.
Cowan et al. 2016 [20]	EIM	Principles: (1) monitor PA as a vital sign; (2) compare each patient's current PA level with national guidelines, (3) provide PA counselling and/or referrals for each patient not meeting national PA guidelines.
Bopp et al. 2015 [25]	EIM	EIM on Campus, an initiative through ACSM (2009), urges universities and colleges to promote exercise and its health benefits on their campuses.
Dijkstra et al. 2020 [32]	SEM	eSEM - practice of SEM in athletic and public health contexts supported by electronic processes and communication. TeleSEM - SEM patient service often used for follow-up, chronic care, medication management, specialist consultation, other clinical services provided remotely via secure video, audio connections, mobile phone applications.
Lobelo et al. 2020 [36]	EIM	Between 2010 and 2013, EIM established in 39 countries, with seven EIM regional centres.
Neunhaeuserer et al. 2021 [40]	SEM	SEM is a professional qualification for physicians responsible for the health and care of athletes, as well as for functional evaluation and exercise prescription for patients with chronic diseases. Sixteen countries have an independent and/or recognized specialization.

SEM – Sport and Exercise Medicine; EIM – Exercise is Medicine; PA – physical activity; eSEM – E-Sport-and-Exercise-Medicine; teleSEM – tele-Sport-and- Exercise-Medicine

level, there were three cases at the national level (40), and 11 cases on health care institution pathways [8, 19, 20, 28, 29, 32–34, 37, 38, 43], including eight on clinical pathways [28, 29, 32–34, 37, 38, 43], one on primary care preventive consultation [19], and two on rehabilitation [8, 20]. Among the members involved in SEM and EIM pathways, doctors were mentioned in nine articles [8, 19, 20, 29, 32, 33, 37, 38, 43], while fitness personnel was mentioned in seven [19, 20, 28, 29, 33, 34, 43], Two articles specifically referred to SEM doctors [8, 37]. In terms of institutions involved in these pathways/applications of SEM and EIM, schools were mentioned in two articles [17, 33], and government organizations mentioned in two articles [19, 33]. Among the studies on SEM and EIM, two articles focused on school-based interventions [17, 25], three articles discussed intervention model development [28, 37, 38], and seven articles described physician consultation and referral pathways for interventions [8, 19, 20, 29, 32, 34, 43]. (Tab. 3).

What are the tools used in SEM and EIM? Thirteen articles were included in the analysis [25, 29–34, 36, 37, 39, 41, 42, 46, 47] (Tab. 4). According to the IPAHc pathway framework, the tool functions can be categorized into three types. The first type is education and promotion, which is covered in three articles, including a website [25, 33], and platform-specific articles [30]. The second type is information collection, which is discussed in three articles, including National Referral Database [39], E=M tool [42], and big data [47]. The third type is physical assessment, which is explored in nine articles. This category includes non-specific social media platforms [32], health history forms/electronic health records (EHRs) [33,39], wearable activity devices [29, 31], exercise = medicine (E=M) tools [34, 42], 'I CAN' tool [37], questionnaires, activity logs, pedometers, and research-grade and consumer-oriented accelerometers [36]. The fourth type is PA intervention, which is covered in six studies, including PA health monitoring mobile apps [29, 31–33, 41] and E=M tools [42]. (Tab. 4)

What are the barriers to SEM and EIM integration in healthcare?. Table 5 summarizes the barriers to integrating PA into primary care. There are 11 barriers in EIM and SEM, with lack of education/training and lack of time most frequently mentioned, in nine articles. This is followed by a lack of tools and resources with six articles, a lack of knowledge/skills and access to needed distribution with five articles, and other factors mentioned in fewer than five articles. (Tab. 5)

DISCUSSION

This scoping review aimed to clarify the development and concept of IPAHc and to analyze the pathway, challenges, and tools for IPAHc. From the included articles, the study focused on developed regions, encompassing research on prevention, diagnosis, sports injury, rehabilitation, and tool usage. IPAHc has become an important solution to several health issues facing people today. Through the scoping review, it was found that although IPAHc has developed relatively quickly in recent years, it is still in the exploratory practice phase and faces many obstacles in its implementation. The pathway of integration revolves around PA consultation and/or referral, utilizing a multi-disciplinary collaborative approach, with information technology receiving increased attention and playing a key role as the medium through which the subjects are linked. In the following, four issues of the review are explored.

First, in terms of the theory and development of IPAHc, combining the concepts of SEM and EIM, SEM is a young discipline in the health sciences [24] that takes a multi-disciplinary, holistic approach to action in the field of preventive and rehabilitative medicine [17], for all levels of participation [40]. On the other hand, EIM is biased towards the application of care, providing PA counselling and/or referral for each patient who does not meet national PA guidelines [20, 28, 29, 31, 42, 45], and revolves around the implementation of EIM 'solutions' [19]. The presented review demonstrates that IPAHc involves incorporating physical activity vital signs (PAVS) into electronic medical records

Table 3. Pathways/Applications of SEM and EIM

Nation School Hearcare (Clinical Primary care Rehabilitation)

Author, Year	Organization	Participant Characteristics	Institution/Members	Path/Application
Matheson et al. 2011[17]	Exercise Organization	Students	F-MARC	Align soccer's popularity with curricular changes to promote health in public schools in its 208 member nations.
Lobelo et al. 2014[19]	Health care institutions (EIM: prevention evaluation)	Non-communicable disease population	National Task Forces, HCPs, fitness professional education, media	Augment clinical and community integration activities with carefully targeted activities in policy and surveillance, evaluation, HCPs and fitness professional education, and media and industry support.
Bopp et al. 2015[25]	EIM On Campus (EIM)	College Students	A chair dedicated to EIM. A group of kinesiology faculty and a student health services representative, the Kinesiology Club	EIM week activities, exercise stations set up at campus locations to encourage short PA competitions, and successful outreach methods (website, social media, etc.).
Cowan et al. 2016[20]	Health care institutions (EIM: Rehabilitation)	Rehabilitation	Rehabilitation HCPs, Healthcare Providers, Exercise Professionals	Intervention pathways: safety screening, readiness for change, simple customized physical activity prescriptions, referrals. Aims: increase access to physical activity resources; improve health outcomes.
Stoltenberg et al. 2018[28]	Health care institutions (EIM:Implementation evaluation)	Clinical practices evaluation model	Care manager, nurse practitioner, health coach	RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework informs development of the evaluation model.
Jagannathan et al. 2018[29]	Health care institutions (EIM: Clinical)	Patients on dialysis	Physicians, Patients, EIM-Fitness Professionals (Community), Insurance	Three-step intervention: Step 1: develop framework for PA intervention; Step 2: synthesize findings from Aim 1 to implement PA interventions; Step 3: assess short-term effectiveness, focusing on implementation barrier identification.
Pullen et al. 2019[8]	Health care institutions (SEM: Sports injuries and rehabilitation)	Sport-related injury	General Practitioner, SEM clinic	Integration of SEM in the National Health Service; general practitioners refer sport-related injury patients to SEM clinics.
Dijkstra et al. 2020[32]	Health care institutions (SEM: Clinical)	Athlete/SEM patients	Doctors, physiotherapists, podiatrists; athletes, coaches	TeleSEM and eSEM provide three types of services: planning consultation, implementation consultation, post-consultation action.
Thompson et al. 2020[33]	Health care institutions (EIM:clinical)	cardiometabolic diagnoses or musculoskeletal/ pain	HCPs work with an interdisciplinary team	The Population Health Management model: HCPs work with interdisciplinary team to refer patients to fitness center or "Life Center" for supervised 12-week exercise and health behavior change intervention with qualified EIMG professionals. The intervention consists of two 1-hour sessions per week in a community-based setting.
	Country (EIM)	Disease management	Singapore: Various health care associations and fitness organization	EIM Singapore works with specialists to incorporate exercise interventions into their disease management pathways. A mainstay of EIM Singapore's mission is to train physicians in exercise prescription, and train community health counselors called Health Peers.
	Country (EIM)	General practice	Polish: EIM National Center team, Polish Ministry of Health, the National Institute of Public Health	Integration of physical activity into health care systems. Educating medical students and fitness professionals during conferences, lectures, workshops; 2 community-based projects: "Walk for Health—Invite Your Doctor" and "Active Family".
	Country (EIM)	Promote health and treat/control chronic diseases	Chile: medical students; HCPs, exercise professionals	EIM National Center promotes physical activity and treatment and control of chronic diseases through online courses for medical students and EIM workshops.
Krops et al. 2020[34]	Health care institutions (EIM: Clinical)	PIE=M Tool	Clinicians, department managers, lifestyle coaches, patients	Implementation pathway involves analyzing levels and determinants of physical activity in different patient populations; next, examining barriers, facilitators, and current implementation status of exercise as medicine; finally, developing implementation strategies based on the analysis.
Myers et al. 2021[37]	Health care institutions (SEM: Clinical)	Maternity, Enablement, Renal and Complex Medical Unit	SEM consultants, medical staff	Secondary Care Clinical Pathways, COM-B ('Capability,' 'Opportunity,' 'Motivation,' 'Behaviour') model.
Linke et al. 2021[38]	Health care institutions (EIM: Clinical)	Chronic diseases	Key stakeholders and leaders, providers, staff, and patients	Use implementation science and quality improvement models to adapt, implement, evaluate integration of EIM into primary care clinics.
Porter et al. 2022[43]	Health care institutions (EIM: Clinical)	All referred patients	HCPs, EIMG™Pros, EIMG® Referral Team	Comprehensive PA assessment. Based on patient's needs and circumstances, develop a personalized PA prescription that may include a referral to a community-based PA center through a dedicated referral team.
Total Number	3	2	8	1 2

SEM: Sport and Exercise Medicine, EIM: Exercise is Medicine, F-MARC: FIFA Medical Assessment and Research Centre, HCPs: health care providers, PA: physical activity, eSEM: E-Sport-and-Exercise-Medicine, teleseme: tele- Sport- and- Exercise- Medicine, EIMG: Exercise is Medicine Greenville, PIE=M: Physicians Implement Exercise = Medicine Tool

Table 4. Application of tools in SEM and EIM

Education | Information collection | Physical assessment | PA intervention

Author, Year	Tools	Functions
Bopp et al. 2015 [25]	Outreach (website, social media, etc.)	Education, publicity (provide information, pictures, videos and news stories, all educational materials).
Jagannathan et al. 2018 [29]	'Wearable' with associated smartphone app; available electronic activity monitors	Monitoring, self-monitor progress, evaluating goals.
Shurlock et al. 2018 [30]	Social Media (e.g., LinkedIn and Twitter)	Health promotion and education.
Bowen et al. 2019 [31]	Wearable activity devices or smartphone apps	Assess the patient's current PA level efficiently monitor progress toward achieving set fitness goals.
Dijkstra et al. 2020 [32]	Dedicated sports medicine apps, e.g. Physiotools and non-specific social media platforms, e.g. VSee, WhatsApp, Skype, or Zoom	Follow-up consultations management of chronic conditions, medication management, specialist consultation, many other clinical services.
Thompson et al. 2020 [33]	Activity trackers, mobile phone apps, websites, health history form / EHR	Education, self-directed resources, assessment risk
Krops et al. 2020 [34]	E=M screening and referral	PA prescriptions, screening, referrals.
Lobelo et al. 2020 [36]	Questionnaires, activity logs, pedometers, research-grade and consumer-oriented accelerometers	Assess PA levels in children and adolescents.
Myers et al. 2021 [37]	'I CAN' tool	Documents a patient's physical capability.
Steele et al. 2021 [39]	National Referral Database	Offer observational data.
dos Santos et al. 2021 [41]	Wearable devices, smartphone apps, online training prescriptions	Introducing new research fields and expanding options for access to training on an individualized basis, prescribed by qualified professionals.
Bouma et al. 2022 [42]	E-M tool for PA recommendations and referrals	Collection of patient information; diagnosis; consultation. PA recommendations; PA referrals.
Davenport et al. 2022 [47]	Big Data	Data collection regarding exercise across the population.
TOTAL	3	3 | 9 | 6

PA – physical activity; EHR – electronic health record; E – Exercise; M – Medicine

(EMRs) to assess the PA of all population groups across the lifespan, including pregnancy and foetal stages, infancy, early childhood, preschool age, school age, puberty, adolescence, middle and old age. This can guide individuals towards fitness goals as well as disease prevention and treatment.

Both SEM and EIM have evolved significantly in recent years and are being implemented more widely. Sixteen European countries possess an independent and/or recognized SEM specialization [40]. As a global initiative, EIM has been implemented in 37 countries [18], across 275 college and university campuses worldwide [33], with the establishment of an EIM Credential [33]. The EIM initiative has been organized after early promotion, and the second phase will revolve around the implementation of the EIM 'Solution'. This, in essence, is the integration of clinical healthcare provider services with community evidence-based PA programmes [19]. This study argues that the combination of both SEM and EIM theories can better respond to the current challenges faced globally, and provide a more comprehensive analysis of the IPAHc. Although SEM and EIM have been promoted and developed to a certain extent, they are still at the stage of practical exploration and need to establish a comprehensive system of discipline and training, and related theoretical research for future development.

Second, based on this review of IPAHc pathways/applications, the intervention population encompasses chronic disease prevention and management [17, 19, 31, 33, 44], disease treatment [29, 37, 41], rehabilitation [8, 20], and student populations [25,36]. The interventions involve mainly government organizations [19, 33], fitness professionals [19, 20, 28, 29, 33], physical therapists [28, 32], or SEM [8, 28, 32, 37] and other physicians [8, 19, 28, 29, 32–34, 37], as well as schools [25, 33] and other organizations [17, 33]. The intervention pathways, as outlined in both the EIM and SEM frameworks, integrate clinical healthcare provider services with community-based, evidence-based PA programmes as the primary solution [19, 37]. This involves incorporating a Physical Activity Vital Sign (PAVS) into electronic medical records (eEMRs), conducting assessments by healthcare providers, and referring patients to community PA or SEM clinics that offer comprehensive programs, places, and professionals (the 3 Ps) within their communities. Self-directed resources such as activity trackers, mobile phone apps, websites, and bike share can also be utilized. At the national level, a multi-actor collaborative intervention system is based on their characteristics [33].

Intervention paths may vary across disease types, with physically inactive and/or non-communicable disease patients having (1) PA assessment, (2) PA prescription, and (3) referral to community PA as the primary approaches [19]. Clinical intervention pathways include (1) multilevel partner collaboration, (2) clinical exercise and health behaviour change interventions, and (3) easy accessibility in a community setting [29, 33, 37]. Patient rehabilitation

Table 5. Barriers to PA integration primary care

STUDY	FACTORS										
	Education/ Training	Safety	Knowledge/ skills	Prescription Materials	Physician Interest	Lack of resources	Lack of time	Reimburse-ment	Tools	Patient	Referral channels
Matheson et al. 2011 [17]	+										+
Thornton et al. 2016 [44]	+						+			+	
Pojednic et al. 2017 [26]	+		+	+	+	+	+		+	+	
Fowles et al. 2018 [27]				+	+	+	+				
Pullen et al. 2019 [8]											+
Bowen et al. 2019 [31]	+	+	+	+	+	+	+	+	+	+	+
Dijkstra et al. 2020 [32]	+								+		
Thompson et al. 2020 [33]	+						+	+	+		
Krops et al. 2020 [34]	+						+		+		+
Smock et al. 2020 [35]	+	+	+			+					
Bowen et al. 2021 [45]						+	+			+	
dos Santos et al. 2021 [41]									+		
Nauta et al. 2022 [14]	+		+		+	+	+	+			
Bouma et al. 2022 [42]			+				+				+
TOTAL	9	2	5	3	4	6	9	3	6	4	5

pathways involve HCPs, exercise specialists/SEM physicians, and individualized recovery programmes (in-hospital and out-patient rehabilitation) [8, 20]. From the perspective of the specific implementation of IPAHc, it may be necessary to evaluate the specific implementation path [17, 38] and hospital environment [28]. In contrast, school-based PA interventions are often the most promising approach for increasing PA among adolescents. Such interventions require interprofessional collaboration and the involvement of community organizations in developing tools to provide support, including ways to track PA, incorporate activity measures into EHRs, and use assessments to offer patient-specific recommendations [36]. For college students, the Exercise is Medicine On Campus (EIM-OC) programme has been organized and carried out with EIM-OC as an action guide [25].

The review shows that integration requires multiple synergies, including enhanced communication and cooperation, and that health is affected by multiple factors [48]. The WHO has emphasized the need for stronger partnerships across sectors to enable the delivery of effective programmes, services, and safe environments that engage and support people of all ages and abilities to be physically active [2]. In addition, the WHO stresses the importance of stronger governance structures and regulations to ensure environments that support safe PA and inclusive programmes and sports [2]. The WHO has also called for the development of broader, deeper, and more innovative financing mechanisms, which can build a sustainable and robust system to provide PA and sports opportunities for everyone [2]. In the future, a systematic intervention system should be established to better involve people in different situations. It is necessary to consider the integration of PA for all age groups into the healthcare pathway, establishing an effective protection system to ensure the full utilization of sports activities in prevention, treatment, and rehabilitation.

Third, the analysis of the IPAhc framework reveals that healthcare providers need to use electronic medical records for screening assessments, online platforms for referrals [20, 28, 29, 31, 42, 45], teleSEM for teleconsultation services, and dedicated sports medicine applications; these require extensive information technology involvement. Throughout the pathway of IPAHc, websites [28,42] and social media [42, 43] can provide education, advocacy, and supportive videos and articles. Wearable activity devices, smartphone apps, and online training prescriptions will allow clinicians to individualize PA advice [29, 31, 41]. Researchers are developing EIM tools for PA recommendations and referrals, as well as mobile apps with detection capabilities, such as PA health monitoring [44], pedometers[36], 'I CAN' tools [35] for researchers, policymakers, practitioners, and clinicians. The UK's National Referral Database provides valuable insights for these stakeholders [39].

The review shows that information technology has been widely used in IPAHc. There is growing evidence that self-monitoring and behaviour changing programmes using computer-tailored interfaces can be more effective in modifying lifestyle risk factors than traditional approaches [17]. It has been suggested that tailored counselling, including shared decision-making, support materials, and follow-up, contributes to behaviour change. Individualized digital data opens new possibilities for health management in terms of targeted interventions, and has the potential to change the face of global health service delivery [32]. A digital and intelligent holistic healthcare model based on medical health guidance, published in the 2019 edition of *Nature Journal*, discusses multi-source, multi-layer spatiotemporal factors affecting individual health. Intelligent deep learning algorithms provide virtual health prescription suggestions, and in the future an artificial intelligence (AI) virtual coach may interact with users by voice. When all personal data and the totality of medical literature can be considered together, patients can be offered a holistic approach to prevention [48]. This review finds that information technology has been widely used in IPAHc pathways, such as educational outreach, assessment consultation, measurement interventions, and follow-up. The integration of multi-source (meta-) multi-layer spatiotemporal factors has been made possible by breaking time and space constraints and becoming a link between different institutions. With developments in science and technology, information technology will play an increasingly important role in the future of healthcare and exercise as medicine.

Finally, among the challenges in IPAHc, lack of time has been identified as a major barrier against counselling services offered by healthcare providers [14, 26, 27, 31, 33, 34, 42, 44, 45], mainly because today's physicians face many competing demands and work in a productivity-based model of care. This model rewards physicians for seeing more patients, so behavioural counselling in practice is often overlooked [33]. Many patients have multiple health concerns, resulting in insufficient time for PA discussions [31]. Lack of educational training in PA and/or counselling is also a significant hindrance [14, 17, 26, 31–35, 44], as most practitioners do not have a formal education related to PA in medical school [33] and thus lack the knowledge [14, 26, 31, 35, 42] and confidence to prescribe exercise for a patient [33]. A lack of resources [14, 26, 27, 31, 35, 45] and tools [26,31–34, 41] are notable barriers. The EIM recommends that healthcare providers refer patients to appropriate community resources and self-directed activities. However, many clinicians face limited community resources, high out-of-pocket costs for facilities or individuals [31], and a lack of effective tools [41]. Other barriers to discussions of PA in the healthcare system include safety [31, 35], prescription materials [26, 27, 31], physician interest [14, 26, 27, 31], patient factors [26, 31, 44, 45], and triage channels [8, 17, 31, 34, 42].

Throughout the implementation of EIM, there have been concerns that EIM narratives may inadvertently lead to negative consequences, such as making healthcare providers the sole gatekeepers of exercise information. The significant inequities in access to care may result in a less effective delivery of exercise advice outside the healthcare framework (e.g., fitness advocates and physical education teachers) [47]. Navigating the political climate of a large system is challenging, and change initiatives like the Positive Hospitals pilot can be overshadowed by a larger agenda without strong senior leadership [37].

In considering these issues, it is essential to engage multiple stakeholders in the existing model. This includes other academic disciplines (e.g., human behaviour, public health, epidemiology, and healthcare delivery research), government agencies (e.g., ministries of education, transportation, environmental design, and urban planning), the technology industry (e.g., social media companies), healthcare funders, and international sports federations [17]. Evidence suggests that interventions should address individual, social, and environmental factors to improve the likelihood of influencing behaviour [29]. The WHO also advocates the establishment of multi-sectoral collaboration mechanisms to build active societies, active environments, active people, and active systems [1]. The socio-ecological model integrates behaviour theories and social ecology to explain determinants of PA at the individual, social, environmental and policy levels, and help identify different environments where PA can be promoted [49].

By addressing the multi-level influences for PA, the EIM intervention is rooted in socio-ecological approaches to increase the impact and sustainability of the intervention [29]. Social ecology has been widely used in interventions for different populations such as pregnant women [50], preschool children[51], children and adolescents [52], university students [53], adults [54], the elderly [55], and diabetic patients [56]. The WHO convened a multi-participant technical consultation to develop a proposed framework for stimulating health policy and systems research (HPSR) in rehabilitation based on the social-ecological model [57]. Due to the varying influencing factors of different groups, it is necessary to establish a supportive social-ecological environment tailored to specific populations. Because of the large differences in regional environments, we propose a small social ecology theory based on group PA, which is a relatively supportive interpersonal, organizational, community, and public policy environment within a certain region based on group characteristics.

Limitations of the study. First, one of the criteria for inclusion in the analysis was the publication of papers in English. There may be other relevant studies published in other languages. Furthermore, only the more widely-used SEM and EIM concepts were reviewed, while other approaches were not included in the analysis. The concept and the theory presented in this paper need to be further refined and validated, and specific physical activity promotion pathways need to be explored based on the characteristics of different groups. Despite these limitations, the authors believe that this is the first systematic review of IPAHc approaches that provides a comprehensive understanding of its theory and development, pathways, tools, and challenges.

CONCLUSIONS

The presented scoping review demonstrates that IPAHc has been developing for decades and has entered the stage of practical exploration, as well as of professional development. This process requires the collaboration of multiple disciplines, with healthcare providers and the community as the two main stakeholders. IPAHc involves embedding PAVS into EMRs to assess the PA of the entire population based on PA

guidelines, guide individuals in fitness, disease prevention, disease treatment, and rehabilitation. The intervention pathway includes healthcare provider assessment and referral to community PAs or SEM clinics. Although IPAHc is used across different groups, there are some differences in intervention methods.

Additionally, information technology has been widely utilized in the form of websites, electronic medical records, social media, wearable devices, mobile software, and referral tools. However, SEM and EIM still face many obstacles in implementation, such as lack of time, inadequate education/training, and insufficient resources and tools. Information technology is a critical component in addressing these challenges.

Acknowledgments

We would like to thank all authors of the studies included in this scoping review. This work was supported by the Gdansk University of Physical Education and Sport; Yunnan Provincial Department of Education Science Research Fund Project, grant number 2022J1286.

Data availability statement. The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Competing Interests

The authors declare that there are no competing interests.

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