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The Interplay of Actual and Perceived Motor Competencies and Health-Related Factors in Childhood

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List of Abbreviations

AMC	Actual Motor Competencies
BMI	Body-Mass-Index
CFA	Confirmatory Factor Analysis
EMOKK	Entwicklung motorischer Basiskompetenzen in der Kindheit (in English: Development of basic motor competencies in childhood)
EXSEM	Exercise and Self-Esteem Model
HRF	Health-Related Fitness
LPA	Latent Profile Analysis
MOBAK	Motorische Basiskompetenzen (in English: Basic motor competencies)
MVPA	Moderate to Vigorous Physical Activity
OECD	Organization for Economic Co-Operation and Development
PA	Physical Activity
PE	Physical Education
PISA	Program for International Student Assessment
PMC	Perceived Motor Competencies
PMSC	Pictorial Scale of Perceived Movement Skill Competence
PSCA	Pictorial Scale of Perceived Competence and Social Acceptance
SDQ	Self-Description Questionnaire
SEMOK	Selbstwahrnehmung motorischer Basiskompetenzen (in English: Perceived basic motor competencies)
SEM	Structural Equation Model
SES	Socio-economic Status
TGMD	Test of Gross Motor Development
UNICEF	United Nations Children’s Fund
WHO	World Health Organization

1 Introduction

Physical activity (PA) plays a fundamental role in the healthy development of children. Beyond promoting cardiovascular fitness and preventing chronic conditions, regular PA has also been linked to psychological benefits across the lifespan (Alvarez-Pitti et al., 2020; Anderson & Durstine, 2019; Durstine et al., 2013). Despite its recognized importance, a large proportion of children and adolescence worldwide do not meet the recommended daily 60 minutes of moderate to vigorous physical activity (MVPA). The World Health Organization (WHO) refers to this lack of PA as a “global burden” (WHO, 2022a, p. 6). The high prevalence of physical inactivity is alarming, not only for its negative consequences on individual health outcomes but also for its high future societal costs, highlighting the need for policymakers to prioritize PA promotion among young people (Pratt et al., 2014).

A key requisite for participation in PA and sports is the acquisition of actual motor competencies (AMC) during early childhood and the primary school years. AMC form the basis for the further development of sport-specific skills and, in the long term, an active lifestyle (Hulteen et al., 2018). However, Bolger et al. (2021) pointed out that preschool-aged children (3–5 years) demonstrated average AMC, whereas children aged 6–10 years showed below-average levels compared to normative data. Conceptual models, such as Seefeldt’s “proficiency barrier” (1980) and the developmental model proposed by Stodden et al. (2008), demonstrate that insufficient AMC can create barriers to participation in movement and sports, possibly resulting in a negative spiral of engagement and development that can further lead to declined physical health but also to less participation in social contexts and to exclusion (Eime et al., 2013).

Beyond AMC, perceived motor competencies (PMC) have become a focus in models on children’s motor development (Stodden et al., 2008). PMC refer to a child’s subjective perception of their motor competencies (Estevan & Barnett, 2018). Particularly in early childhood, PMC influence both AMC and PA, as children who have high PMC and perceive themselves as competent are more likely to participate in play and sports and continually develop their AMC, while children with low PMC may avoid these situations. While AMC can be objectively measured with standardized tests, there is still a lack of validated, child-appropriate instruments to assess PMC in young children, that is, the preschool and early primary school ages (4–8 years).

At the same time, mental health is a growing subject of interest and research, particularly due to the COVID-19 pandemic and in a time of global conflicts and wars (Kaman et al., 2025). Rising rates of anxiety, depression, and other mental health disorders among all age groups (Kaman et al., 2025; McGorry et al., 2024; Ravens-Sieberer et al., 2022) have led the Lancet Psychiatry Commission to declare a “global youth mental health crisis” (McGorry et al., 2024). The WHO (2022b, p. 8) defines mental health as a “state of well-being” and “not only the absence of ill-being”, what includes the capacity to learn, form relationships, and participate in society. Recognizing that mental health can be increased by PA, the WHO also published a review on mental health benefits and promotion (WHO, 2019).

In response to the growing concern about children’s well-being and mental health, international organizations such as the Organization for Economic Co-Operation and Development (OECD) and

United Nations Children's Fund (UNICEF) have broadened their monitoring to include child well-being indicators, e.g., the OECD's Program for International Student Assessment (PISA; OECD, 2017, 2023; UNICEF Innocenti, 2020). Alongside such international and policy developments, educational settings and schools are increasingly recognized as key environments for promoting AMC, PA, and mental health, through both structured and unstructured PA interventions (Andermo et al., 2020; Bundesinstitut für öffentliche Gesundheit, 2025; Stamm & Bürgi, 2023).

The construct of mental health has also been integrated into motor development models. For example, Lima et al. (2022) expanded Stodden et al.'s (2008) developmental model by including mental health, proposing that mental health, PA, AMC, and PMC are interconnected factors. While the benefits of PA for mental well-being are well-documented for adults (Vella et al., 2023; White et al., 2024), there remains a gap of research for children. Moreover, there is a lack of research specifically investigating the relationship between AMC and mental health in early childhood. Preliminary evidence suggests that children with lower AMC may experience reduced well-being, possibly mediated via lower health-related fitness (HRF) or social exclusion (Gu et al., 2019; Mancini et al., 2019; Redondo-Tébar, Fatouros, et al., 2021). Regarding PMC, Visser et al. (2020) did not find direct associations between PMC and well-being in children but found that PMC and psychosocial well-being predicted children's MVPA.

Despite growing acknowledgments of these links, there is still insufficient research on how AMC, PMC, PA, and mental health parameters interact during childhood. Therefore, more research is needed to explore these interrelations by integrating knowledge in both motor development and health research. A lack of validated PMC assessments, especially for young children, highlights the need to develop additional child-appropriate instruments.

The present dissertation systematically addresses this gap by adopting a holistic, interdisciplinary perspective integrating theoretical frameworks of motor development (Lima et al., 2022; Stodden et al., 2008) and considering models from educational science (Helmke, 2014). By focusing on the development and validation of a new, child-appropriate instrument for PMC assessment, as well as exploration of the relationships between AMC, PMC, and health-related factors, this work aims to provide new insights relevant to educators, researchers, and policymakers. The aims and structure of this dissertation are described in the following subchapters.

1.1 Project Context of this Dissertation

This dissertation is embedded in the larger research project "Development of Basic Motor Competencies in Childhood" (in German: Entwicklung motorischer Basiskompetenzen in der Kindheit [EMOKK]), which was funded by the Swiss National Science Foundation (grant number 200840). The aim of the EMOKK project was to observe and explain how basic motor competencies of preschool and primary school children develop over time considering various factors. In addition to individual factors (e.g., gender, body mass index [BMI], age) and extracurricular influences (e.g., participation in organized sports), school-related factors were also taken into account in this project (e.g., the quality of physical education [PE]). Moreover, potential cultural differences in children's motor development were examined, since data were collected in German- (Zurich, St Gallen, Baselland), Italian- (Ticino), and French-speaking (Bern, Jura, Neuchâtel, Fribourg) regions of Switzerland.

The EMOKK research framework was based on Helmke's (2014) offer-and-use model, which conceptualizes learning as an active, self-directed, and individual process. While learning outcomes are influenced by the quality of teaching and the learning opportunities provided, they also depend on how pupils make use of these opportunities, shaped by their individual characteristics and family support. Contextual and cultural factors inside and outside school further affect these educational processes. In the EMOKK project, the offer-and-use model was adapted to the context of PE, whereby health-related factors were added to the model (Figure 1). In this dissertation, the focus is on the connection between AMC and PMC and health-related factors. The health-related factors were further divided into PA and mental health parameters (i.e., health-related quality of life [HRQoL] and social integration; blue box, Figure 1). This extension recognizes that not only subject-specific and interdisciplinary competencies, but also health-related factors are outcomes of PE.

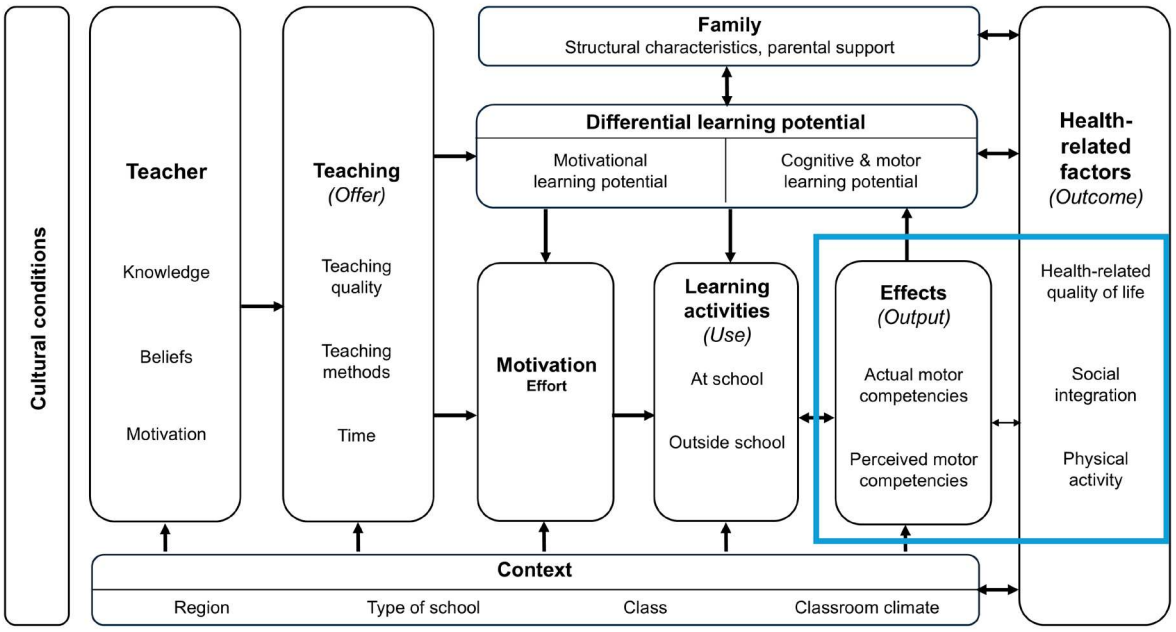

Figure 1. The offer-and-use-model (Helmke, 2014; Kunter & Trautwein, 2013, p. 17), with the addition of health-related factors.

1.2 Aims and Framework of the Dissertation

The overarching aim of this dissertation was to investigate the interplay of AMC, PMC, PA, and health-related factors in children while considering the interface between health sciences, motor development research, and educational sciences. The constructs and the investigated relationships between the constructs are presented in the working model in Figure 2. The specific objectives of the four publications were as follows:

- Publication 1: To develop and validate an instrument to assess perceived motor competencies in first- and second-grade children, aligned with the MOBAK approach (Herrmann et al., 2016) and to investigate the associations between actual and perceived motor competencies and PA.
- Publication 2: To examine the relationship between actual motor competencies and social integration in the class.

- Publication 3: To introduce HRQoL as a mental health parameter and investigate the associations between actual motor competencies, social integration and general HRQoL as well as physical well-being as a subdimension of HRQoL.
- Publication 4: To integrate all constructs in a person-centered approach, identifying distinct profiles of children with varying levels of actual and perceived motor competencies, PA, and physical, psychological, and social well-being.

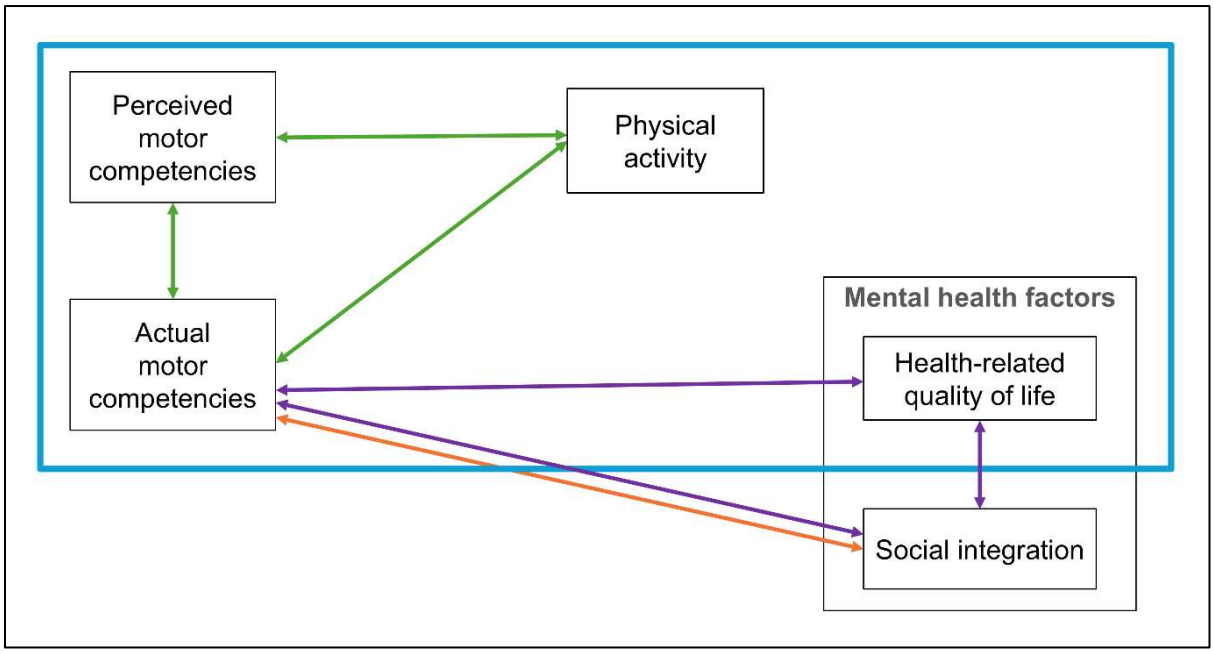

Figure 2. Working model for this dissertation.

For this dissertation, data were assessed considering multiple methods in preschool[1] (4–6 years) and primary school children (6–8 years):

- **AMC:** Standardized motor competence tests (MOBAK instruments for preschool and primary school; Herrmann, 2018; Herrmann et al., 2020)
- **PMC:** Children's self-perceptions via the newly developed SEMOK instrument for first- and second-grade children (Bretz et al., 2024)
- **PA and HRQoL:** Parent questionnaires assessing children's participation in organized sports as well as HRQoL for preschool and primary school children (KIDSCREEN-10, KIDSCREEN-27; Ravens-Sieberer, 2016)
- **Social integration:** Teacher ratings of children's social integration in preschool and primary school children (Perceptions of Inclusion Questionnaire; Venetz et al., 2019)

The publications are based on different datasets covering various age groups and using different instruments. Data for Publications 1 and 4 were collected from children in the first and second grade. Publication 2 includes data from preschool children, while Publication 3 analyzes data from both

[1] In Switzerland, preschool is part of the compulsory school system. Children typically enter the first year of preschool at age four and the second year at age five. After completing two years of preschool, they enter the first grade of primary school.

preschool and primary school children. The instruments used and measurement points are described in the corresponding publications.

1.3 Structure of This Dissertation

The structure of the dissertation follows the logic of the outlined research objectives of the four publications. Chapter 2 introduces the theoretical and conceptual foundation related to motor development. It begins with an overview of key constructs in motor development in childhood: PA, AMC, and PMC. These are defined, contextualized, and linked to existing models, such as the MOBAK framework (subchapter 2.3.2). As one main aim of this dissertation was to develop an instrument to assess PMC in first- and second-grade children, the process of its development is presented in subchapter 2.4, beginning with the assessment of PMC in young children (subchapter 2.4.1) and considerations for the development of the instrument (subchapter 2.4.2). The chapter concludes with a summary of **Publication 1**, which presents the development and validation of the SEMOK-1-2 instrument for assessing the PMC of first- and second-grade children (subchapter 2.4.3).

Chapter 3 addresses the integration of mental health parameters into motor development research. First, definitions and models of mental health are introduced, followed by a classification of health-related factors for the context of this dissertation. Subchapter 3.1 discusses how mental health parameters can be embedded into motor development frameworks and presents the empirical state of research on mental health parameters and PA, AMC, and PMC. As social integration and health-related quality of life were considered as mental health parameters in this dissertation, both constructs are presented, followed by **Publication 2** and **Publication 3** (subchapter 3.2). Subchapter 3.3 focuses on the use of person-centered approaches in child development research, highlighting the need to consider both variable-and person-centered approaches. Chapter 3 concludes with a summary of **Publication 4**, which investigated the interplay of these factors through latent profile analysis (LPA).

The discussion (chapter 4) summarizes the findings of the dissertation (subchapter 4.1) and situates them within the existing body of research (subchapter 4.2). Next, strength and limitations are analyzed, as well as prospects for further research (subchapter 4.3). In addition, theoretical, empirical and practical implications of the results are outlined (subchapter 4.4). Finally, the dissertation is rounded off by a conclusion (subchapter 4.5).

2 Motor Development in Childhood

This chapter introduces the theoretical and conceptual framework for this dissertation by addressing motor development as a core component of child development (subchapter 2.1). Building on this understanding, a key development model by Stodden et al. (2008) is introduced, highlighting the dynamic and bidirectional relationships between AMC, PMC and PA (subchapter 2.2). Next, key constructs of motor development are defined and contextualized individually (subchapter 2.3). The development of an instrument to assess the PMC of first- and second-grade children is the focus of subchapter 2.4. That subchapter presents existing assessments of PMC in children, presents considerations for the development of the new SEMOK-1-2 instrument, and concludes with a summary of Publication 1.

2.1 Relevance of Motor Development in Childhood

Movement plays a central role in the overall development of children. According to Zimmer (2020, 2022), movement is a key factor in child development, as children explore their environment and acquire knowledge by movement. Through movement, children not only train their muscles and coordination but also learn to manage risks, experience success and failure, and strengthen their sense of self-efficacy. As PA often occurs in social contexts, it provides opportunities for children to learn cooperation, establish rules, and adhere to them. These experiences promote the development of social competencies and lay the foundation for social development. Moreover, the physical demands of movement enhance muscular strength and endurance, supporting physical and motor development (Bös, 2003). Altogether, movement contributes holistically to healthy child development across cognitive, personal, social, and physical domains (Zimmer, 2020, 2022). It also contributes to the prevention of chronic diseases and supports positive health outcomes across the lifespan (Alvarez-Pitti et al., 2020; Anderson & Durstine, 2019; Durstine et al., 2013).

Hulteen et al. (2018) proposed a lifespan model of PA development describing how AMC evolve and form the basis for lifelong PA engagement. This model will be shortly presented, enriched by integrating neurodevelopmental perspectives on how motor control emerges and is refined throughout development.

At the lowest neurological level, motor responses are based on reflex arcs that are automatic reactions present at birth, such as grasping, which do not require conscious control (Draganski & Thelen, 2018). At the second level, the spinal cord acts as an information relay whereby stimuli are transmitted via afferent nerve fibers to the central nervous system and trigger efferent motor responses, such as withdrawing from a painful stimulus. Simple movements such as maintaining posture or balance are coordinated here through localized reflex pathways. As development progresses, more complex motor programs are established at the third level involving the brainstem, cerebellum, and cerebral cortex. These include learned movement sequences that require coordination and intentional control. Repeated practice leads to automation of spatial and temporal movement patterns, freeing up cognitive resources for higher order tasks (Draganski & Thelen, 2018). At the highest level, movements such as skipping or catching a ball become automated, requiring minimal conscious attention (Roth, 2002). Since complex

movement programs are based on simple movement programs, delays in the simple programs can be associated with later development of complex movement programs (Draganski & Thelen, 2018; Roth, 2002).

This neurodevelopmental trajectory aligns with Hulteen et al.'s (2018) conceptual model, which outlines the progression from reflexive and rudimentary movements in infancy (e.g., grasping, crawling) to so-called "foundational movement skills" (Hulteen et al., 2018) or "basic motor competencies" (e.g., throwing, balancing, jumping; Herrmann et al., 2021b) that are developed through socio-cultural and geographical filters.

These motor competencies are essential for overcoming the so-called "proficiency barrier" (Seefeldt, 1980), which represents a critical threshold in fundamental movement skills. Reaching this threshold is necessary for successful acquisition of more advanced, sport-specific skills, which in turn can support long-term engagement in PA throughout the lifespan (Hulteen et al., 2018).

The need for fundamental motor patterns was also pointed out by Clark and Metcalfe (2002), who draw a metaphor of the mountain of motor development, in which fundamental motor patterns form the point from which children climb up the mountain to context- and sport-specific motor skills. All developmental stages are associated with physical (e.g., weight status) and psychological (e.g., perceived competence) attributes (Hulteen et al., 2018) and embedded in a cultural, scholastic, and familiar context (Bronfenbrenner, 1994; Herrmann et al., 2021b).

In summary, the development of AMC is underpinned by neurobiological maturation and shaped by environmental and cultural contexts. The foundational movements learned in early childhood serve as building blocks for more complex skills and are essential for participation in play and sports. These processes are not only physical but also closely tied to cognitive, social, and emotional development (Hill et al., 2023). This understanding of motor development sets the stage for more detailed models that focus on how AMC interacts with other factors, such as PA and PMC.

2.2 Mechanisms of Motor Development

The developmental model proposed by Stodden et al. (2008) serves as a foundational framework for understanding the dynamic, reciprocal interactions between AMC, PA, PMC and HRF throughout childhood (Figure 3). At the core of the model is the bidirectional relationship between AMC and PA: Children with higher levels of AMC are more likely to participate in PA, while repeated engagement in PA helps further develop AMC. This interaction is mediated by PMC, which plays a critical role in children's motivation and willingness to engage in PA. Children who perceive themselves as competent are more likely to participate in physical challenges, which can reinforce both AMC and PA. Conversely, those with low PMC may avoid such challenges, which limits opportunities to improve motor skills and experience success.

Stodden et al. (2008) introduced the concept of engagement spirals to illustrate these developmental dynamics. Children with high AMC and PMC are more likely to enter a positive spiral, where their participation in PA enhances their AMC and reinforces their PMC. In contrast, children with lower AMC

may enter a negative spiral, facing failure, reduced motivation, less participation, and poorer physical and psychological outcomes, including higher risk for obesity.

The strength and nature of the relationships proposed in the Stodden model (2008) vary by developmental stage: In early childhood, PA is considered important for developing AMC, but the association is relatively weak because young children differ widely in their experiences and in external factors such as access to PA opportunities. As children reach middle and late childhood, however, AMC becomes more crucial for their participation in sports and PA (Herrmann et al., 2016; Hulteen et al., 2018).

In middle and late childhood, reciprocal relationships between AMC, PMC, and PA become more established and complex. The feedback children receive from their environment, such as success, failure, and peer comparison, shapes their self-perception, motivation, and behavior in increasingly complex ways. HRF supports this process by enabling longer and more intense activity, especially in later childhood. However, HRF is seen as a reinforcing factor rather than the starting point of the cycle. In summary, AMC, PMC and PA co-develop throughout childhood, with important implications for lifelong health and participation in PA (Stodden et al., 2008).

Several studies support Stodden's model's (2008) key assumptions. Robinson et al. (2015) conducted a narrative review to investigate the evidence supporting the model and found positive associations between AMC, PMC, and PA, as well as inverse relationships with weight status. Barnett et al. (2022) identified evidence for the pathway from AMC to PA as well as the pathway from PA to AMC, mediated via PMC. Both reviews show evidence of a positive association between AMC and PA, the strength of which remains indeterminate.

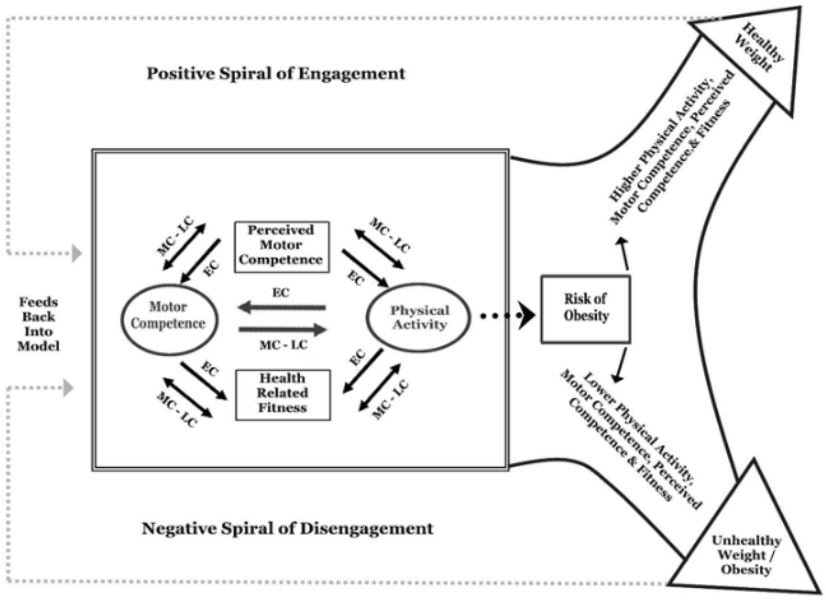

Figure 3. Developmental mechanisms influencing physical activity trajectories of children (Stodden et al., 2008, p. 294). EC = early childhood, MC = middle childhood, LC = late childhood.

PMC have been shown to mediate the relationship between AMC and PA, particularly when children have accurate perceptions of their motor competencies. For example, Utesch et al. (2018) demonstrated

that accurate self-perception, where children estimated their competencies realistically, predicted PA participation better than PMC alone. Similarly, Field et al. (2024) found that children who initially overestimated their motor competencies improved both AMC and PA over time, which suggests that inflated PMC can have adaptive benefits during early childhood. Moreover, PMC in early childhood predicted both PMC and AMC in middle childhood (Niemistö et al., 2023) and AMC predicted PA later in childhood (Barnett et al., 2009; Lopes et al., 2011). It has consistently been shown that boys have higher self-perception related to object movement than girls (Herrmann & Seelig, 2017b; Strotmeyer et al., 2022; van Veen et al., 2020). In addition, children in organized sports show higher PMC than children who are not active in organized sports (Niemistö et al., 2019).

The reliability of these findings depends in part on the alignment of measurement tools. Estevan and Barnett (2018) emphasized the importance of using task-specific, aligned instruments to measure AMC and PMC and of ensuring that both constructs are assessed within the same domains. However, as noted in a systematic review by Barnett et al. (2022), much of the current evidence remains inconclusive due to methodological inconsistencies and the predominance of cross-sectional studies.

2.3 Key Constructs of Motor Development

In the following subchapter, the key constructs of Stodden et al.'s (2018) model are presented in more detail. As HRF was not in the focus of this dissertation, the three constructs PA, AMC, and PMC are described further.

2.3.1 Physical Activity

PA is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985, p. 126). This definition is widely accepted and used in different research disciplines. However, Piggin (2020) pointed out that the definition refers mostly to the physiological level and suggested considering the complexity of PA by including cognitive, social, and educational aspects, such as interests, emotions, and relationships.

In the German-speaking research community, two distinct terms are commonly used to describe PA. The first, *körperliche Aktivität* (in English: physical activity), widely aligns with Caspersen's definition, wherein all movements are considered that lead to energy expenditure. Second, *sportliche Aktivität* (in English: sport), refers to a structured form of PA that involves the conscious use of movement and its effects (e.g., adaption phenomena) with the aim of participating in targeted training programs to improve health, sport-specific skills, or physical fitness. The term *körperlich-sportliche Aktivität* (in English: physical and sport activity) encompasses everyday PA and sports activities that are performed voluntarily and consciously and, due to their structured nature, can be beneficial for health (Wagner & Brehm, 2008). Woll et al. (1998) differentiated between various facets of physical and sport activity: The biological-physical facet includes the duration, frequency, intensity, and type of the activity, whereas the type also contains precise information about the quality of the activity (e.g., motor dimensions, complexity, and social context). The psychosocial facet encompasses environmental aspects (e.g., in a group vs. alone) as well as cognitive, emotional, and affective processes within the person during the

activity (body and group experience). The last facet is the biographical facet, which describes behavioral aspects such as whether an individual engages in continuous, lifelong activity or remains passive (Woll et al., 1998).

In this dissertation, the idea is to understand PA as participation in a culture of sport, play, and movement (Gogoll, 2022). Therefore, PA is understood as physical and sport activity, which encompasses cultural, social and educational aspects. These were also mentioned by Piggin (2020).

The assessment of PA can take different forms depending on the research focus. Objective measurements, such as those obtained with accelerometers or other wearable devices, provide insight into the duration and intensity of activity (Konstabel et al., 2019). Alternatively, subjective methods such as questionnaires allow for an understanding of the nature and context of PA, such as frequency, type, and participation in organized sports (Jekauc et al., 2013). Questionnaires are available for the self-reporting of children, such as the Physical Activity Questionnaire for Older Children (Kowalski et al., 2004) as well as for parents to assess their children's PA behavior (Prieto-Botella et al., 2022). Contextual information on the type of PA or the social setting is especially important when considering children's participation in a "culture of sports and movement", where the quality and type of engagement may significantly shape developmental outcomes (Neuber & Golenia, 2018).

In the EMOKK project, children's PA was assessed via parent questionnaires (Herrmann et al., 2025). Parents reported whether their child participated in a sports club, the sport, and the frequency of practicing the sport per week. Reported sports were then categorized as team sports (e.g., basketball) or individual sports (e.g., swimming), and weekly frequencies were summed up to create separate scores for team and individual sports participation. Other types of sport, such as informal play with peers outside, free play on the school playground, or optional school sports, were also assessed in the EMOKK project but are not part of this dissertation.

2.3.2 Actual Motor Competencies

AMC refer to a person's ability to perform a wide range of motor tasks with skilled performance, incorporating movement quality, coordination, and control underlying a particular motor outcome, which includes both fine and gross motor competence (Gallahue et al., 2012). They encompass the capacities necessary to manage routine tasks effectively (Burton & Miller, 1998; De Meester et al., 2020; Estevan & Barnett, 2018; Robinson et al., 2015). AMC are typically categorized into different areas of competence, including object control/object movement and locomotion/self-movement. Object movement includes activities such as throwing, catching, or kicking a ball, while self-movement pertains to competencies related to body control, such as running, balancing, or jumping (Herrmann et al., 2016). In health-oriented research, the term *motor competence* is mostly used as an umbrella term for different motor performance dispositions such as motor performance or fundamental motor skills (Estevan & Barnett, 2018; Robinson et al., 2015).

Recent research, primarily involving cross-sectional studies, has explored various factors associated with AMC. In several European countries, differences in AMC levels have been observed between boys and girls, with boys generally demonstrating higher competence in object movement and girls showing

slightly better AMC in self-movement (Herrmann, 2018; Slykerman et al., 2016; Wälti et al., 2022). This discrepancy may be attributed to socialized gender norms, a topic that has been examined by various authors (Gramespacher et al., 2020; Peral-Suárez et al., 2020). Furthermore, age-related differences in AMC have been noted, with older children typically exhibiting greater AMC than their younger peers (Barnett, Lai, et al., 2016; Herrmann et al., 2017; Quitério et al., 2018). Participation in sports has also been shown to enhance AMC, with children engaged in sports activities demonstrating higher AMC levels compared to those who do not participate. In terms of specific types of sports, children involved in team sports (e.g., soccer, basketball) perform better in object movement, while those participating in individual sports (e.g., track and field, gymnastics) show stronger AMC in self-movement (Gramespacher et al., 2020; Herrmann et al., 2017; Kress et al., 2023).

AMC can be measured via different instruments. While the Test of Gross Motor Development (TGMD; Webster & Ulrich, 2017) is a process-oriented assessment that examines qualitative aspects of movement (e.g., movement patterns), the Körperkoordinationstest für Kinder (Kiphard & Schilling, 2017) and the Test of Basic Motor Competencies (MOBAK; Herrmann, 2018) examine quantitative outcomes of motor performance (e.g., number of correct jumps or balls caught). Other tests, such as the Movement Assessment Battery for Children (M-ABC-3; Henderson & Barnett, 2024), mainly aim to identify motor impairments and are often used in clinical contexts. The test instrument should be selected considering the research approach and aim. Due to the large number of test instruments available, one should be selected depending on the sample and the subject of the investigation. While the M-ABC test may be more appropriate in clinical settings, the MOBAK tests are suitable for assessments in educational settings.

Herrmann, Gerlach, and Seelig (2016) developed the construct of “basic motor competencies” (BMC; in German: *Motorische Basiskompetenzen* [MOBAK]) based on an educational and sports pedagogical perspective that aligns with the pedagogical-psychological understanding of competence of Weinert (2001). BMC are understood as motor performance dispositions that develop out of situation-specific requirements and enable individuals to cope with specific situations arising in the context of sports and play. They are also prerequisites to participate in sport and movement culture. They can be learned sustainably, are explicitly context-dependent, and represent functional performance dispositions. Accordingly, it is not the performance itself that can be understood as presenting BMC but rather the underlying performance disposition that is necessary to be able to solve certain types of tasks. The indicators of BMC are neither context-free motor abilities (e.g., strength) nor sport-specific skills (e.g., shot put) but mastering a specific motor task. BMC can be operationalized through eight tasks that form the two latent factors of object movement and self-movement (Herrmann et al., 2016).

The MOBAK instruments assess AMC in two domains: object movement (throwing, catching, bouncing, and dribbling) and self-movement (balancing, rolling, jumping, and running), each measured with four standardized items (Herrmann, 2018). Children complete two attempts per task, rated dichotomously (0 = *failed*, 1 = *successful*), with a maximum of 2 points per item. For throwing and catching, six attempts are given, and scores are based on the number of successful trials: 0–2 = 0 points, 3–4 = 1 point, 5–6 = 2 points. Therefore, each domain has a maximum score of 8 points. Testing occurs during a regular 45-minute PE lesson, with children assessed in small groups by trained test administrators who provide

standardized instructions and demonstrations. The MOBAK instruments were developed and validated for preschool (Herrmann et al., 2020), first and second, third and fourth (Herrmann, 2018), and fifth and sixth grade (Herrmann & Seelig, 2017a). The instruments were developed in line with the competence requirements in the Swiss curriculum (D-EDK, 2015). As the EMOKK project was situated within educational science and assessed AMC as educational objectives in PE, the MOBAK test instruments were selected as appropriate tools. In this dissertation, the umbrella term *AMC* is used for consistency and clarity within the broader research context and also contains the construct of BMC.

According to Stodden et al. (2008), motor development is interconnected with both physical and psychological characteristics, such as HRF and PMC. PMC are recognized as crucial competencies that impact motor development and are further elaborated in the following subchapter.

2.3.3 Perceived Motor Competencies

In subchapter 2.2, PMC were highlighted as important in motor development (Stodden et al., 2008). PMC refer to one's perception of one's actual level of motor competence (De Meester et al., 2020; Estevan & Barnett, 2018). The construct of PMC is relevant in the context of child development and PA, as PMC can be seen as a motivational factor for PA behavior (Bardid et al., 2016; van Veen et al., 2020). Their role in the context of PA was emphasized in the conceptual model of developmental mechanisms influencing the PA trajectories of children developed by Stodden et al. (2008).

Self-perceptions are conceptually summarized in the construct of self-concept. Self-concept refers to the perception a person has about him- or herself in various domains. The research-leading model is the hierarchical, multidimensional self-concept model proposed by Shavelson et al. (1976). According to the Shavelson model, self-concept is a multidimensional, complex construct that arranges an individual's self-perceptions into separate but interconnected facets with a hierarchical system. At the highest level is the global self-concept, which represents a person's overall sense of self. This global self-concept is divided into two domains: academic and non-academic self-concepts. The academic self-concept is further divided into specific subject areas, such as mathematics, languages, or other school subjects. The non-academic self-concept is divided into the social, emotional, and physical self-concepts, which in turn are divided into sub-areas, such as peers and significant others for social self-concept, particular emotional states for the emotional self-concept, and physical ability and physical appearance for the physical self-concept.

For clarity, the terms *self-concept*, *self-efficacy*, and *self-esteem* are distinguished from one another. While self-concept refers to one's general perception of oneself with specific domains, self-efficacy reflects an individual's belief in their ability to successfully perform tasks in specific situations, including the task, the context, and their perceived competence (Bandura, 1997). Donellan et al. (2011, p. 718), defined self-esteem as "an individual's subjective evaluation of her or his worth as a person". In contrast to self-concept, an individual's self-esteem is not about talents, abilities, competencies, or external evaluation but the feeling that one is good enough (Donnellan et al., 2011; Orth & Robins, 2014).

Estevan and Barnett (2018) proposed a hierarchical model of the multidimensional structure of self-perception (Figure 4) by adding the construct PMC to the model of Fox and Corbin (1989). PMC can be

further differentiated into perceived competence in stability, locomotor, object control, and active play skills (Estevan & Barnett, 2018). As such, PMC represent children's self-perceived competence to perform motor tasks and can also be described as a domain-specific ability self-concept.

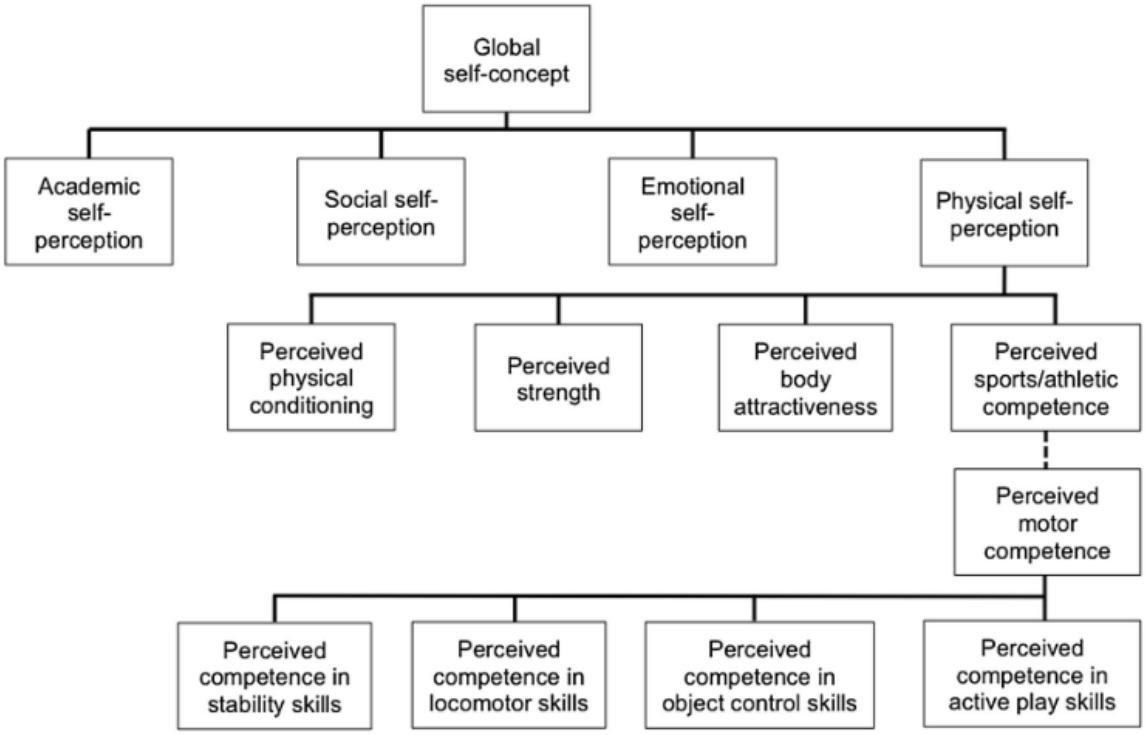

Figure 4. Hierarchical model of the multidimensional structure of self-perception with PMC as the correspondent domain of perceived sports competence in children (Estevan & Barnett, 2018, p. 2690).

Hierarchical models such as those proposed by Shavelson et al. (1976) and Estevan and Barnett (2018) emphasize the organization and dimensionality of self-concepts and self-perceptions. These models incorporate a bottom-up process progressing from specific activities to domain-specific self-concepts, and ultimately to the global self-concept (Dapp et al., 2023).

Sonstroem and Morgan (1989) developed the Exercise and Self-Esteem Model (EXSEM) to provide a theoretical foundation for the mechanisms through which athletics and PA affect self-esteem. According to their model, engagement in sports and exercise initially enhances physical self-efficacy through bottom-up processes (e.g., through the perception of improved strength or fitness). This experience of competence then contributes to higher perceived physical competence on a more general level, which, in turn, promotes greater physical acceptance. Both perceived physical competence and physical acceptance together influence global self-esteem (Sonstroem & Morgan, 1989).

The positive change in self-esteem can also reinforce motivation and self-efficacy for further engagement in PA. In their study on children's PMC, Herrmann and Seelig (2017b) equated the construct of self-efficacy in the EXSEM to PMC, and they also measured AMC and physical self-concept to empirically model the EXSEM. Their findings showed that the effect of AMC on physical self-concept was mediated almost entirely by PMC (Herrmann & Seelig, 2017b). Other studies with children reported a positive impact of PA on the physical self-concept, e.g., with self-perceived physical appearance, self-perceived sport competence, and self-perceived physical fitness (Zamorano-García et al., 2023).

Strotmeyer et al. (2022) found that the effect of AMC on the physical self-concept was strongly mediated by PMC, especially in object control. The EXSEM supports the skill-development approach, which posits that the physical self-concept is shaped by PA and AMC. In contrast, the self-enhancement approach assumes that physical self-concept influences AMC. A third perspective, the reciprocal effect model, proposes a bidirectional relationship in which physical self-concept and AMC influence each other. While some studies, such as that of Asendorpf and Teubel (2009), have supported the skill-development approach consistent with EXSEM, others have provided evidence for the reciprocal effect model (Ahnert & Schneider, 2006; Marsh et al., 2007).

A positive self-perception, i.e., a positive attitude toward oneself and one's own abilities, is central to well-being. A positive self-concept is an essential prerequisite for achieving desirable psychological, behavioral and educational outcomes, which in turn can contribute to health and well-being (Craven & Marsh, 2008). Beyond global self-esteem, which can be seen as a part of mental health (Lubans et al., 2016), domain-specific self-concepts are strongly correlated with key indicators of psychological well-being (Marsh et al., 2006). Moreover, individuals with high global self-esteem show better mental health for both genders in all age groups (Orth & Robins, 2022).

In early childhood, children often lack the capacity to reflect on their successes and failures, which leads them to overestimate their abilities (Harter, 2012). As they grow older, their self-concept becomes more nuanced and differentiated, allowing them to recognize both their strengths and their weaknesses (Harter, 2012). This development also involves peer comparison, which contributes to a more realistic understanding of their abilities (Harter, 2012; Harter & Pike, 1984). Children with a low self-concept are less likely to take on challenging tasks, potentially missing out on valuable opportunities for motor development (Stodden et al., 2008).

Especially for a young age group, the development of age-appropriate instruments is challenging due to low reading competencies. Therefore, the development of an instrument to assess PMC in first- and second-grade children was an aim in this dissertation.

2.4 Development of the SEMOK-1-2 Instrument

In this subchapter, assessments of physical self-concept and PMC in children are presented, followed by the foundational work and the development process. The subchapter is rounded off by the summary of Publication 1 (subchapter 2.4.3).

2.4.1 Assessments of Physical Self-Concept and Perceived Motor Competencies in Children

The first objective of this dissertation was the development of an age-appropriate instrument to assess PMC in first- and second-grade children. This subchapter aims to provide an overview of existing instruments that can be used to assess PMC in children.

Marsh et al. developed the Self-Description Questionnaires (SDQ) for preadolescents (SDQ-I, 8–12 years; Marsh, 1990a), adolescents (SDQ-II, 13–16 years; Marsh, 1990b), late adolescents and young adults (SDQ-III, 16–25 years; Marsh & O'Neill, 1984) to assess the multidimensional self-concept. All

SDQs contain scales to assess area-specific facets of academic (e.g., self-concept in mathematics) and non-academic self-concepts (e.g., self-concept of physical abilities). The questionnaires were originally developed to validate Shavelson et al.'s (1976) self-concept model, assuming a hierarchical and multidimensional structure. Marsh et al. (2002) developed a questionnaire for preschoolers due to the non-existence of suitable and sufficient instruments to assess self-concept in very young children (Byrne, 1996; Wylie, 1989). The SDQ for preschoolers (SDQP) is based on the SDQ-I and is used to assess two areas of academic self-concept (verbal and math) and four areas of non-academic self-concept (physical, appearance, peers, and parents), wherein the questionnaire is read aloud for the child and can be answered in a two-step approach. A well-implemented and widely used questionnaire for the assessment of perceived competencies is the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984), which contains items in the categories of cognitive competence, physical competence, peer acceptance, and maternal acceptance.

More questionnaires have been developed for assessment of the physical self-concept of children. The Physical Self-Description Questionnaire for Children (PSC-C; Marsh et al., 1994) contains the subscales sport competence, appearance, endurance, flexibility, coordination, strength, and velocity with three items per subscale. An instrument that aligns to the test items of the Test of Gross Motor Development (Webster & Ulrich, 2017) is the Pictorial Scale for Perceived Movement Skill Competence for Young Children (PMSC; Barnett, Vazou, et al., 2016); it assesses PMC by using illustrations for the items. The instrument contains six items for object control and six for locomotor control. The PMSC has been validated in many languages and countries and is a well-established instrument for studies investigating PMC, as the aligned TGMD can also be used for assessing AMC (Estevan, Molina-García, et al., 2019; Estevan, Menescardi, Castillo, et al., 2021).

Since research has shown that measures for self-perception and actual competence should align, the aim was to develop an instrument to assess PMC in first- and second-grade children, analogously to the MOBAK-1-2 instrument (Herrmann, 2018). The MOBAK instruments have become internationally recognized and widely used in different disciplines and for different research questions to assess AMC (Carcamo-Oyarzun & Herrmann, 2020; Wälti et al., 2022). Aligned to the MOBAK instrument for fifth and sixth grade (Herrmann & Seelig, 2017a), Herrmann and Seelig (2017b) developed the SEMOK-5-6 questionnaire (in German: *Selbstwahrnehmung motorischer Basiskompetenzen*) to assess the PMC of fifth- and sixth-grade children. In this instrument, the eight MOBAK items are formulated as statements (e.g., "I can change rhythm while jumping") and answered on a 5-point scale (1 = *not at all*, 5 = *for certain*). This instrument was the first PMC instrument aligned with the MOBAK approach. The two-factor structure of the SEMOK-5-6 questionnaire was confirmed, analogous to the MOBAK instrument. The latent AMC and PMC competence areas correlated with $r = .73$ for object movement and $r = .83$ for self-movement. In addition, physical self-concept was assessed using four items (e.g., "I'm very good at sports"; 1 = *absolutely wrong*, 4 = *absolutely correct;* Gerlach, 2008). A high correlation was found between physical self-concept and PMC in self-movement ($r = .75$) and object movement ($r = .75$), which supports the validity of the SEMOK-5-6 questionnaire.

Strotmeyer et al. (2022) adapted the SEMOK-5-6 instrument (Herrmann & Seelig, 2017b) for third- and fourth-grade children based on the corresponding MOBAK-3-4 instrument (Herrmann, 2018). Therefore,

the items were modified, e.g., for jumping: “I can jump rope on the spot” (1 = *not at all*, 5 = *confidently*). Confirmatory factor analysis (CFA) confirmed the two-factor structure, comparable to SEMOK-5-6 and the MOBAK instruments. The manifest correlations between AMC and PMC were $r = .44$ for object movement and $r = .38$ for self-movement. As the correlations were investigated on a manifest level, they were lower than in the study by Herrmann and Seelig (2017b).

2.4.2 Considerations for the Development of the SEMOK-1-2 Instrument

Given the lack of an instrument for assessing PMC aligned to the MOBAK instrument for children younger than those in the third grade, the first objective of this dissertation was to develop an instrument for first- and second-grade children. The following points were considered in the development of the instrument (Sauer et al., 2020):

a) Economic assessment of PMC: Compared to other instruments used to assess PMC in young children, which are carried out individually with each child (e.g., PMSC; Barnett, Vazou, et al., 2016), the SEMOK-1-2 questionnaire should be applicable in a classroom setting enabling the answers of 15–20 children to be assessed simultaneously.
b) The questionnaire should not contain any written instructions or descriptions and should therefore be suitable for children with poor reading skills, as the SEMOK-1-2 should be used in the first school year. Therefore, the MOBAK tasks were simplified and presented as illustrations with a fox (“Foxy”), whereby the children could answer on a pictorial response scale (Harter & Pike, 1984; Sauer et al., 2020). Both tasks and pictorial response scale were represented by Foxy (Figure 5).
c) Finally, the illustrations should not be assigned to a gender or an ethnicity in order to avoid multiple illustrations of the same task performed by female and male characters.

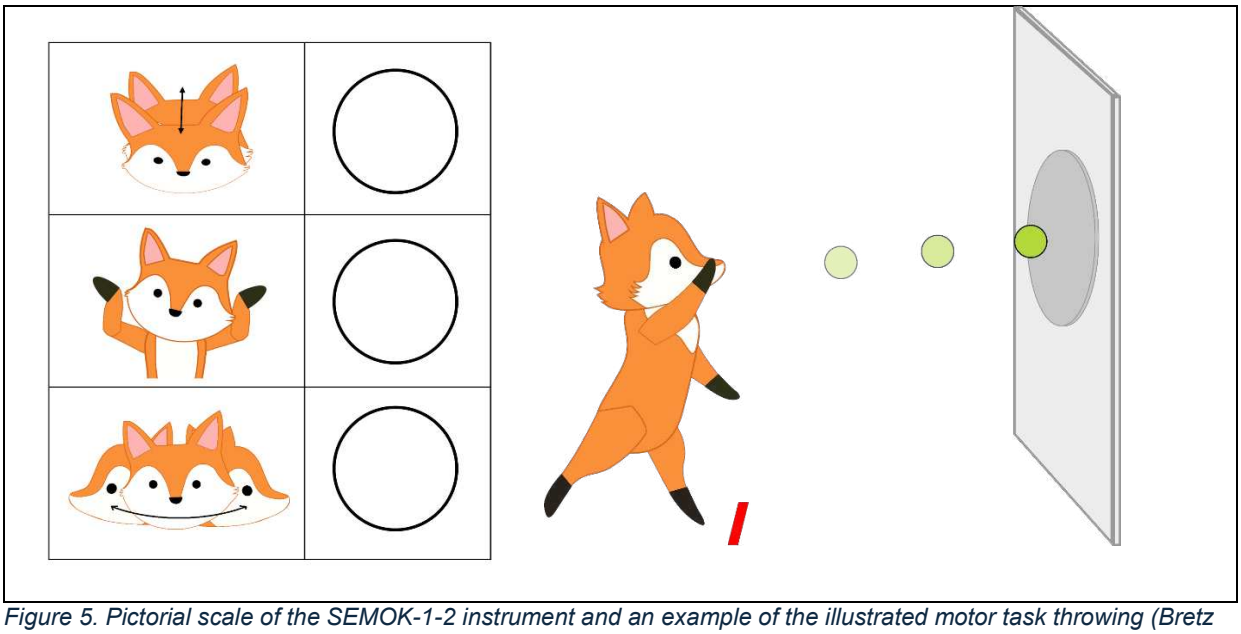

Figure 5. Pictorial scale of the SEMOK-1-2 instrument and an example of the illustrated motor task throwing (Bretz et al., 2023, pp. 5–6)

In the EMOKK project, PMC were assessed prior to AMC during the last 15 minutes of a regular classroom lesson. All motor tasks were explained verbally, supported by an illustration of the motor task. The questionnaire used pictorial response options coded as follows: positive (nodding) = 2 points,

neutral (shrugging the shoulders) = 1 point, and negative (shaking head) = 0 points. Scores were then summed for each competency domain, with a maximum of 8 points per domain.

The SEMOK instrument could be used to assess the PMC of children in the class setting. From a subjective perspective, the assessment was economical, as the children answered the SEMOK-1-2 instrument in 10–15 minutes per class, either in the classroom or in the gym prior to AMC assessment. The instrument was understandable for both first- and second-grade children. In the following subchapter, a summary of Publication 1 is presented.

2.4.3 Summary of Publication 1

Bretz, K., Strotmeyer, A., Seelig, H., & Herrmann, C. (2024). Development and validation of a test instrument for the assessment of perceived basic motor competencies in first and second graders: The SEMOK-1-2 instrument. *Frontiers in Psychology, 15*, Article 1358170. https://doi.org/10.3389/fpsyg.2024.1358170

Introduction

Motor development in early childhood encompasses both AMC and PMC. While AMC refer to observable motor competencies, PMC pertain to a child's self-perception of their motor abilities (Estevan & Barnett, 2018). Understanding PMC is crucial, as they influence motivation, participation in PA, and overall well-being. As there was no aligned instrument for assessing PMC analogous to the MOBAK instrument for first- and second-grade children (MOBAK-1-2; Herrmann, 2018), the SEMOK-1-2 instrument was developed to provide a reliable and valid tool for evaluating PMC in this age group.

Methodology

The study involved 404 children (49% boys) aged 6 to 9 years (M = 7.8 years, SD = 0.69) from the German-speaking region of Switzerland. The SEMOK-1-2 instrument was designed to align with the existing MOBAK-1-2 test, which assesses AMC in two domains: object movement (e.g., throwing, catching) and self-movement (e.g., balancing, jumping). To accommodate young children's reading abilities, the SEMOK-1-2 utilized illustrated motor tasks with verbal explanations and pictorial response options. Data collection included the assessment of PMC via the SEMOK-1-2 questionnaire prior to AMC by using the MOBAK-1-2 test, as well as information on PA levels, measured by participation in team (e.g., soccer) and individual sports (e.g., track and field). CFA was conducted to evaluate the factorial validity of the SEMOK-1-2. Structural equation modeling (SEM) was carried out to examine the relationships between AMC, PMC, and PA.

Results

Factorial Validity: CFA supported a two-factor structure for the SEMOK-1-2, corresponding to object movement and self-movement domains. Model fit indices suggested a good fit ($\chi^2(19) = 26.447$, $p = .118$, CFI = .940, RMSEA = .032). Factor loadings ranged from .35 to .69, and the correlation between the two factors was $r = .66$ ($p < .001$).

Criterion Validity: Strong correlations were found between AMC and corresponding PMC domains: $r = .88$ ($p < .001$) for object movement and $r = .85$ for self-movement ($p < .001$). These correlations indicate that children with higher AMC reported higher levels of PMC, whereas those with lower AMC reported correspondingly lower levels of PMC.

Associations with PA: Children who participated more frequently in team sports demonstrated higher levels of both AMC ($r = .20$, $p < .001$) and PMC ($r = .53$, $p < .001$) in object movement. Similarly, frequent participation in individual sports was positively associated with higher PMC in self-movement ($r = .39$, $p < .001$). Gender differences were also observed, with boys more engaged in team sports and girls more active in individual sports.

Discussion

The SEMOK-1-2 instrument exhibited strong factorial and criterion validity, making it an appropriate tool for assessing PMC in young children. The alignment between AMC and PMC underscores the instrument's effectiveness in capturing children's self-perceived motor competencies. The associations between PMC, AMC, and PA highlight the interconnectedness of self-perception, actual competence, and engagement in PA. The study had several limitations. First, interviewing children in a classroom setting may have led to mutual influence on responses, and the simplified illustrations and instructions may not have fully captured the criteria for the motor tasks, potentially contributing to ceiling effects. Additionally, the cross-sectional design prevented causal interpretations, and no retest for reliability analysis was possible. The development and validation of the SEMOK-1-2 instrument fills a gap in assessing PMC in early childhood. Its strong psychometric properties and practical design make it suitable for use in educational and research settings. By providing insights into children's PMC, the SEMOK-1-2 can inform interventions aimed at promoting PA and overall development. Future studies should examine its applicability in different contexts as well as its ability to detect longitudinal changes or changes resulting from intervention programs.

Authors' contributions

The study was conducted as part of the EMOKK project, which was led by Christian Herrmann. Kathrin Bretz developed the instrument, with support from Anne Strotmeyer and Christian Herrmann. The preliminary pilot study was made possible by Anne Strotmeyer and Miriam Kehne. Kathrin Bretz coordinated sample recruitment and data collection. Data analysis was performed by Kathrin Bretz, with methodological guidance from Harald Seelig and Christian Herrmann. The manuscript was drafted by Kathrin Bretz, and all authors contributed to its critical review and approved the final version.

3 Mental Health Parameters

After introducing the key constructs of the motor development model (Stodden et al., 2008; Figure 3) and presenting the newly developed SEMOK-1-2 instrument, this subchapter describes and contextualizes the construct of mental health. Various definitions are considered, with a categorization of mental health parameters based on theoretical foundations. Subchapter 3.1 presents motor development models that integrate mental health. Subchapter 3.2 focuses on the constructs of social integration and HRQoL and contains the corresponding publications. In subchapter 3.3, the potential of person-centered approaches in child development research is presented. Subchapter 3.4 contains the final publication of this dissertation investigating both motor development factors and well-being by using a person-centered approach.

In recent years, increasing attention has been directed toward children's well-being, particularly in light of the challenges brought on by the COVID-19 pandemic (Bringolf-Isler et al., 2021; Li et al., 2025; Moss et al., 2023; Ravens-Sieberer et al., 2022). In Switzerland, approximately one in three adolescents aged 14 to 19 years reported experiencing mental health issues (Barrense-Dias et al., 2021). Globally, around 13% of the population are affected by mental health disorders, such as depression and anxiety, with rates rising during the pandemic (WHO, 2022b). Across all disciplines, the fundamental question remains: What exactly constitutes mental health?

According to the WHO, mental health is "a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, to learn well and work well, and to contribute to their communities. Mental health is an integral component of health and well-being and is more than the absence of mental health disorder" (WHO, 2022b, p. 8). Given the complexity of different theoretical frameworks in the various scientific disciplines (Hornberg, 2016), there is no consistent definition of mental health and well-being. However, it is widely accepted that mental health is multidimensional (Hornberg, 2016; The WHOQOL Group, 1995).

There are various ways to conceptualize and assess mental health. Outcomes are typically grouped into two main categories: indicators of well-being, such as overall life satisfaction, self-esteem, and quality of life, and indicators of ill-being, which include symptoms of anxiety and depression (Frasquilho et al., 2016; Gu et al., 2019; Lubans et al., 2016). The idea of differentiating between mental health and mental illness as separate but correlated constructs is also proposed by the Dual Continuum Model of mental health. This model proposes that mental health should be understood not as the absence of mental illness but as two independent and coexisting constructs (Keyes, 2013; Sullivan & Celebre, 2025; Westerhof & Keyes, 2010; WHO, 2022b). The model depicts mental health on a double continuum, with manifestation of mental health represented on the y-axis and the manifestations of mental illness on the x-axis. Based on this model, individuals can be categorized as languishing, moderate, or flourishing, considering their recent mental health and mental illness status. Seventy percent of adults with mental illnesses (e.g., generalized anxiety disorders) show moderate or flourishing mental health, as they have high mental health (e.g., well-being, life satisfaction; Keyes, 2002, 2013). At the same time, individuals without mental illness do not automatically have flourishing mental health, as this also depends on their level of mental well-being. The model has been examined in various studies (Keyes, 2002; Sullivan &

Celebre, 2025) and confirms that an individual can experience mental health and mental illness simultaneously, and that assessment of indicators of both mental illness and mental health should be considered in mental health research.

Despite its considerable interest in research, mental health remains difficult to define consistently across disciplines. The multidimensionality of related concepts has led to different theoretical approaches and operationalizations with different measurements. While the field of clinical research or psychosomatic rehabilitation may prioritize indicators of mental ill-being (e.g., depression, anxiety), public health approaches may emphasize quality of life or social integration. Educational research, in turn, might focus on subjective well-being and social belonging (OECD, 2021). To address this complexity, a categorization of health-related factors (subchapter 1.1, adapted offer-and-use model; Helmke, 2014) distinguishing between mental health factors and physical health factors (Table 1) was conducted for this dissertation. Mental health factors are further divided into dimensions of mental well-being and mental ill-being, while physical health factors include measures of PA, HRF, and body composition. The instruments used to assess these constructs are included in Table 1. The constructs written in bold are investigated in this dissertation.

	Construct	Factors	Subdomains	Assessment	Example
Health-related factors	Mental health factors	Mental ill-being	Depression, anxiety, fear, fatigue, stress	e.g., Revised Child Anxiety and Depression Scales (RCADS; Chorpita et al., 2000)	*I worry that bad things will happen to me.* (Scale: never – always)
		Mental well-being	**Health-related quality of life (HRQoL)** (including physical, social and psychological effects of well-being and functioning)	e.g., **KIDSCREEN-27** (Ravens-Sieberer, 2016)	*Thinking about the last week… Have you felt fit and well?* (Scale: not at all – extremely)
			Social well-being (**social integration**, social ties, peer relationships)	e.g. **Perceptions of Inclusion Questionnaire** (PIQ; Venetz et al., 2019)	*I have very good relationships with my classmates.* (Scale: not at all true – certainly true)
			Psychological well-being (hedonic well-being and eudaimonic well-being)	e.g., Positive and Negative Affect Scale – Child Form (PANAS-C; Laurent et al., 1999)	*Indicate how much you have felt this way during the past few weeks: Cheerful* (Scale: not much or not at all – a lot)
			Physical well-being	e.g., Chalder Fatigue Scale (Chalder et al., 1993)	*Do you have less strength in your muscles?* (Scale: less than usual – much more than usual)
	Physical health factors	Physical activity	Moderate-to-vigorous activity (MVPA)	e.g., Accelerometers (Konstabel et al., 2019)	-
			Sport participation	e.g., **Participation in organized sport activities**, playing outside (Herrmann et al., 2025)	*Is your child a member of a sports club? If yes, what sport(s) does your child practice at the club?*
		Health-related fitness	Cardiorespiratory endurance, muscular strength, muscular endurance, flexibility	e.g., ALPHA health-related fitness test battery for children and adolescents (Ruiz et al., 2011)	*e.g., 20 m shuttle run test (cardiorespiratory endurance), handgrip strength (musculoskeletal strength)*
		Body composition	**Body mass index (BMI)**, waist circumference, skinfold thickness	e.g., Measuring height and weight to calculate the BMI, classification by Cole et al. (2000)	-

Table 1. Categorization of health-related factors with popular assessment instruments for children. Subdomains in bold are investigated in this dissertation.

3.1 Integrating Mental Health into Motor Development Models

Besides its importance in educational research, medicine, and psychology, interest in the construct of mental health has also grown in motor development research (Moss et al., 2023; Visser et al., 2020).

Since holistic developmental approaches should be applied across disciplines (Stodden et al., 2023), it is essential to consider children's well-being outside mental health research. The extension of Stodden et al.'s (2008) model proposed by Lima et al. (2022) responds to this need by incorporating mental health parameters alongside physical health (Figure 6). In this model, PMC, AMC, HRF, and PA and their relationships are summarized in Block A in a manner analogous to Stodden et al.'s model (2008) and are assumed to be interrelated with weight status (dotted arrow; Block B). Lima et al. (2022) expect the variables in Block B to be directly associated with cognition and academic performance, metabolic health, and mental health (dotted arrows; Block C).

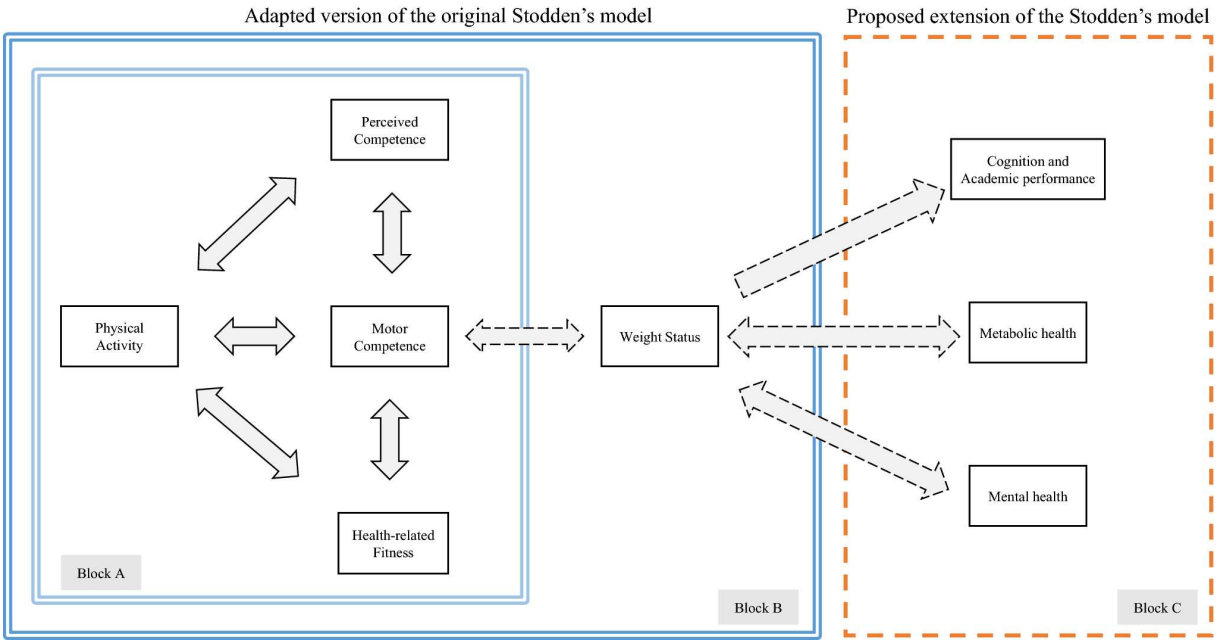

Figure 6. Proposed extension of Stodden et al.'s model by Lima et al. (2022, p. 681).

Regarding mental health parameters, positive associations with HRF, AMC, and PA have been found in children and adolescents (Andermo et al., 2020; Gu et al., 2019; Lubans et al., 2016). The causal mechanisms linking the variables in the model to mental health parameters (Lima et al., 2022) are not yet fully understood, but several studies have indicated the relevance of neurobiological, psychological, and behavioral mechanisms (Lubans et al., 2016; Mancini et al., 2019), as well as contextual factors such as social interaction (Vella et al., 2023).

In addition to that of Lima et al. (2022), other conceptual models for the interaction between motor development factors and mental health have been developed. Lubans et al. (2016) developed a conceptual model for the effects of PA on the mental health outcomes of children and adolescents and conducted a systematic review of the evidence based on this model. In Lubans et al.'s (2016) model, PA leads to better mental health outcomes, such as higher mental well-being and reduced ill-being, through neurobiological (e.g., release of endogenous opioids, such as endorphins), psychosocial (e.g.,

social connectedness), and behavioral processes (coping and self-regulation skills). Hill et al. (2023) developed a conceptual model in which AMC is identified as a mediator between PA and domains of cognition and social-emotional health. As in Lubans' (2016) model, Hill et al. (2023) also proposed neurobiological, psychosocial, and behavioral mechanisms through which PA influences (via AMC) cognition and social-emotional health.

The Environmental Stress Hypothesis (Cairney et al., 2013; Mancini et al., 2016) considers low levels of AMC as a barrier to participation in PA and sports, which can in turn lead to poorer mental health. Low AMC is seen as a primary stressor that can lead to numerous negative psychosocial consequences (secondary stress). Mediated by secondary stressors (e.g., interpersonal conflicts, low social integration, few friendships), this can lead to internalizing problems such as anxiety disorders and depression. The theory also integrates social resources (e.g., social support) and personal resources (e.g., self-esteem), which in turn have direct and indirect impacts on the relationships between motor problems and internalizing problems.

There are therefore various models indicating the importance of mental health parameters in motor development research. The authors highlight various ways in which PA can affect mental health (e.g., mediated via AMC; Hill et al., 2023; Lubans et al., 2016) or how insufficient AMC can have a negative impact on mental health through exclusion (Environmental Stress Hypothesis; Cairney et al., 2013).

For a better understanding of the connections between motor development parameters and mental health, empirical evidence for the relationship between mental health parameters and PA, AMC, and PMC is presented in the following subchapters.

3.1.1 Physical Activity and Mental Health Parameters

Research examining the link between PA and mental health parameters has consistently shown beneficial associations. Several studies have found that increased PA is related to lower levels of psychological ill-being and higher levels of psychological well-being (Andermo et al., 2020; Biddle & Asare, 2011; Rodriguez-Ayllon et al., 2019; Verswijveren et al., 2024). Ibáñez Román et al. (2023) observed a dose-response relationship during adolescence wherein mental well-being positively predicted PA engagement. Their findings also indicated that PA, in turn, predicted mental well-being one year later. This reciprocal relationship—suggesting that mental health is both an outcome and a prerequisite of PA—is also hypothesized by the models developed by Lima et al. (2022) and Hill et al. (2023). White et al. (2024) highlighted the beneficial effects of PA in reducing depression, anxiety, and psychological distress in children, mediated by resilience. The positive effect was also mediated through social support, with evidence suggesting that a sense of belonging may be relevant for the relationship between PA and mental health (White et al., 2024). Kohake et al. (2025) investigated the associations between PA and health-related factors during the pandemic and showed associations between physical factors and PA (positive: fitness; negative: physical fatigue, adiposity), psychological factors and PA (positive: well-being, health-related life satisfaction; negative: stress, psychological fatigue), and social factors and PA (positive: relationships with friends, negative: loneliness).

Participation in organized sports has also been recognized as beneficial for youth development, supporting physical health (e.g., encouraging healthy lifestyles), psychological growth (e.g., increasing self-confidence), and social integration (e.g., promoting teamwork; Fraser-Thomas et al., 2005). A systematic review by Boelens et al. (2022) suggested a small but positive impact of organized sports on children's mental health, although most studies focused on indicators of mental ill-being. The authors proposed that these benefits may arise indirectly through increased PA. Bjørnarå et al. (2021), who synthesized findings from multiple reviews, reported moderate associations between participation in organized sports and reduced anxiety and depression in children and adolescents. They also found limited-to-moderate evidence of causal links between sports participation and improved psychological and social health. However, the overall evidence remains mixed. Hoffmann et al. (2022) similarly noted that while team sport participation was linked to better mental health parameters, involvement in individual sports was sometimes associated with poorer mental health parameters. For children and young people, participation in team sports or group PA was beneficial for mental health by reducing mental ill-being parameters such as anxiety and depression symptoms (Vella et al., 2023). The authors highlighted that global PA guidelines refer to frequency, intensity, and time/duration of PA for health benefits while providing little information about the context of PA. They recommended investigating the type of PA, the physical and social environments, the delivery method (e.g., supervised or unsupervised), and the domain (e.g., school, work; Vella et al., 2023). In reviews on the association between PA and mental health, children and adolescents were the group with the fewest studies available (Vella et al., 2023; White et al., 2024), which may be due to the challenges of measuring PA and mental health in children, as this is often possible only through parent questionnaires, depending on the age of the children.

In the German-speaking context, the research consortium Move for Health has investigated relations between young people's sport behavior and their mental health by collecting systematic data (Deutsche Sportjugend, 2023; Göttlich et al., 2025). In terms of well-being, children aged 5–12 years who regularly participated in a sport were less likely to have poor or very poor health, as measured from the parents' view with the KIDSCREEN-10 index (Erhart et al., 2009). In addition, children who were active in sports clubs reported better overall health, greater overall life satisfaction, and higher levels of happiness than non-members (Göttlich et al., 2025). A significant positive association was found between regular PA and HRQoL, overall life satisfaction, and overall health status. Furthermore, there was a positive correlation between the number of PA days per week and these health-related factors. In adolescents, similar positive but weaker correlations were found between PA and HRQoL, overall life satisfaction, and overall health status (Göttlich et al., 2025).

Different school-based PA interventions have been developed aimed at children's AMC but also children's mental health or social-emotional competencies. The Animal Fun program (Piek et al., 2010) was designed to enhance the motor development and social development of young children. Based on the Environmental Stress Hypothesis, it should also result in positive mental health outcomes. The program is inclusive by involving all children in the class and includes imitation of animal movements in a fun, non-competitive way. It consists of elements of fine and gross motor development as well as social-emotional development, and it allows the difficulty level of activities to be adapted to the children's

learning level and group (Piek et al., 2010). Children who participated in the Animal Fun program showed improved prosocial behavior and decreased values in hyperactivity/inattention compared to the control group (Piek et al., 2015). The MOVI-KIDS program (Redondo-Tébar et al., 2023) is a non-competitive school-based PA intervention focusing on motor development and the improvement of children's HRQoL. The program starts with a warm-up, includes basic movement games, playground games, or dance, and ends with a cool-down. For girls, no effect of the PA intervention on their HRQoL was found. Boys in the intervention group had better total HRQoL scores and emotional well-being scores than those in the control group. No effect was found for the subdimensions physical well-being, self-esteem, family, or friends. Fairclough et al. (2024) investigated the intervention effects of the Move Well, Feel Good program, which is a school-based motor competence intervention to promote mental health. After ten weeks of the program in regular PE lessons, the children exhibited improved AMC, reduced internalizing problems and total difficulties, and enhanced prosocial behavior. No significant changes in well-being or psychosocial outcomes such as global self-worth were found (Fairclough et al., 2024).

3.1.2 Actual Motor Competencies and Mental Health Parameters

The relationship between AMC and mental health parameters is less well established compared to PA and mental health parameters. Gu et al. (2019) explored both direct and indirect pathways linking AMC to mental health parameters by considering mental well-being and ill-being in adolescents, finding a significant positive relationship between AMC and HRQoL and a significant negative relationship between AMC and depression. Moreover, adolescents with better AMC showed higher cardiorespiratory and muscular fitness, and both factors were also significantly positively related to mental well-being and significantly negatively related to mental ill-being (Gu et al., 2019). In addition to the correlations between AMC, HRF, and mental health, the authors identified an indirect effect between AMC and mental health, mediated through HRF. AMC were explained to be a positive predictor of HRF, which in turn was a positive predictor of AMC, therefore confirming the reciprocal relationship mentioned above (Gu et al., 2019).

A similar result was reported by Redondo-Tébar, Fatouros, et al. (2021), who investigated the correlations between AMC, HRQoL, and cardiorespiratory fitness in typically developing (pre)school children. In this age group, AMC were significantly positively correlated with HRQoL in the subdimensions of self-esteem, friends, and school as well as global HRQoL score. Further, the relationship between AMC and physical well-being was mediated via cardiorespiratory fitness, which aligns with the findings of Gu et al. (2019).

Even if the Environmental Stress Hypothesis has been empirically investigated mainly in children with developmental delays and not in typically developing children (Mancini et al., 2017, 2019; Wagner et al., 2016), it can be assumed that even non-clinical deficits in AMC can lead to a reduction in social participation. Giske et al. (2018) found a negative relationship between AMC and participation in play among toddlers aged 30 months. The authors assumed that only broad AMC enable children to participate in play. Studies using peer-rating approaches showed that children with good AMC were more popular and better integrated into peer groups than those with poorer AMC (Kauer & Roebers, 2012; Schwarz, 2013). Further evidence for this was observed by Wälti et al. (2024), who observed

weak positive correlations between various HRQoL subscales and children's AMC particularly in the competence area of self-movement.

In a longitudinal study, Lopes et al. (2022) found that children with higher levels of AMC showed higher self-esteem than children with lower levels of AMC, and AMC positively predicted self-esteem one year later in boys and girls, which also supports the EXSEM. Children with low AMC cannot hide their limited AMC from other children, as movements, play, and physical activities are very exposed. This could lead to social exclusion from sports and play activities or to their own reluctance to participate due to their low AMC. However, to know what they are capable of, they need to perceive their own motor competence. The following subchapter examines empirical evidence on the relationship between PMC and mental health parameters.

3.1.3 Perceived Motor Competencies and Mental Health Parameters

Regarding the association between PMC and mental health parameters, studies of children have focused primarily on self-esteem as a mental health outcome.

In academic research, global self-esteem is frequently regarded either as a component of mental health or as an indicator of mental health status (Lubans et al., 2016). Additionally, it is considered as a protective factor that may reduce the risk of psychological issues, such as anxiety and depression (Henriksen et al., 2017). Orth and Robins (2022) showed in their meta-analysis that individuals with higher self-esteem tend to exhibit more favorable mental health outcomes.

The relationship between PA, PMC, and self-esteem was explored by Visser et al. (2020). The authors found that both PMC and self-esteem were positively associated with PA at the start of the study and were significant predictors of PA levels one year later. Using a person-centered approach, Bardid et al. (2016) examined the AMC and PMC levels of children and identified four distinct groups. Children with either high AMC and high PMC or low AMC combined with high PMC reported greater global self-esteem compared to those with high AMC but low PMC or those with both low AMC and low PMC (Bardid et al., 2016). These findings underscore the critical role of PMC in supporting children's overall sense of self-esteem.

3.2 Social Integration and Health-Related Quality of Life

In the previous subchapters, the integration of mental health in a motor development model was described (Lima et al., 2022; Figure 6), as well as the associations with PA, AMC, and PMC. For Publication 2 and 3, the constructs of social integration and HRQoL are introduced in the following subchapters, as these associations with AMC were investigated.

3.2.1 Social Integration

Mental health in childhood is closely shaped by social experiences and relationships (Birrell et al., 2025; Wickramaratne et al., 2022). In this context, AMC play a critical role, as they influence children's opportunities for participation in group activities and physical play (Herrmann et al., 2016), which are relevant for building social ties. Children with lower AMC may struggle to join peer activities, which could lead to social exclusion (Cairney et al., 2013).

Social integration can be defined as “the extent to which [an individual] has social ties or social connections” or “the converse of social isolation (e.g., disengagement from social ties, institutional connections or community participation)” (Seeman, 1996, p. 443). Public health and epidemiologic literature clearly show that social relationships have a protective and promoting effect on physical and mental health and decrease all-cause mortality (Becofsky et al., 2015; Wickramaratne et al., 2022).

In their conceptual model of the effects of PA on the mental health outcomes of children and adolescents, Lubans et al. (2016) introduced social connectedness as a hypothesized psychosocial mechanism linking PA and mental health outcomes. The Environmental Stress Hypothesis assumes that low levels of AMC lead to secondary stress, such as social exclusion from peer activities (subchapter 3.1.2). This can result in internalizing problems and poor mental health (Mancini et al., 2019). People have a need to belong and feel supported (Deci & Ryan, 2008). When these social needs are met, people experience social well-being. Social well-being encompasses various components of the social environment, which together lead to a positive overall assessment of social life. Social well-being is central to health, as social isolation is associated with higher risks of health impairment (Seeman, 1996). Group membership (e.g., in clubs) in particular strengthens the feeling of belonging, thus improving social well-being (Pressman et al., 2017).

Social integration can be assessed in different ways. Peer nominations and peer ratings are used to assess children’s social preferences from their own perspective. In peer ratings, each child is given stickers featuring pictures of their classmates and asked to place them on a rating scale (e.g., *do not like at all – really like*). For peer nominations, a story-based scenario is presented (e.g., a birthday party), and children choose three classmates they would like to take on the bus (positive nominations) and three they would not (negative nominations; Kauer & Roebers, 2012). Another way to assess social integration in the class is to ask teachers, since they are involved in the class and can observe group dynamics. For this purpose, the Perceptions of Inclusion Questionnaire (PIQ) was developed (Venetz et al., 2019). This instrument can be used for teachers to individually assess a child’s social integration, by answering statements such as “He/she has a lot of friends in his/her class” (0 = *strongly disagree*, 3 = *strongly agree*; Venetz et al., 2019). In the EMOKK project, social integration was assessed using the PIQ. Social relationships were assessed using an observational questionnaire about the competencies and interests of the children (in German: *Kompetenzen und Interessen von Kindern* [KOMPIK]; Mayr, 2012; Mayr et al., 2011). It contained statements such as “Your child has close friendships with other children” (0 = *disagree*, 4 = *agree*), which were answered by the parents.

Adopting a viewpoint that considers social integration and social relationships key aspects of mental health, this subchapter turns to empirical evidence to explore how children’s AMC interact with their social relationships. In early childhood, both social competencies and AMC are essential for successful participation in play and sport activities with peers. The following subchapter summarizes **Publication 2**, in which an exploratory investigation on the connection between social relationships and AMC in preschool children was conducted.

3.2.2 Summary of Publication 2

Herrmann, C., **Bretz, K.,** Kühnis, J., Seelig, H., Keller, R., & Ferrari, I. (2021). Connection between social relationships and basic motor competencies in early childhood. *Children, 8*(1), Article 53. https://doi.org/10.3390/children8010053

Introduction

Early childhood is a crucial period for the development of both AMC and social relationships. AMC, encompassing self-movement and object movement, are essential for children's participation in PA and sports (Herrmann et al., 2016). Simultaneously, the ability to form and maintain social relationships contributes significantly to a child's overall development and well-being (World Health Organization Division of Mental Health & Division of Mental Health, 1994). While previous studies have explored these domains separately, the interrelation between motor competencies and social relationships in early childhood remains under-examined. This study investigated the connection between AMC and social relationships among preschool children.

Method

The study involved 548 preschool children (51% girls) aged between 55 and 80 months (M = 68.0 months, SD = 6.8) from the Swiss cantons of Ticino and Nidwalden. The children's AMC were assessed using the MOBAK-KG instrument, which evaluates two domains: self-movement (e.g., balancing, rolling) and object movement (e.g., throwing, catching; Herrmann et al., 2020).

Social relationships were evaluated from two perspectives: Teachers assessed children's social integration using the PIQ (Venetz et al., 2019), and parents assessed children's social relationships using the KOMPIK questionnaire (Mayr, 2012; Mayr et al., 2011). These instruments provide insights into children's social connections and integration within their class and peer groups.

Results

The analysis revealed significant correlations between AMC and social relationships. A significant correlation was found between parents' assessments of their children's relationship skills and their self-movement (r = .12, p = .047) as well as with their object movement (r = .14, p = .020). Additionally, children with higher AMC seemed to be better socially integrated in their class (object movement: r = .23, p < .001; self-movement: r = .23, p < .001). We also found a positive association between social relationships and social integration (r = .19, p = 0.001). Considering gender, we observed differences in the strength of these correlations. For boys, higher scores in self-movement and object movement were associated with better social integration in their class (self-movement: r = .39, p < .001; object movement: r = .47, p < .001). In contrast, these correlations were not significant among girls. Additionally, gender differences were observed in AMC and social integration. Boys outperformed girls in object movement, while girls scored higher in self-movement and were rated as better socially integrated by teachers. These findings suggest that AMC and social relationships are interconnected, with variations depending on gender.

Discussion

The study underscores the link between AMC and social relationships in early childhood and the importance of considering both domains in developmental assessments and interventions. The stronger correlations observed among boys may reflect the higher value placed on physical abilities within male peer groups, influencing social integration. For girls, other factors may play a more prominent role in their social relationships. These findings have practical implications for early childhood education and PE programs. Incorporating activities that promote both AMC and social interaction can support holistic child development. Tailoring interventions to address gender-specific needs may enhance their effectiveness. However, several limitations should be noted. Children's social integration was not assessed directly but through teacher and parent ratings, which could have contributed to the ceiling effect in girls, especially given the predominantly female teachers. Additionally, the cross-sectional design prevents conclusions about causality.

This study contributes to understanding of the interplay between AMC and social relationships in early childhood. By demonstrating significant associations, particularly among boys, it emphasizes the need for integrated approaches in early education that foster both physical and social development. Addressing the limitations in future research, such as in longitudinal designs, will help clarify causal pathways and determine the long-term impacts of AMC on children's health and well-being.

Authors' contributions

Christian Herrmann and Ilaria Ferrari coordinated the externally funded project and, in collaboration with Kathrin Bretz, Harald Seelig, Jürgen Kühnis, and Roger Keller, contributed substantially to the conceptualization and design of the study. Kathrin Bretz led the theoretical framing and contextual discussion of the manuscript. Christian Herrmann conducted the statistical analyses, with support from Kathrin Bretz. The manuscript was drafted jointly by Kathrin Bretz and Christian Herrmann, both of whom made significant contributions to analysis and interpretation of the data. All authors critically reviewed, revised, and approved the final version of the manuscript.

3.2.3 Well-Being and Health-Related Quality of Life in Childhood

As mentioned in chapter 3, mental health can be categorized into mental well-being and ill-being (Table 1). Various concepts from psychology and the WHO definitions (Diener et al., 2009; Vittersø, 2016; WHO, 2021) define well-being as a multidimensional construct that includes social, physical, emotional, and psychological dimensions. The WHO describes well-being as a resource for daily life that is influenced by social, economic, and environmental factors. Well-being also encompasses quality of life and the ability of individuals and societies to contribute to the world in a meaningful and purposeful way (WHO, 2021).

One construct through which well-being can be operationalized is HRQoL, which includes subjective well-being in different areas of life. To date, there is no standardized definition, but in general, physical, psychological, social, family-related, and work- or school-related factors are considered (The WHOQOL Group, 1995).

Several studies on HRQoL have found that overall HRQoL decreases with age, with the highest levels observed among children aged 3 to 6 years. A particular decline has been noted in school-related well-being and physical well-being. This decline is more pronounced in girls than in boys, especially in physical well-being among children and adolescents aged 11 to 17 years (Buecker et al., 2023; Erhart et al., 2009; Michel et al., 2009; Ravens-Sieberer et al., 2007). No gender differences are reported in younger children, while from adolescence, girls show lower general HRQoL than boys (Ellert et al., 2014). In addition to age and gender, socioeconomic status (SES) influences HRQoL. Children from families with high SES report better overall quality of life compared to those from families with medium or low SES. Furthermore, children with chronic illnesses or pain have significantly lower HRQoL scores (Ellert et al., 2014; Ravens-Sieberer et al., 2007).

Age, gender, SES, and health status are important determinants of the HRQoL of children and adolescents. Bringolf-Isler et al. (2021) found that the HRQoL of Swiss children aged 5 to 11 years was lower in 2020 than in 2014/15. In a German sample, 7- to 11-year-old children reported lower HRQoL during the pandemic compared to the period before (Ravens-Sieberer et al., 2021, 2022). Current evidence suggests that well-being levels remain lower post-pandemic than in pre-pandemic years (Li et al., 2025). In German-speaking countries, HRQoL has been studied to assess quality of life of children, adolescents and adults (Ravens-Sieberer et al., 2007) and to identify trends of well-being depending on age, gender, and other factors.

Different instruments are available for assessing the HRQoL of children (Ravens-Sieberer, 2000). The KINDL questionnaire is available to assess the HRQoL of children and adolescents aged between 4 and 17 years, with different instruments developed for different age groups (Ravens-Sieberer & Bullinger, 1998). In all age groups, a child version and a parent version are available. Further, a disease-specific subscale is available for children with illnesses. Next to the KINDL, the KIDSCREEN instruments were developed to assess the HRQoL of 6- to 18-year-old children and adolescents from both child and parental perspectives (Ravens-Sieberer, 2016), and agreement between the child's and the parent's ratings was confirmed (Stevanovic et al., 2013). Different KIDSCREEN versions are available: The KIDSCREEN-10 index measures general HRQoL (Ravens-Sieberer et al., 2010), whereas the KIDSCREEN-52 and KIDSCREEN-27 differentiate subscales of HRQoL such as physical, psychological, and social well-being (Ravens-Sieberer, 2016; Robitail et al., 2007). In the EMOKK project, we used the parent versions of the KIDSCREEN-10 and KIDSCREEN-27 instruments due to the economic assessment.

To investigate the association between AMC and mental health factors, the interplay between children's AMC, HRQoL, and social integration was explored in Publication 3.

3.2.4 Summary of Publication 3

Bretz, K., Seelig, H., Ferrari, I., Keller, R., Kühnis, J., Storni, S., & Herrmann, C. (2022). Basic motor competencies of (pre)school children: The role of social integration and health-related quality of life. *International Journal of Environmental Research and Public Health, 19*(21), Article 21. https://doi.org/10.3390/ijerph192114537

Introduction

AMC enable children to participate in PA and sports (Hulteen et al., 2018). They are not only essential for physical development but also facilitate children's participation and interaction with other children in sports and play situations. HRQoL, encompassing physical, psychological, and social dimensions, is a vital indicator of children's overall health status and well-being (Ravens-Sieberer, 2016). While previous research has explored the individual relationships between AMC, social integration, and HRQoL, there is a lack of studies examining the interconnectedness of these domains for (pre)school-aged children. This study investigated the associations between AMC, social integration, and HRQoL among preschool and primary school children.

Methodology

A cross-sectional study design was employed involving two cohorts: 1163 preschool children (M = 5.7 years, SD = 0.57; 52% boys) and 880 first- and second-grade primary school children (M = 7.5 years, SD = 0.58; 51% boys) from Switzerland. AMC were assessed using the MOBAK instruments for preschool and primary school, which evaluate two domains: self-movement (e.g., balancing, rolling) and object movement (e.g., throwing, catching; Herrmann, 2018; Herrmann et al., 2020). Social integration was evaluated by teachers using the PIQ (Venetz et al., 2019), while general HRQoL was assessed from the parents' perspective using the KIDSCREEN-10 index (Erhart et al., 2009) and in a subsample (n = 384) the subdimension physical well-being of the KIDSCREEN-27 questionnaire (Ravens-Sieberer, 2016). Data analyses included descriptive statistics, correlation analyses, and structural equation models to examine the relationships among AMC, social integration, and HRQoL.

Results

The findings revealed significant positive correlations between AMC and social integration in both preschool and primary school children. Children with higher AMC scores were more likely to be well-integrated socially with their class. Among preschoolers, AMC were significantly associated with physical well-being (self-movement: r = .20, p = .004; object movement: r = .29, p < .001), while no association was found with general well-being. Considering the gender of preschoolers, no difference between general HRQoL was observed between boys and girls, while boys showed higher values in physical well-being than girls. For primary school children, a positive association was found between general HRQoL and AMC in self-movement (r = .14, p = .005), while no significant association was seen between general HRQoL and object movement. An association between social integration and general

HRQoL was found (r = .13, p < .001) for primary school children. Finally, girls showed slightly higher general HRQoL scores than boys in primary school.

Discussion

The study underscores the interconnectedness of AMC, social integration, and HRQoL in early childhood. The positive associations suggest that children with higher AMC are more likely to experience better social relationships and overall well-being. By fostering environments that promote PA and motor competence acquisition, educators can support children's social and emotional development, ultimately contributing to improved HRQoL. The observed gender differences in HRQoL among primary school children warrant further investigation to identify underlying factors and inform targeted interventions. The use of the KIDSCREEN-10 instrument, while valid for general HRQoL, does not capture the full range of dimensions included in KIDSCREEN-27. Therefore, an instrument should be used in future studies that allows differentiation of different well-being dimensions. Additionally, the reliance on teacher and parent reports for assessing social integration and well-being, as well as the consideration of factors such as SES, may introduce bias and limit the depth of the findings. The cross-sectional design further restricts causal interpretations.

The study provides empirical evidence linking AMC with social integration and HRQoL in (pre)school children. Implementing programs that enhance AMC may have benefits promoting not only physical health but also participation in social contexts and social well-being, as well as overall quality of life. Future research should explore longitudinal effects and assess the impact of targeted interventions aimed at improving AMC and, in turn, children's social integration and HRQoL.

Authors' contributions

This study was conducted as part of the EMOKK project, in which Christian Herrmann and Ilaria Ferrari were project investigators. Sample acquisition and data collection were coordinated by Kathrin Bretz, Jürgen Kühnis, and Simone Storni. The manuscript was drafted by Kathrin Bretz. All authors contributed to the critical revision and approved the final version of the manuscript.

3.3 From Bidirectional, Variable-Centered Approaches to a Holistic, Person-Centered Approach

Previous research on the relationship between AMC, PMC, PA, and mental health parameters such as HRQoL has largely relied on variable-centered approaches. This is also true for the first three publications in this dissertation. Generally, variable-centered approaches typically examine bivariate or multivariate associations in large samples, offering insights into directional effects or correlations—often framed within a model, as proposed by Stodden et al. (2008). Such studies are adequate to identify general trends and test theoretical assumptions about bidirectional pathways. However, they often overlook the complex intra-individual configurations that may characterize children's developmental profiles.

The model proposed by Lima et al. (2022; subchapter 3.1) meets the demand for a more holistic view of child development, explicitly integrating cognitive, mental health, and behavioral factors. This broader perspective emphasizes the need to understand children as whole individuals embedded in dynamic systems. In the context of the empirical studies in this dissertation, such analyses might suggest group-level implications such as "boys perform better in object movement", "children in organized sports report higher PMC" (Bretz et al., 2024), or "children with stronger AMC are better integrated socially" (Bretz et al., 2022). While statistically robust, these findings may oversimplify the diversity of the associations.

In contrast to variable-centered approaches, person-centered approaches provide a complementary perspective by identifying subgroups of children who share similar patterns of multiple variables (Geiser, 2011). These approaches move beyond population-level associations to explore how combinations of AMC, PMC, PA, and well-being co-occur within individuals. Such differentiation is particularly relevant for developing targeted interventions and for understanding risk and resilience profiles in early childhood. Person-centered analyses, such as LPA, can identify latent typologies and structures in data. These profiles are inferred from patterns in the data rather than directly observed, and each individual is assigned to a latent profile with a certain probability. This is the likelihood that a person belongs to a particular latent profile, and the most probable profile assignment is made for each individual (Geiser, 2011; Weller et al., 2020).

In line with recent calls for more individualized and holistic models of child development (Stodden et al., 2023), the final publication of this dissertation extends traditional variable-centered frameworks by applying a person-centered analytic strategy. In **Publication 4**, LPA was used to identify distinct subgroups of children based on their levels of AMC, PMC, PA, and well-being. This approach allows for a nuanced understanding of how motor and well-being factors cluster together and provides empirical support for a more individualized view of development (van der Gaag, 2023). By integrating motor competence factors and well-being through a person-centered lens, this study contributes to a more comprehensive framework supporting children's health.

3.4 Summary of Publication 4

Bretz, K., Kress, J., & Herrmann, C. (2025). *The interplay of actual and perceived motor competencies, physical activity and well-being: A child-centered approach* [Manuscript submitted for publication].

Introduction

Motor development in children is a complex process influenced by multiple interacting factors (Gallahue & Ozmun, 2006; Hulteen et al., 2018). While traditional research has often employed variable-centered approaches to investigate relationships between AMC, PMC, PA, and well-being, the current study adopted a person-centered approach to identify distinct child profiles based on these variables. This novel perspective allows for a more holistic understanding of how these factors coexist and interact, providing valuable insights for targeted intervention strategies to promote healthy motor development and well-being in early childhood.

Methods

A total of 427 first- and second-grade children (M = 7.78 years, SD = 0.70) from German-speaking Switzerland participated in the study. AMC were assessed using the MOBAK-1-2 instrument (Herrmann, 2018), which includes the domains of object movement (e.g., throwing, catching) and self-movement (e.g., balancing, jumping). PMC were measured with the SEMOK-1-2 questionnaire (Bretz et al., 2024), which mirrors the MOBAK tasks through pictorial and verbal child self-assessment. Parents reported on PA levels and participation in organized team and individual sports. They also reported on their children's HRQoL via the KIDSCREEN-27 questionnaire covering physical, psychological, and social well-being (Robitail et al., 2007). In addition to manifest correlations, LPA was used to identify distinct profiles within the dataset, based on nine variables across the constructs: (1) frequency of team sports, (2) AMC object movement, (3) PMC object movement, (4) physical well-being, (5) psychological well-being, (6) social well-being, (7) PMC self-movement, (8) AMC self-movement, and (9) frequency of individual sports

Results

Children with higher AMC also showed higher PMC in both object movement (r = .39, p < .001) and self-movement (r = .26, p < .001). Positive correlations were observed between sport participation and both AMC and PMC. Children involved in team sports performed better in object movement (r = .20, p < .05) and had a higher perception of their corresponding AMC (r = .31, p < .001). Meanwhile, participants in individual sports showed higher AMC (r = .11, p < .05) and PMC (r = .15, p < .001) in self-movement. Weak but significant correlations were found between AMC in self-movement and physical (r = .11, p < .05) and social well-being (r = .13, p < .05). In team sports, frequency was positively associated with social well-being (r = .11, p < .05).

LPA revealed three distinct profiles of children:

- **Profile 1: Highly Competent Team Players (15%)**: Children in this group exhibited high AMC and PMC, especially in object movement, actively participated in team sports, and reported high levels of well-being in all domains. This profile had a strong male predominance (81.8%).
- **Profile 2: Competent Self-Movers (74%):** Children in the largest group were characterized by high AMC and PMC in self-movement, moderate AMC/PMC in object movement, greater participation in individual sports, and similarly high levels of well-being as Profile 1. Gender distribution was more balanced (41.9% boys, 58.1% girls).
- **Profile 3: Low-Participating Overestimators (11%):** This group showed low AMC across both competence domains but overestimated their competencies (higher PMC than AMC scores), had the lowest PA participation, and demonstrated significantly lower scores for all well-being subdimensions compared to the total sample and the well-being scores of Profiles 1 and 2. Profile 3 contained 62.2% boys. This profile also showed the largest discrepancy between AMC and PMC.

Discussion

This study provides empirical evidence for the complex interplay of the AMC, PMC, PA, and well-being of young children, reinforcing Stodden's (2008) developmental model of motor competence (Lima et al., 2022). Consistent with other studies, participation in team sports was associated with AMC and PMC in object movement, while engagement in individual sports was associated with AMC and PMC in self-movement (Herrmann & Seelig, 2017b; Niemistö et al., 2019). The presence of low AMC, low PA, and a low well-being profile (Profile 3) suggests the need to address not only AMC but also realistic self-perceptions and to promote greater PA opportunities. This study is limited by its cross-sectional design, a lack of direct self-reported well-being data from children, and consideration of other PA data, such as outdoor play, which could be considered in future studies. In addition, other children than those in the three profiles were not identified due to methodical suggestions of not considering children in profiles containing less than 5% of the sample. Adopting a child-centered approach, this study is among the first to jointly examine the AMC, PMC, PA, and well-being profiles of early primary school children. The findings indicate that early intervention focusing on both AMC and PMC, as well as social participation through organized sports, could foster positive developmental spirals and reduce the risk of poor motor development and psychological outcomes. Targeted interventions should aim to enhance children's AMC while fostering positive, yet realistic, self-assessments. Future longitudinal and intervention studies are needed to examine the stability of these profiles and the long-term effects of interventions.

Authors' contributions

This study was conducted as part of the EMOKK project under the leadership of Christian Herrmann. Kathrin Bretz conducted the statistical analyses and drafted the manuscript. Johanna Kress and Christian Herrmann contributed to the critical revision and final approval of the manuscript.

4 Overall Discussion

This final chapter provides an integrated discussion of the main findings of this cumulative dissertation. It aims to synthesize the results of the four individual articles in the context of current theoretical models and research on early childhood motor development and mental health parameters. First, the dissertation is shortly summarized (subchapter 4.1). Second, a synthesis of the findings and overall contribution to the research field of the dissertation is presented (subchapter 4.2). Third, the strengths and limitations of this dissertation as well as prospective research directions are discussed (chapter 4.3), and fourth, implications are identified (subchapter 4.4). The dissertation is rounded off by a conclusion (subchapter 4.6).

4.1 Summary

This cumulative dissertation aimed to provide an in-depth understanding of the interplay of AMC, PMC, PA, and mental health parameters in terms of social integration and HRQoL in (pre)school children. The project was grounded in the extended version of Helmke's (2014) offer-and-use model (Figure 1). The dissertation draws on the conceptual models developed by Stodden et al. (2008) and Lima et al. (2022), which conceptualize bidirectional associations between AMC, PMC, PA, and mental health parameters that can potentially contribute to either positive or negative engagement spirals in childhood.

- Publication 1 contributes to the state of research by developing and offering a pictorial instrument that can be used in an economic way to assess the PMC of first- and second-grade children. Results showed that AMC and PMC were positively related, with team sport participation linked to higher scores in both object movement AMC and PMC, emphasizing the context-specific nature of sport participation in early childhood.
- Publication 2 provides substantial evidence on the connection between AMC and social relationships in preschool children, revealing that higher AMC were associated with better social integration, particularly among boys. The findings suggest gender-specific links between AMC and social integration at an early age.
- Publication 3 advances current knowledge by confirming the association between AMC and social integration in both preschool and first- and second-grade primary school children. By integrating general HRQoL into the analyses, it shows evidence for a small positive association between children's AMC self-movement and their general HRQoL as well as between general HRQoL and social integration. In preschool children, physical well-being was moderately associated with both AMC object movement and self-movement.
- Publication 4 essentially supports understanding of how combinations of motor development factors could identify "healthy" profiles or profiles "at risk". By using a person-centered approach, three profiles based on AMC, PMC, PA, and well-being were identified, ranging from highly active and competent children to low-participating overestimators with low well-being. The findings underscore the importance of recognizing patterns and misaligned self-perceptions, which may place some children "at risk" of a negative spiral of engagement or development.

Together, these four studies provide substantial insight into the interplay and development of the AMC, PMC, PA, and mental health factors of children aged 4–8 years.

4.2 Integration into the Broader Research Context

Based on the theoretical and empirical work in this dissertation, the following topics were identified as central.

4.2.1 Actual Motor Competencies as Physical, Social, and Psychological Enablers

AMC play a central role in enabling children's engagement in PA, supporting broader developmental outcomes (Robinson et al., 2015). In Publication 1, AMC were positively associated with PA participation, especially in children involved in team sports, who demonstrated higher AMC in object movement, while children participating in individual sports performed better in self-movement (Bretz et al., 2024). As the study was based on cross-sectional data, a causal relationship could not be established. Both directions between AMC and PA are supported in the literature. In Hulteen et al.'s (2018) conceptual model, a basic level of AMC is required to overcome the proficiency barrier, develop sport-specific skills, and participate in different sports. Stodden et al.'s (2008) model hypothesizes that in early childhood, PA leads to improved AMC, while with increasing age, AMC become determinants for sustained PA engagement. Herrmann (2025) confirmed this reciprocal relationship in a longitudinal analysis of first- and second-grade children showing that earlier participation in organized sports predicted increases in AMC, which in turn led to greater subsequent engagement.

AMC were also positively linked to mental health parameters, particularly social integration and HRQoL, as shown in Publications 2 and 3. Among preschoolers, children with higher AMC seemed to be better integrated socially. While this association was only significant for boys in Publication 2, Publication 3 showed significant positive associations for both girls and boys (Bretz et al., 2022; Herrmann et al., 2021a). Other studies have also found a positive association between AMC and social integration (Kauer & Roebers, 2012; Schwarz, 2013). These findings are also consistent with the Environmental Stress Hypothesis. It assumes that low AMC can lead to secondary stress such as exclusion, which can result in long-term mental health problems (Mancini et al., 2016). Gasser-Haas et al. (2020) found evidence that the association between AMC and internalizing problems was mediated by peer problems.

Regarding general HRQoL, first- and second-grade children with better AMC exhibited higher values in general HRQoL, while this association was nonsignificant for preschoolers (Publication 3; Bretz et al., 2022). When considering subscales of HRQoL for preschoolers, positive associations were found between AMC in both object movement and self-movement and physical well-being (Publication 3; Bretz et al., 2022) and in first and second graders between self-movement and physical well-being as well as social well-being (Publication 4; Bretz et al., 2025). Even if the associations were small, the findings may suggest that children with better AMC, especially in self-movement, have higher levels of physical well-being because they are able to participate more in sports and play situations, which in turn may lead to higher levels of social well-being. Other studies on this topic have reported similar results (Giske et al., 2018; Redondo-Tébar, Ruiz-Hermosa, et al., 2021), some of which identified a mediation through HRF

(Gu et al., 2019; Redondo-Tébar, Fatouros, et al., 2021), while others found PA and mental health to be associated, mediated through social relationships (White et al., 2024).

The four publications included in this dissertation demonstrate that AMC are positively associated with PMC, social integration, and both physical and social well-being. The findings reinforce the importance of early support for AMC as a foundation for sustained health and development.

4.2.2 Context-Specificity of Physical Activity

Children can participate in different PA contexts and environments, such as playing outside with their peers or participating in sports clubs or after-school programs (Neuber & Golenia, 2018). In studies on children's PA behavior, associations with mental health, or motor development, PA is often assessed quantitatively with devices such as accelerometers (Konstabel et al., 2019; White et al., 2024), which do not provide information about the context in which children are active. However, the type of sport matters: Team sports are associated with higher AMC in object movement, while individual sports are linked to greater self-movement levels (Gramespacher et al., 2020; Herrmann et al., 2017). This was also confirmed in Publication 1, in which participation in team sports was associated with object movement in AMC, but also in PMC, and participation in individual sports with self-movement in both AMC and PMC (Bretz et al., 2024).

Kress et al. (2024) demonstrated that children who were active in team sports participated more frequently in informal play than those in individual sports. This trend was also observed in the long term, with children who participated in organized sports demonstrating higher levels of PA later in life (Hänggi et al., 2024). Positive mental health outcomes, such as increased well-being, have been linked to group-based PA and team sports settings (Eime et al., 2013; Vella et al., 2023). These benefits could be due to a sense of social belonging, peer interaction, and shared goals. A similar result was identified in Publication 4, in which a positive association between team sports participation and social well-being was found (Bretz et al., 2025)

Beyond the effects of participation in organized sports on PA levels and mental health, additional socialization and developmental benefits have been proposed (Gerlach, 2008; Schneider & Diehl, 2012). Schneider and Diehl (2012) concluded that participation in sports, whether at school, in clubs, or during leisure time, positively influences physical resources (e.g., improved AMC), psychological resources (e.g., motivation), and social resources (e.g., social support). They discussed how sport serves as a tool for socialization both in and through sports, aligning with Kurz's (2009) concept of the dual mandate in PE. Education *in* sports should engage children in a PA and sports culture by supporting their building the competencies and motivation needed to participate independently, while education *through* sports focuses on children's personal development by fostering broader, interdisciplinary competencies (Kurz, 2000).

PA interventions may not only enhance well-being by increasing MVPA but also strengthen peer relationships and promote positive experiences such as happiness and enjoyment, which children experience through these interventions (Kvalø & Natlandsmyr, 2021). This underlines the potential of PA as both health-promoting behavior and a developmental environment.

4.2.3 Perceived Motor Competencies as a Key Motivational Factor

PMC are a critical driver of children's motivation to engage in PA (Bardid et al., 2016). According to Stodden et al.'s (2008) model, which was later investigated by Robinson et al. (2015), AMC and PMC reinforce each other over time, contributing, with PA and HRF, to a positive or negative developmental spiral. However, misalignments between AMC and PMC, particularly underestimation, can hinder progress.

In Publication 1, the SEMOK-1-2 instrument was developed and validated to assess PMC in first- and second-grade children. Aligned with the MOBAK-1-2 instrument, the SEMOK-1-2 confirmed positive and significant associations between AMC and PMC (Bretz et al., 2024). Boys had higher scores in object movement in both AMC and PMC, and children who participated in team sports showed higher PMC in object movement. These findings demonstrate that children at this age already differentiate between self-movement and object movement and that PMC vary by the type of sports children participate in. These results align with studies by Strotmeyer et al. (2022) and Herrmann and Seelig (2017b), which investigated this relationship with children from third through sixth grade. As expected, children overestimated their motor competence, which can be explained by their developmental stage: Children of this age are not yet able to assess themselves realistically due to a lack of reflection on failures and comparisons to their peers (Harter, 1999; Washburn & Kolen, 2018).

PMC do not just reflect a perception, as they also contribute to motivation. Carcamo-Oyarzun et al. (2023) investigated fifth- and sixth-grade children with different levels of AMC and PMC as well as different levels of motivation and enjoyment of PE. The authors identified three profiles: Children with high AMC and aligned PMC (high-aligned) showed levels of motivation and enjoyment similar to those with low AMC and intermediate PMC (non-aligned)—suggesting that PMC contribute to high motivation (Bardid et al., 2016). Children with low AMC and low PMC (low-aligned) displayed low motivation and low enjoyment of PE. Even if the motivation and enjoyment of children in the non-aligned profile were high, they showed significantly fewer minutes of MVPA per day than children in the high-aligned profile, similar to the children in the low-aligned profile (Carcamo-Oyarzun et al., 2023). This finding is consistent with the findings in Publication 4, in which children in Profile 3 (the low-participating overestimators) had significantly lower PA participation than other children (Bretz et al., 2025). Various studies have shown that children aged 4 to 11 years with high levels of both AMC and PMC have higher PA levels than children with low levels of or differences between AMC and PMC (Estevan, García-Massó, et al., 2019; Utesch et al., 2018). This can also be observed longitudinally (Estevan, Menescardi, García-Massó, et al., 2021).

Publication 4 offered deeper insights into PMC by identifying Profile 3, namely low-participating overestimators. These children also showed significantly lower well-being than the total sample, which suggests that inflated self-perceptions may mask developmental needs and contribute to social exclusion. Children with high PMC might have higher levels of motivation, but they also need appropriate AMC to actually participate in sports and play activities with others. It is possible that children become frustrated when they are motivated but cannot participate, which in turn could result in lower well-being.

Therefore, differentiated situations should be created, e.g., in PE, in which children can participate and experience success through achievable tasks.

4.2.4 Proficiency Barrier Outside Actual Motor Competencies

The concept of a proficiency barrier, first proposed by Seefeldt (1980), provides an important theoretical lens to understand the challenges some children face in achieving AMC. According to it and to Hulteen et al.'s (2018) model, children with low AMC cannot overcome the proficiency barrier to develop further sport-specific skills and also experience limitations in accessing opportunities for participation in sports and PA. As stated by the Environmental Stress Hypothesis, children with low AMC also experience exclusion and are more likely to develop internalized problems (Mancini et al., 2016). These restrictions, in turn, can affect their PMC and reduce social integration, creating a self-reinforcing cycle of limited engagement that can also result in a negative spiral of engagement.

The central focus of this dissertation was not only the associations between AMC and health-related factors but also the constellations of factors which could act as inhibitors and enhancers of children's motor development (Stodden et al., 2008). The findings of the studies included, especially Publication 4, suggest that children in Profile 3 exhibit a "risk constellation" by having low AMC, high overestimation, low participation in PA, and low physical, psychological, and social well-being. All these factors are associated with motor development (Lima et al., 2022), and the combination of low values in these factors may hinder children from progressing in motor development. Consequently, there may be different factors contributing to a "barrier":

- Low participation: Children who are socially excluded or lack motivation to engage experience a barrier to developing AMC in social interactions in play and sports.
- Low PMC/high overestimation of competencies: Children with low PMC may lack confidence in their abilities and therefore do not even try to participate in sports and play interactions with other children. However, it is only through trial, repetition, and practice that AMC can improve. Children with a strong overestimation of their own AMC may not see the need to practice and may be excluded from groups because they are unable to accurately estimate their AMC.
- Low well-being: Children with low physical well-being (due to pain or health problems) may not want to or be able to participate in sports and play. Children with low social well-being who do not feel integrated may avoid social situations with other children and peers. Children with low psychological well-being, who may be suffering from mental ill-being (e.g., anxiety, depression), may simply not participate or take part in sports activities due to these symptoms. Children with low self-esteem would also avoid situations in which they have to interact and be compared with other children.
- Interplay of all factors: Publication 4 revealed only small associations on a manifest level between well-being and AMC in self-movement as well as team sports. However, LPA revealed a group that scored low on all the factors examined (Profile 3). This suggests that it is not a low score on a single variable that puts children "at risk" of entering a negative spiral of engagement of motor development and PA but rather low scores on multiple motor development factors. Moreover, the higher percentage of boys in Profile 3 (62.2%) suggests that boys may be particularly affected by low physical ability, as physical competence often plays a central role in male peer relationships and

group acceptance during childhood (Blomberg, 2015). The low well-being scores could only be compared with the total sample from Publication 4, where Profile 3 showed statistically lower values (Bretz et al., 2025).

In addition, other barriers are possible. For example, environmental barriers such as limited access to safe play spaces or sports facilities may occur, especially in low SES environments or in urban areas where opportunities for play and sports are unsafe or unavailable. Furthermore, socioeconomic and contextual barriers are conceivable, such as socioeconomic disadvantages or language barriers. Especially children at this young age are dependent on their parents. A lack of parental support or encouragement could also be a barrier for children to participate in PA. For children with physical disabilities, chronic health conditions, and mental ill-being, it is more difficult to participate in PA situations. As children with health concerns have lower well-being compared to their peers (Ravens-Sieberer et al., 2007), it is important to create opportunities for participation.

While gender differences were not the primary focus of the four studies, they were examined throughout the research. Consistently with prior findings on AMC (Barnett, Lai, et al., 2016; Wälti et al., 2022), boys demonstrated higher AMC in object movement, whereas girls were better in self-movement. These gender differences are already observable in preschool and early primary school age (Bretz et al., 2022, 2024, 2025; Herrmann et al., 2021a). Findings regarding social integration were inconsistent. In Publication 2, associations between AMC and social integration were not significant for girls, while boys showed medium to strong effect sizes in these associations. In contrast, the study reported by Publication 3 found that correlations between AMC and social integration in girls were small to medium but significant in both preschool and primary school cohorts. Notably, in one subsample (subsample 2, n = 384 children) of Publication 2, social integration was more closely linked to object movement in boys and to self-movement in girls. This pattern may reflect differences in play environments and gender-typical PA and play preferences. For example, data from the Children and Youth Report demonstrate that girls are more likely to participate in activities such as dance or gymnastics, whereas boys more frequently engage in ball sports (Lamprecht et al., 2021). These trends are also evident in school and playground contexts, where girls might participate more in activities such as Chinese jump rope, while boys are often involved in various games. When children possess the skills needed for a particular activity, they are more likely to integrate successfully because they can participate fully. Similarly, findings from Publication 4 indicate that children in Profile 3 (low-participating overestimators with low levels of well-being) contained a higher proportion of boys than girls. This could indicate that boys may be more affected by limited AMC, potentially because friendships between boys are more dependent on physical competencies (Blomberg, 2015; Schneider & Hasselhorn, 2018). Nevertheless, further research is needed to explore gender-specific differences in AMC and social integration, with the aim of understanding these dynamics without reinforcing gender stereotypes.

4.3 Strengths and Limitations

This dissertation offers important theoretical and methodological advancements, but it also has limitations. In this subchapter, the strengths and limitations are identified and discussed.

4.3.1 Strengths

A key strength of this dissertation is its interdisciplinary approach. By considering educational process models (extended offer-and-use model; Helmke, 2014) with motor development frameworks (Lima et al., 2022; Stodden et al., 2008) and well-being frameworks (OECD, 2021), it provides a holistic, multi-layered understanding of factors in child development. The inclusion of mental health parameters in motor development research represents a conceptual innovation and responds to current calls for interdisciplinary integration (Stodden et al., 2023). In addition, the dissertation contains publications in which the associations between motor development factors and mental health parameters were investigated in a sample of typically developing children.

A major contribution that was one focus in this dissertation is the development and validation of the SEMOK-1-2 questionnaire, the first instrument aligned with the MOBAK instruments to assess the PMC of first- and second-grade children. The alignment of the instrument is relevant, as it could be measured, and children with accurate PMC were more physical active (Carcamo-Oyarzun et al., 2023; Utesch et al., 2018). A strength of the SEMOK-1-2 instrument is its suitability for children of early primary school age, a group in which self-assessments are challenging and for which appropriate tools, especially to assess PMC, are limited. Additionally, the instrument is designed for efficient and economic administration in group settings, such as school classes or PE lessons. It allows both teachers and researchers to assess the PMC of multiple children simultaneously. This broadens its practical applicability for both research and educational practices assessing PMC at this critical stage of development. It enables the identification of children “at risk”, namely those with low or overestimated PMC, so that they can be identified and supported in developing positive-realistic self-perceptions.

A further strength lies in the use of data from multiple perspectives: AMC were assessed via standardized motor tests (MOBAK-1-4, Herrmann, 2018; MOBAK-KG, Herrmann et al., 2020), PMC were measured with the SEMOK-1-2 instrument (Bretz et al., 2024), parents provided information on children’s PA and well-being (KIDSCREEN-10, Erhart et al., 2009; KIDSCREEN-27, Ravens-Sieberer, 2016), and teachers rated children’s social integration in the class context (Venetz et al., 2019). This comprehensive, multi-informant approach increases the validity of the findings and reduces single-source bias.

The dissertation also contributes to methodological innovation. It is the first study to apply a person-centered approach to this specific research field by using LPA, enabling the identification of complex child profiles across multiple domains (AMC, PMC, PA, and well-being). This approach allows for a more differentiated view than traditional variable-centered methods and can identify children with a risk constellation of low motor development factors and well-being.

Another strength lies in the selection of the sample. Children in preschool and early primary school are often underrepresented in studies, especially regarding the associations between AMC and mental

health parameters (Vella et al., 2023; White et al., 2024). Recognizing the challenges of assessing data from young children's perspectives, the studies incorporated multiple data sources, such as parent questionnaires. Further, the studies are based on large samples from various Swiss cantons and language regions, which enhances the robustness and representativeness of the results for the Swiss context.

4.3.2 Limitations and Future Directions

Despite these contributions, several limitations must be considered. The cross-sectional design limits the ability to draw causal conclusions. While associations between variables could be established, causal pathways and longitudinal trajectories remain unknown. Future research should address this through longitudinal or interventional designs.

Several studies have identified mediating effects, for example, PMC mediating the relationship between PA and AMC (Barnett et al., 2022). Such mediation analyses were not conducted in this dissertation, although they would have been possible with the available data. To draw more precise conclusions about these relationships or the existence of mediating factors, additional and more advanced statistical analyses, such as longitudinal SEM, cross-lagged panel models, or latent growth curve models, are required. Notably, PA, AMC, and PMC are closely interrelated and reciprocal, which makes it challenging to disentangle their relationships and determine which variables have the most direct correlations.

While reporting the effect sizes, it is important to recognize that several of the identified associations in this study were weak to medium, varying by the type of correlation (manifest vs. latent), subsample, and gender. According to Cohen (1988), correlations with $r = |.10|$ are classified as small and those around $r = |.30|$ as medium effect. Notably, in Publications 2 and 3, most latent associations between AMC and social integration as well as AMC and general HRQoL were small, while medium-sized effects were seen only seen in subsample 2 ($n = 384$), such as between social integration and self-movement in preschoolers, with further gender-specific difference: In girls, social integration was more strongly correlated with self-movement and in boys with object movement. The small effect sizes might be due to the multicollinearity of the variables and, despite the small sizes, might contribute to development, wherein small effects might still be meaningful.

Apart from participation in organized club sports and the categorization into team and individual sports, no other PA variables (e.g., physical and sports activities with family or peers or in natural environments) were considered in this dissertation. Future studies should consider other contexts of PA, as there is evidence that nature connectedness is positively associated with well-being (Arola et al., 2023).

Besides the assessment of the PMC of first- and second-grade children, the child perspective was not systematically included. Although data were gathered via teacher and parent reports, young children's own views on their well-being and PA participation were not assessed. This limitation points to the importance of including child-centered and child-appropriate assessments of well-being, as recommended by the OECD (2021) as well. Researchers should develop child-appropriate instruments to assess dimensions of well-being from the child's perspective.

Finally, school- and community-level environmental factors, such as access to movement opportunities and SES, were not assessed in this work, even though they may also influence children's motor and psychosocial development. Future research should explore these contextual influences more comprehensively.

Despite the important advances, the dissertation also reveals the urgent need for longitudinal research. The cross-sectional design limits causal interpretations. Therefore, follow-up studies are necessary to track developmental trajectories over time. Longitudinal studies might also address the unresolved question of selection versus socialization effects. It remains unclear whether children with higher AMC and well-being self-select into organized sports and social activities (selection) or whether these activities improve their AMC and well-being (socialization). Moreover, it would be valuable to follow up on the children in the different profiles to examine whether they transition between profiles over time or remain stable: for instance, whether children in Profile 3 persist in being inactive with low AMC, possibly entering a negative spiral of engagement (Bretz et al., 2025).

A key message of this dissertation is the necessity to adopt a broad, multidisciplinary perspective when considering children's health and well-being in relation to AMC and PA. Different research traditions and practical contexts may prioritize varying definitions and operationalizations of well-being and mental health, e.g., by considering self-esteem as a mental health parameter and otherwise being a central construct in self-concept research. Consequently, it remains important to apply precise, multidimensional constructs while at the same time including the children's views wherever possible to ensure the validity and relevance of research findings.

Studies on PMC also include physical self-concept or motivation, as both factors are associated with AMC and PMC (Carcamo-Oyarzun et al., 2023; Herrmann & Seelig, 2017b; Menescardi et al., 2022; Strotmeyer et al., 2022). In future studies, it would be desirable to assess these factors to investigate the EXSEM in younger children or to identify correlations between PMC and PA mediated by motivation. It could also be determined whether low-participating overestimators (Publication 4; Bretz et al., 2025) show high motivation despite low participation, similar to the study by Carcamo-Oyarzun et al. (2023). Estevan and Barnett (2018) proposed a hierarchical model of self-perceptions and included not only perceived object control, stability, and locomotor skills but also perceived active play skills, which refer to cycling or skating (Figure 4). In addition to these perceptions, it would have been interesting to assess perceived social-emotional competencies in sports, as this dissertation assessed PA via sports club participation. Children also need social-emotional competencies such as relationship skills, cooperation, and problem-solving to participate (Högger, 2015), especially in team sports. Future studies should also assess social-emotional competencies in addition to AMC, as both are important for participation.

4.4 Implications

This subchapter outlines the main theoretical and empirical implications of the dissertation, focusing on the integration of mental health and well-being in both motor competence and educational contexts.

4.4.1 Theoretical and Empirical Implications

From a theoretical perspective, the work in this dissertation contributes to the integration of mental health parameters into the motor competence model, emphasizing the reciprocal relationships between children's AMC, PMC, PA, and well-being. It draws on theories from motor development models in educational research. The EMOKK project was based on the offer-and-use model (Helmke, 2014) and supplemented by health-related factors (Figure 1) proposing that not only subject-specific (AMC) and interdisciplinary (PMC) competencies are outcomes of PE but also health-related factors such as PA and mental health parameters. To explain the interactions between motor development factors such as AMC, PMC, and PA a motor development model was needed. Therefore, the Stodden et al. (2008) model was incorporated, along with its extension incorporating mental health parameters, developed by Lima et al. (2022). Although the models cannot be combined, potential extensions or points of consideration within both models can be derived based on the empirical results and the theoretical work conducted in this dissertation (Table 2).

Offer-and-use model (Helmke, 2014)	**Developmental PA models** (Lima et al., 2022; Stodden et al., 2008)
include children's well-being as both a prerequisite and a potential outcome as well as part of the learning process (such as emotional processes; Vieluf et al., 2020)	capture the context in which children participate in PA, especially for mental health outcomes (Vella et al., 2023), and investigate the context-specificity of PA on AMC and PMC

Table 2. Recommendations with extensions and considerations for the offer-and-use model and motor development models.

In the offer-and-use model, used as the reference model for the EMOKK project, well-being has not been integrated explicitly. According to Helmke, teaching quality encompasses characteristics of good teaching, including the classroom climate (Helmke, 2014; Klieme, 2013), which is important in PE (Herrmann et al., 2023). Well-being and mental health parameters can also be understood as part of the individual learning potential of the pupils that includes motivational learning potential (self-concept, interest) and cognitive-motor learning potential (e.g., cognitive competencies). Social ties and social integration within the classroom are essential for well-being in class (Birrell et al., 2025). Therefore, well-being could be integrated as both an individual learning prerequisite and an individual-, classroom-, or community-level outcome. This aligns with the definition of mental health in which it is a state of well-being that enables individuals to function by participating in their communities and to learn well (WHO, 2022b). As the construct of well-being is multidimensional, different facets of it could be considered, such as social, psychological, and physical well-being, especially in PE. Consequently, mental health parameters should be considered as both a prerequisite and an outcome of the learning process.

4.4.2 Practical Implications

From a practical perspective, the findings have direct implications for educational practice and school-based interventions. The identification of a vulnerable group of children with low AMC and overestimated PMC, associated with low participation and reduced well-being, highlights the need for more targeted intervention strategies. Schools should focus not only on AMC promotion but also on accurate self-

perceptions and social integration through inclusive play and movement activities to bring children into a flourishing state (Keyes, 2002). Schools and community programs could prioritize structured, inclusive PA offers that also promote social integration and address self-perception issues.

Learning goals related to well-being (e.g., emotional regulation, empathy) are defined in Swiss curricula (D-EDK, 2015; Högger, 2015) and could be used as criteria for educational quality. School evaluations and internal development processes may incorporate assessment of student well-being. This aligns with OECD frameworks, including the integration of well-being indicators in the PISA study (OECD, 2017, 2020).

The SEMOK-1-2 questionnaire provides a valuable and efficient screening tool that can be used by educators to detect children who may overestimate their motor competencies or struggle with low PMC. The identification of distinct child profiles in this dissertation, including one group with low AMC, overestimated PMC, low PA participation, and low well-being, indicates a need for multidimensional intervention strategies.

Interventions should focus not only on improving AMC but also on fostering positive-realistic self-assessments and creating supportive peer environments. Movement-based group activities and inclusive play structures in schools can be specifically designed to enhance both AMC and social bonding, thereby reinforcing children's psychological well-being and engagement in PA.

Teachers should also avoid practices that may expose or stigmatize less motor-competent children, such as allowing pupils to select their own teams, which often leave weaker children unchosen or excluded (Grimminger, 2013, 2014). Instead, structured and inclusive methods of group formation should be used to promote social inclusion. Furthermore, teachers should be mindful of pupils' well-being, not only in their own relationships with pupils but also in intentionally fostering positive peer relationships, as these are crucial for social integration and participation.

The OECD Child Well-being Framework (OECD, 2021) defines child well-being as a multidimensional construct encompassing education, social relationships, material conditions, and subjective experiences. Reports such as *How's Life* (OECD, 2020) emphasize that student well-being is not a secondary concern but a central policy goal. The OECD significantly contributes to embedding well-being as a central concern in multiple disciplines, especially education, by providing comprehensive frameworks, comparative data, and policy guidance that highlight well-being as a multidimensional concept and not merely a health issue (OECD, 2021). The inclusion of well-being indicators in international assessments such as PISA (OECD, 2017) reflects a growing global recognition of the link between emotional health and educational outcomes.

4.5 Conclusion

This dissertation underscores that promoting AMC in early childhood is about much more than physical abilities or performance. It is about empowering children to engage confidently and joyfully with their peers, their environments, and try new challenges. By integrating mental health parameters into models of motor development, this work calls for a shift toward holistic, child-centered approaches in research,

education, and policy. These approaches recognize the importance of social integration, well-being, and self-perception alongside AMC.

Drawing on the findings from four empirical studies, this work offers new insights into the complex interplay between AMC, PMC, PA, and mental health parameters in early childhood. It also provides a foundation for future research and practical applications in the fields of education, sport pedagogy, and child development.

The dissertation makes several contributions to both theory and practice. First, it empirically supports the integration of mental health factors into established motor development models, such as the model proposed by Lima et al. (2022).

Second, the development and validation of the SEMOK-1-2 questionnaire offers a practical instrument aligned with the MOBAK-1-2 instrument to assess the PMC of early primary school children, helping fill a critical gap for both practitioners and researchers.

Third, the use of a person-centered approach via LPA represents a methodological innovation. It enabled the identification of meaningful child profiles that revealed possible interactions between AMC, PMC, PA, and physical, psychological, and social well-being and children “at risk”, which could result in a negative spiral of engagement and development. These findings deepen understanding of how different children experience and engage with movement and play in their daily lives.

While this dissertation contributes substantial to new knowledge, it also points out important next steps, including the need for longitudinal and interventional research, the development of instruments to assess the child’s own perspective, and further exploration of contextual factors, such as the context of PA, that shape PA engagement, development, and well-being.

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Abstract

This cumulative dissertation examines the complex interplay between actual motor competencies (AMC), perceived motor competencies (PMC), physical activity (PA), and mental health parameters in early childhood (at 4–8 years). Situated at the intersection of educational science, motor development research, and health science, the studies aim to address theoretical and empirical gaps. In four empirical studies, a holistic, child-centered perspective is adopted viewing AMC not only as physical competencies but also as a part of a motivational and psychosocial system. This dissertation is primarily based on models by Stodden et al. (2008) and the version expanded by Lima et al. (2022). The EMOKK project (in English: Development of Basic Motor Competencies in Childhood), in which the present dissertation is embedded, used Helmke's (2014) offer-and-use model as its theoretical foundation. Helmke's model was expanded to include health-related factors to examine PA and mental health parameters, such as social integration and health-related quality of life (HRQoL).

In the first publication, the SEMOK-1-2 instrument—an instrument for assessing the PMC of first- and second-grade children (ages 6–8 years)—was developed and validated. The SEMOK-1-2 instrument conceptually closely aligns with a measure of AMC, namely the MOBAK-1-2 instrument (Herrmann, 2018). The included 404 children responded to tasks, demonstrated by an illustrated fox, using a 3-point scale analogous to the MOBAK-1-2 instrument. The two-factor structure of the MOBAK instrument was confirmed. Additionally, strong latent correlations were found between actual competence and self-perception in both object movement and self-movement. Boys and children who participated more frequently in team sports exhibited higher AMC and PMC in object movement.

The second publication investigated the interplay between AMC and social relationships among 548 preschool children (ages 4–6 years). Structural equation models revealed positive latent correlations between AMC and social integration within the class, with children possessing higher AMC appearing to be better integrated. The associations between the constructs were notably stronger for boys than for girls.

In the third publication, the associations between social integration and AMC were confirmed for both preschool children (n = 1163) and first and second graders (n = 880). Furthermore, the construct of health-related quality of life (HRQoL) was introduced as a key parameter of mental health, and its associations with social integration and AMC were examined. While general HRQoL was unrelated to AMC and social integration in preschool, it was weakly associated with social integration and AMC self-movement in first- and second-grade children. In preschool, a moderate association was found between physical well-being and AMC, with a stronger correlation for self-movement.

In the fourth publication, latent profile analysis identified three groups of children differing in terms of (their) sports engagement, AMC, PMC, and well-being. One profile of children was identified to be "at risk" by showing low levels of PA participation, AMC, and well-being.

In summary, motor competence factors are associated with parameters of mental health, thus supporting the model of Lima et al. (2022). In addition, this dissertation contributes to a holistic, interdisciplinary

consideration of motor competence factors in childhood, highlighting the interactions between AMC, PMC, sports participation, and psychosocial health. Based on cross-sectional data, it provides fundamental insights into the interplay of these factors, laying the ground for longitudinal studies. By bridging various scientific disciplines, this work offers theoretical and practical foundations for further research as well as more inclusive interventions in both school and out-of-school contexts.

Zusammenfassung

In dieser kumulativen Dissertation wird das komplexe Zusammenspiel zwischen tatsächlicher und wahrgenommener motorischer Kompetenz, körperlicher Aktivität und Parametern der mentalen Gesundheit im frühen Kindesalter (4 bis 8 Jahre) untersucht. Dabei bewegen sich die Untersuchungen im Feld zwischen Bildungswissenschaft, Motorikforschung und Gesundheitswissenschaften. In vier empirischen Studien wird ein ganzheitlicher, kindzentrierter Blick auf Faktoren der motorischen Entwicklung gelegt, wobei motorische Kompetenzen nicht nur als physische Kompetenzen, sondern als Teil eines motivationalen und psychosozialen Systems verstanden werden. Die Dissertation basiert auf den Modellen von Stodden et al. (2008) sowie der erweiterten Fassung von Lima et al. (2022). Als Ausganspunkt der EMOKK-Studie (Entwicklung motorischer Basiskompetenzen in der Kindheit), in die diese Dissertation eingebettet war, wird das Angebots-Nutzungs-Modell von Helmke (2014) herangezogen und um gesundheitsbezogene Faktoren erweitert, um neben körperlicher Aktivität die soziale Integration und gesundheitsbezogene Lebensqualität als Faktoren der mentalen Gesundheit zu untersuchen.

Im Rahmen der ersten Publikation wurde das SEMOK-1-2 Instrument entwickelt und validiert – welches die wahrgenommene motorische Kompetenz von Kindern der ersten und zweiten Klasse (6-8 Jahre) erfasst. Das SEMOK-1-2 wurde analog zum MOBAK-1-2 Instrument (Herrmann, 2018) entwickelt. Die 404 Kinder, welche an der Studie teilnahmen, konnten die Aufgaben, die von einem Fuchs vorgemacht wurden, auf einer dreistufigen Antwortskala, analog zum MOBAK Instrument, beantworten. Die zweifaktorielle Struktur der MOBAK-Instrumente konnte bestätigt werden. Zudem zeigten sich hohe latente Zusammenhänge zwischen tatsächlicher Kompetenz und deren Selbstwahrnehmung im Etwas-Bewegen und Sich-Bewegen. Jungen und Kinder, die häufiger am Teamsport teilnahmen, zeigten höhere tatsächliche Kompetenzen und eine höhere Selbstwahrnehmung im Etwas-Bewegen.

In der zweiten Publikation wurde das Zusammenspiel zwischen motorischen Kompetenzen und sozialen Beziehungen von 548 Kindergartenkindern (4-6 Jahre) untersucht. Mittels Strukturgleichungsmodellen zeigten sich positive latente Zusammenhänge zwischen den motorischen Kompetenzen und der sozialen Integration in die Klasse, wobei Kinder mit höheren motorischen Kompetenzen besser integriert zu sein schienen. Dabei fielen die Zusammenhänge zwischen den Konstrukten bei den Jungen deutlich stärker aus als bei den Mädchen.

In der dritten Publikation konnten die Zusammenhänge zwischen sozialer Integration und motorischen Kompetenzen, sowohl für Kinder des Kindergartens (n = 1163) als auch der ersten und zweiten Klasse (n = 880) bestätigt werden. Zudem wurde das Konstrukt der gesundheitsbezogenen Lebensqualität (HRQoL) als bedeutsames Konstrukt der mentalen Gesundheit eingeführt und die Zusammenhänge mit sozialer Integration und motorischen Kompetenzen untersucht. Im Kindergarten zeigten sich weder Zusammenhänge zwischen der generellen HRQoL und den motorischen Kompetenzen noch mit der sozialen Integration. Bei Kindern der ersten und zweiten Klasse konnten geringe Zusammenhänge zwischen der generellen HRQoL mit der sozialen Integration der Kinder, als auch mit der Kompetenz im Sich-Bewegen festgestellt werden. Bei der Untersuchung des körperlichen Wohlbefindens bei

Kindergartenkindern konnte ein moderater Zusammenhang mit den motorischen Kompetenzen festgestellt werden, wobei dieser für das Sich-Bewegen höher ausfiel.

In der vierten Publikation wurden mittels latenter Profilanalysen drei Gruppen von Kindern identifiziert, welche sich hinsichtlich der Faktoren Sportengagement, motorische Kompetenzen, deren Selbstwahrnehmung und Wohlbefinden unterschieden. Dabei konnte ein Profil als „Risikoprofil“ identifiziert werden, wobei die Kinder ein geringes Sportengagement, geringe motorische Kompetenzen sowie geringe Werte im Wohlbefinden aufwiesen.

Zusammenfassend kann festgehalten werden, dass motorische Kompetenzfaktoren mit Parametern der mentalen Gesundheit in Zusammenhang stehen und somit das Modell von Lima et al., (2022) unterstützt. Zudem trägt diese Dissertation zu einer ganzheitlichen, interdisziplinären Betrachtung von motorischen Kompetenzfaktoren im Kindesalter bei. Sie hebt die Wechselwirkungen zwischen Motorik, Selbstwahrnehmung, Sportpartizipation und psychosozialer Gesundheit hervor. Auf Basis von Querschnittsdaten bietet sie wichtige Einblicke in das Zusammenspiel dieser Faktoren, bildet die Basis für Langzeitstudien und unterstreicht gleichzeitig die Notwendigkeit dieser. Durch die Verbindung von verschiedenen Wissenschaftsdisziplinen liefert die Arbeit theoretische und praktische Grundlagen für weitere Forschung sowie inklusivere Interventionen im schulischen und außerschulischen Kontext.

Overview of the Cumulative Dissertation

Bretz, K., Strotmeyer, A., Seelig, H., & Herrmann, C. (2024). Development and validation of a test instrument for the assessment of perceived basic motor competencies in first and second graders: The SEMOK-1-2 instrument. *Frontiers in Psychology*, *15*, Article 1358170. https://doi.org/doi: 10.3389/fpsyg.2024.1358170

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Appendices

Appendix A – Publication 1

Bretz, K., Strotmeyer, A., Seelig, H., & Herrmann, C. (2024). Development and validation of a test instrument for the assessment of perceived basic motor competencies in first and second graders: The SEMOK-1-2 instrument. *Frontiers in Psychology, 15*, Article 1358170. https://doi.org/10.3389/fpsyg.2024.1358170

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Development and validation of a test instrument for the assessment of perceived basic motor competencies in first and second graders: the SEMOK-1-2 instrument

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Both actual motor competencies (AMC) and perceived motor competencies (PMC) play an important role in motor development research and children's physical and psychological development. PMC refer to children's perceptions of their motor competencies. To assess the PMC of first and second grade children (aged 6–9 years), the SEMOK-1-2 instrument was developed. The instrument is aligned to the validated MOBAK-1-2 instrument which assesses AMC in the competence areas "object movement" and "self-movement" Accounting for possible reading difficulties in younger children, the motor tasks and answer options were illustrated and explained verbally. The purpose of this study was to test and validate the SEMOK-1-2 instrument and investigate the associations between the constructs AMC, PMC and physical activity (PA), whereby PA was measured by the participation in team and individual sports. Data from $N = 404$ pupils in the German-speaking part of Switzerland from first and second grades ($M = 7.8$ years, SD = 0.69, 49% boys) were analyzed. Confirmatory factor analyses were conducted to test the factorial validity of the SEMOK-1-2 instrument. Structural equation models were used to investigate the association between the constructs. The analyses confirmed a two-factor structure with the factors PMC "object movement" and PMC "self-movement", corresponding to the factors existing in the MOBAK-1-2 instrument. Latent correlations between AMC factors and the corresponding PMC factors were $r = 0.79$ for "object movement" and $r = 0.76$ for "self-movement". Associations with external criteria and covariates, such as sex, were associated with both AMC and PMC. Analyses also revealed that children who participated more often in individual and team sports showed higher levels in both AMC and PMC. The confirmation of the two-factorial structure of the SEMOK-1-2 instrument and the associations between AMC and PMC as well as external criteria indicate construct and criterion validity. The SEMOK-1-2 instrument can be economically utilized for assessing PMC and is also suitable for the monitoring of PMC in the context of Physical Education.

KEYWORDS

sport, motor development, Physical Education, sport participation, childhood, test development

1 Introduction

Based on reflexive and rudimentary movements and determined by socio-cultural and geographical influences, children develop and extend their repertoire of motor competencies (e.g., kicking, running; Herrmann, 2018; Hulteen et al., 2018). In childhood, motor competencies are the prerequisites to participate in the culture of sport and movement. Since actual motor competencies (AMC) and perceived motor competencies (PMC) are seen to be driving influencing factors of physical activity (Lopes et al., 2021), the investigation of AMC and PMC as well as their interplay has been the focus of several studies (Barnett et al., 2022; Estevan et al., 2023).

Deficits in AMC have been revealed worldwide. For instance, Bolger et al. (2021) showed, that children in preschool age (3–5 years) show average AMC, while children aged 6–10 years show below-average levels compared to the normative data of the used test instrument. Deficits regarding physical activity could also be observed. The World Health Organization (WHO) recommends at least 60 min of moderate to vigorous physical activity per day for children and adolescents. However, the WHO Global Status Report on physical activity shows that the physical activity recommendations are not achieved by 81% of adolescents (WHO, 2022). Therefore, the assessment and investigation of AMC and PMC as determinants of PA is important, as high levels of both AMC and PMC are positively related to good health attributes (Barnett et al., 2022; Estevan et al., 2023).

The development of AMC is seen as a main goal of Physical Education in school and AMC are considered as important components for sport-specific skills and an active lifestyle over the lifespan (Bildungsdirektion des Kantons Zürich, 2017). Moreover, they are necessary to overcome the proficiency barrier and to develop sport-specific skills (Hulteen et al., 2018). This sport-specific skills can used for participation in different sports and can result in a lifetime of physical activity (Hulteen et al., 2018). All developmental steps are depending on and influenced by biological (e.g., sex) and environmental factors (e.g., participation in learning situations) and associated with physical (e.g., weight status) and psychological (e.g., perceived competence) attributes (Hulteen et al., 2018; Lopes et al., 2021).

AMC refer to the ability to perform various motor tasks, including coordinating gross and fine movements for everyday activities (Robinson et al., 2015; Almeida et al., 2023). As the term "motor competence" is based on several definitions, AMC will be used as an umbrella term to include different definitions and constructs.

Different approaches lead to the use of different test instruments to measure AMC, e.g., Test of Gross Motor Development (TGMD, Webster and Ulrich, 2017), the "Körperkoordinationstest für Kinder" (KTK, Kiphard and Schilling, 2017), or the MOBAK instruments (in German: Motorische Basiskompetenzen, Herrmann, 2018). The Test of Gross Motor Development (TGMD, Webster and Ulrich, 2017) is a process-oriented assessment and examines qualitative aspects of movement (e.g., movement patterns). The test relates to the construct of fundamental movement skills (FMS) which can be measured in the subscales "locomotor skills" and "object control skills." The KTK (Kiphard and Schilling, 2017) is a product-oriented test which measures quantitative outcomes of motor performance (e.g., number of correct jumps). The KTK instrument includes four items which assess gross body control, coordination, and dynamic balance. The MOBAK instruments assess basic motor competencies and refer to the newly developed approach which theoretically substantiates basic motor competencies as an educational goal in Physical Education (Herrmann et al., 2016). The MOBAK instruments were developed for preschool and primary school (first to sixth grade). Accordingly, the difficulties of the test items refer to the educational goals of the curriculum (Herrmann and Seelig, 2017a; Herrmann, 2018; Herrmann et al., 2020). With the MOBAK instruments, the basic motor competencies can be assessed in the competence areas "object-movement" and "self-movement."

Children's self-perceptions are based on concrete, observable characteristics. PMC are an important construct in the context of motor development and are also defined as an educational goal in Physical Education (Stodden et al., 2008; Högger, 2015). PMC refer to the perception of the motor competencies a child thinks to have. As children with low PMC will probably engage less in sports and PA than children with higher levels of PMC, it is seen as an important factor in motor development research (Stodden et al., 2008; Almeida et al., 2023). Estevan and Barnett (2018) have integrated perceived motor competence (PMC) into the hierarchical and multidimensional model of self-concept by Shavelson et al. (1976). Further constructs are differentiated within PMC, analogous to AMC, e.g., PMC in "locomotor skills" and PMC in "object control skills," analog to the construct of "fundamental movement skills" and the dimensions of the TGMD.

Both AMC and PA are associated with improved physical and mental health parameters (Lubans et al., 2010; Robinson et al., 2015; Pate et al., 2019). As mentioned before, national and international studies show, that the recommendations given by the WHO are not achieved by children and adolescents (Hänggi et al., 2022; WHO, 2022). PA is relevant from a health-related perspective throughout the whole lifespan. In early childhood, PA, e.g., running or balancing, is elementary for the development of AMC. Later in childhood, an inverse relationship could be observed, as AMC are relevant for further PA (Stodden et al., 2008). PA can be assessed in different ways. Wearables, such as accelerometers, can be used to measure PA quantitatively. On the other hand, questionnaires can be used to investigate the content of physical activity, such as the participation, type, and frequency in sports clubs. Especially regarding the approach of an idea of participation in the culture of sport and movement, the content, in which children move is relevant (Neuber and Golenia, 2018).

Stodden et al. (2008) postulated a conceptual model and within it a reciprocal and developmentally dynamic relationship between AMC and PA. Children with low levels of AMC cannot overcome the proficiency barrier to develop sport specific motor skills and do not reach the adequate levels of PA and health related fitness. This can result in a higher risk of obesity and a negative spiral of engagement, whereas children with a higher level of AMC can result in a positive spiral of engagement. This relationship can also be mediated by PMC and health related fitness—depending on the phase of childhood. In early childhood, both AMC and PA

are influenced by PMC, whereas reciprocal relationships between PMC and AMC as well as PMC and PA were postulated. PMC is seen as an important factor in motor development as children with low PMC will probably engage less in sports and physical activity than children with high PMC (Stodden et al., 2008; Almeida et al., 2023). In addition, Barnett et al. (2022) conducted a systematic review related to the model and found that the evidence on the relationship between AMC and PMC is insufficient due to cross-sectional studies with different aligned instruments. In a longitudinal study by Utesch et al. (2018), the interplay between AMC and its perception was found to be an important aspect for PA in childhood. Children with high levels of AMC did not necessarily have high levels of PMC and vice versa. The authors concluded that an accurate self-perception of AMC is a significant predictor of PA. Estevan and Barnett (2018) suggested to use task-specific and aligned instruments to measure both AMC and PMC to ensure that the constructs of interest are represented in both assessments.

2 Assessment of PMC in children

Various instruments have been developed to measure PMC, some of which are directly based on and aligned to measure instruments for AMC. McGrane et al. (2016) developed the physical self-confidence scale to assess adolescents perceived confidence at performing specific skills, of which some questions are based on the skills assessed in the TGMD. Herrmann and Seelig (2017b) developed an instrument to assess the PMC of fifth- and sixth-graders (SEMOK-5-6), whereby the questions were aligned to the MOBAK instrument for the assessment of AMC in fifth and sixth grade students (Herrmann and Seelig, 2017a). Due to the low level of reading literacy at the beginning of primary school, instruments are needed specifically for this target group. In the following section, instruments for the assessment of PMC are presented, whereby a newly developed instrument for the assessment of PMC (SEMOK-1-2; in German: Selbstwahrnehmung motorischer Basiskompetenzen) will be introduced.

2.1 Pictorial scales in assessments for children

The assessment of different constructs in young children who cannot read requires specific test instruments, as written questionnaire cannot be used. Attempts to solve this problem led to the development of pictorial instruments or scales. Sauer et al. (2020) conducted a review of pictorial scales in research and practice and developed recommendations for the development of pictorial scales. The review shows, that there is a lack of stringent methodological approaches in the development and validations of these instruments.

There are pictorial instruments which were developed for preschool and primary school children, e.g., to assess children's fears. Muris et al. (2003) used an illustration of a Koala for pictorial response options, representing three different levels of fear. The Koala Fear Questionnaire uses different pictures representing possible fear situations, and the child could choose one of the three Koala faces showing emotional expressions ("no fear," "some fear," "a lot of fear").

In the field of motor competencies, pictorial response options are used in the Pictorial Movement Skill Competence (PMSC) instrument, which alignes to the TGMD (Barnett et al., 2015; Webster and Ulrich, 2017). Due to the young age of the children, the instrument is administered one-on-one to each child and takes about 15–18 min per child. In addition, gender-specific versions for girls and boys are used (Barnett et al., 2015; Estevan et al., 2019). By using this instrument, a child first has to choose between two pictures, whereby one represents the success and the other one the failure of the task. Following this, he/she has to specify whether he/she is "really good" or "pretty good" for the success picture and "sort of good" or "not that good" for the failure picture.

2.2 Development of the SEMOK-1-2 instrument (in German: Selbstwahrnehmung motorischer Basiskompetenzen)

To assess PMC, instruments which are aligned to the AMC instruments are used. As there is no aligned PMC instrument to the MOBAK instrument for the first and second grade yet, the SEMOK-1-2 instrument has been developed to measure PMC of the children. Based on the review by Sauer et al. (2020), the given recommendations will be addressed below. Moreover, the following points were considered in the development of the instrument: (1) Economic assessment of PMC: in contrast to other instruments that assess the PMC of the children in a one-to-one situation, the developed instrument should be applicable in a class setting. (2) Enforceability despite poor reading skills: to be feasible in a classroom setting, the instrument should not require written instructions. Therefore, the motor tasks were illustrated. (3) Neutral gender and ethnic representation of the illustrated animal: to avoid gender and ethnic representation, the tasks were performed by an illustrated fox instead of illustrated children.

Based on the MOBAK-1-2 instrument, which assesses the AMC of the children with each four items in the competence areas "self-movement" and "object movement," the eight PMC items in the SEMOK instrument refer to children's perception of whether they can perform the basic motor requirements (e.g., throwing, catching, balancing, rolling) formulated on the basis of curricular standards in the MOBAK instrument (e.g., "the child can throw a ball against a target"; Herrmann, 2018). A fox named "Foxy" was illustrated performing the tasks. As the motor tasks of the MOBAK instrument can be represented by a picture (Sauer et al., 2020), each task was illustrated, whereby Foxy was performing the task (Bretz et al., 2023, p. 6f). Comparable to Muris et al. (2003), three pictorial response options were illustrated, representing "negative," "neutral" or "positive" valances (Figure 1).

For the PMC assessment, every child receives a questionnaire with the illustrated test items and the pictorial response options next to each item (Figure 2; Bretz et al., 2023, p. 14f). The questionnaire is presented in paper format, with a front and back page, whereby four tasks displayed one below the other on each

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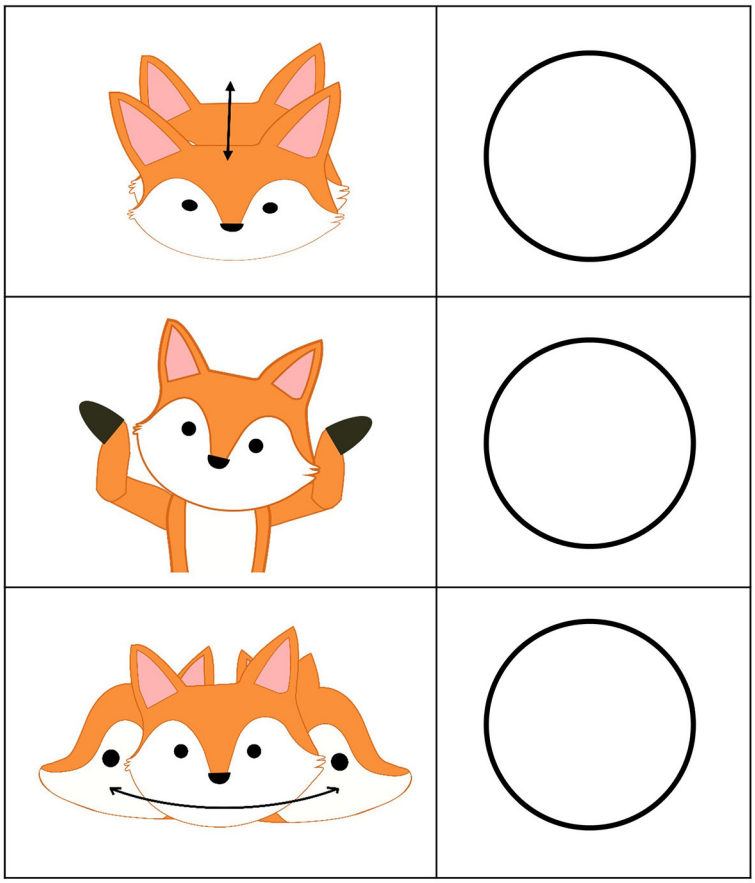

FIGURE 1
Scale of the SEMOK-1-2 instrument. Pictorial response options: nodding, shrugging shoulders, shaking head (Bretz et al., 2023, p. 5).

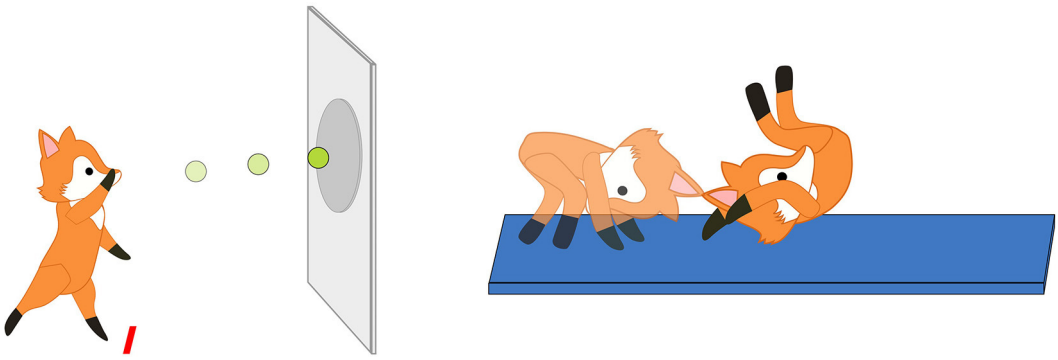

FIGURE 2
Examples of the illustrated motor tasks "throwing" and "rolling" (Bretz et al., 2023, p. 6, 11).

page (Bretz et al., 2023, p. 14–15). In the beginning, the pictorial response options (Figure 1) are explained.

The standardized explanation of the pictorial response option is as follows (translated from German, Bretz et al., 2023): "First of all, we will look at the answer options together. In the first picture, Foxy is nodding, which means that Foxy can do the task. In the second picture, Foxy is shrugging its shoulders, which means that Foxy can partially do the task. In the third picture, Foxy is shaking its head, which means that Foxy cannot do the task. Each time there is a circle next to Foxy's head. On your sheet, you will find this box next to each task Foxy is performing. After the task has been explained, you have time to think about how you can do the task and tick one of the circles. Today there is no right or wrong and it is only about yourself. After explaining the pictorial response options, each task

TABLE 1 Explanation of the SEMOK-1-2 items (translated from German, Bretz et al., 2023).

Item	Explanation
1. PMC throwing	Foxy throws a small ball, about the size of a tennis ball, at a target and hits the target.
2. PMC catching	Foxy catches a small ball, about the size of a tennis ball, with both hands. The ball may only be caught with the hands and must not touch the body.
3. PMC bouncing	Foxy bounces a ball on the floor while walking through a narrow passage. The ball can be bounced with one hand or both hands and must not be lost.
4. PMC dribbling	Foxy dribbles a ball with the feet through a narrow passage. The ball must not be lost in the process.
5. PMC balancing	Here we have built a small seesaw. Foxy balances forward over an inverted long bench that tips over halfway. Then Foxy balances backwards and the bench tips back again. Foxy keeps the balance and does not fall off the bench.
6. PMC rolling	Foxy does a somersault. The chin is close to the chest and the back is round. Then Foxy stands up again.
7. PMC jumping	Foxy hops through a parkour of carpet tiles. Foxy hops between the tiles on one leg, straddling the tiles with both legs.
8. PMC running	Foxy runs sideways from one cone to the other and then back again.

is explained separately followed by the sentence "Now think about yourself and tick one of the circles." After ticking, the children are asked to wait with their arms crossed until all children finish and the next task will be explained. The whole questionnaire takes 10–15 min to complete. The instructions for the items are listed in Table 1. To ensure survey standardization, the test administrators undergo training and are provided with a manual containing the verbal instructions. The motor tasks are not shown but explained verbally only.

2.3 Aim of the study

The MOBAK instruments for the assessment of AMC (Herrmann and Seelig, 2017a; Herrmann, 2018), have been used in numerous studies and are a widely accepted instrument for assessing AMC (Strotmeyer et al., 2020; Herrmann et al., 2021; Wälti et al., 2022; Carcamo-Oyarzun et al., 2023). To assess PMC, aligned instruments for the fifth and sixth grade were developed (Herrmann and Seelig, 2017b) and adapted for the third and fourth grade (Strotmeyer et al., 2022). With the development of the SEMOK-1-2 instrument, the assessment of PMC in younger children can also be assessed.

Against this background, the study aims first to test the construct of the developed SEMOK-1-2 instrument to examine the assumed two-factorial structure, analogous to the MOBAK instrument with the factors "object movement" and "self-movement." Second, to investigate the criterion validity by relating the AMC and PMC constructs. Third, to examine associations between the AMC and PMC constructs and covariates (age, sex and BMI) as well as sports club participation.

3 Materials and methods

The present validation study was a cross-sectional study based on the second measurement point of the longitudinal study "Development of basic motor competencies in children (EMOKK)" (2021–2025), funded by the Swiss National Science Foundation (SNSF; Grant number 200840).

3.1 Actual motor competencies

To measure AMC, the MOBAK instrument for the first and second grade of primary school was used (MOBAK-1-2, Herrmann, 2018). With the MOBAK instrument, AMC can be measured in the competency area "object movement" and "self-movement," operationalized with four items per competency area (object movement: throwing, catching, bouncing, dribbling; self-movement: balancing, rolling, jumping, running) (Herrmann, 2018). Each test item describes a standardized task with corresponding assessment criteria. During the test, each child had two attempts to try to achieve the motor task (no trial run). The two single attempts were rated on a dichotomous scale (0 = failed, 1 = successful), and the individual results were summed up to form the final item score (0 points = no successful attempts, 1 point = one successful attempt, 2 points = two successful attempts). The scores for the test items throwing and catching were calculated differently. In these cases, the children had six attempts each, and the number of successful attempts was recorded. Subsequently, 0–2 successful attempts were scored as 0 points, 3–4 successful attempts as 1 point, and 5–6 successful attempts as 2 points. For each competency domain, a maximum of eight points could be achieved (for details, see Herrmann, 2018). Data was collected in class during a regular 45-min Physical Education lesson. The class was divided into small groups of three to four children each and led through the eight test stations by trained testers. The testers provided a standardized explanation and one demonstration of each test item. The factorial validity of the MOBAK instrument for primary school (MOBAK-1-2) has already been investigated and confirmed in various studies (Herrmann et al., 2016, 2019a). The weight and height of the children was measured as part of the MOBAK test to calculate the Body-Mass-Index (BMI).

3.2 Parent questionnaire

The parents of the children completed a questionnaire. In addition to general information about the child, the questionnaire contained questions about the sports activity of the child, e.g., how often the child plays outside or participates in organized sports activities (in detail, see Herrmann et al., 2023). Parents were asked whether their children participate in a sports club and, if so, to what extent (frequency per week) and in which sports (up to three answers possible, either by ticking predefined sports or as open answers). The type and frequency data were assigned to the categories team sports (e.g., football, handball) or individual sports (e.g., swimming, gymnastics) and summed up. This resulted in sum

values for the variables frequency of team sports and frequency of individual sports.

3.3 Perceived motor competencies

PMC were assessed before measuring the AMC. Therefore, the children filled out the questionnaire during the last 15 min of the regular lesson in their classroom before the Physical Education lesson or on another day before the AMC assessment. The procedure and instructions were briefly described in the previous section.

For subsequent analyses, the answers given to the pictorial response options were coded: "positive"/nodding = 2 points, "neutral"/shrugging shoulders = 1 point, "negative"/Shaking head = 0 points. Following, the points per competency domain were summed up (0–2 points per item, eight points per competency domain). This means that the tasks in the PMC instruments refer to the tasks in the AMC instrument but also that the scores of the AMC and PMC instruments are aligned.

3.4 Sample

AMC and PMC data were collected in the Swiss cantons Basel-Landschaft and Zurich in spring/summer 2023. In total, we contacted parents or legal guardians of 558 children from the first and second grade. Of these children, 404 parents (72.4%), gave their written consent for their children to participate in the study. We included $N = 404$ children ($M = 7.8$ years, SD = 0.69, 49% boys) from 29 classes in the study, with an average class size of $n = 14$. The data was obtained from three different sources (AMC, MOBAK instrument; PMC, SEMOK instrument; PA, parent questionnaire) and was merged. The assessment of AMC, which took place during a Physical Education lesson, involved $n = 378$ children, and data on PMC was collected prior to the assessment in the regular classroom from $n = 391$ children. The parents of $n = 376$ children completed the parent questionnaire at home. The study was conducted in the accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Zurich (Nr. 21.2.5, 19.12.2022). Informed consent was obtained from all parents of the participants in this study and the participation was voluntary and could be canceled at any time.

3.5 Data analysis

The data processing, descriptive and correlational analyses were conducted with SPSS 28 (IBM Corp., 2021). Multivariate analyses were performed by using Mplus 8.8 (Muthén and Muthén, 2017).

At a manifest level, descriptive statistics were calculated. Therefore, sum values regarding the AMC and PMC single items were calculated for AMC "object movement," AMC "self-movement," PMC "object movement" and PMC "self-movement." The mean values were calculated for the total sample and separately for girls and boys. We calculated 95% confidence intervals and Cohen's *d*. As effect sizes Cohen's d were interpreted as small ($d = 0.10$), medium ($d = 0.50$) and large ($d = 0.80$) (Cohen, 1988). Regarding PA, the mean values of frequency in team and individual sports were also calculated for the total sample and girls and boys separately. Moreover, we calculated Spearman correlations for non-parametric data to investigate the associations between the constructs on a manifest level.

Modeling latent structures was carried out in three steps. First, the factorial validity of the SEMOK instrument, which measures PMC, was examined by calculating confirmatory factor analyses (CFA). Second, the criterion validity was investigated, whereby the AMC and the PMC factors were related. Third, correlations with covariates (age, sex, BMI) and the frequency of sports club participation were examined. Influences of the multilevel structure (students from different classes) were tested with the help of interclass correlations (ICC).

3.5.1 Missing data handling

There were missing values due to the different data sources (AMC assessment, PMC assessment, parent questionnaire) and partly different survey days. Some children participated in the AMC assessment, but not in the PMC assessment and vice versa. Moreover, not all parents filled out the parent questionnaire. From children who participated in the assessment of AMC, frequencies of missing values ranged from 0.5% (AMC jumping) to 4.2% (AMC balancing). In the PMC assessment, missing values were only identified for PMC bouncing and PMC dribbling (both 0.5%). Regarding the parent questionnaire, 5.1% of the parents who filled out the questionnaire did not answer the question about sports club participation. Missing values were estimated via the full information maximum likelihood (FIML) algorithm. The FIML procedure is a conservative and well-established procedure in educational research. The FIML procedure prevents bias in the sample composition by preventing a reduction in the sample size (Urban and Mayerl, 2014).

3.5.2 Modeling latent structures

Construct validity of the SEMOK-1-2 instrument was investigated by calculating CFAs.

Model 1a: Due to the two-factorial structure of the MOBAK instrument (Herrmann et al., 2015) as well as the previous SEMOK-5-6 instruments (Herrmann and Seelig, 2017b; Strotmeyer et al., 2022), it was assumed that the developed SEMOK-1-2 instrument would also have a two-factorial structure. Therefore, the factor structure of the SEMOK instrument was tested by calculating a two-factorial CFA with the factors "PMC object movement" (PMC throwing, PMC catching, PMC bouncing, PMC dribbling) and "PMC self-movement" (PMC balancing, PMC rolling, PMC jumping, PMC running).

Model 1b: Based on model 1a, the covariates sex, age and BMI were included as covariates in the model. Modification indices (MI) can be used to check which relaxation of restrictions leads to a statistically significant improvement of the model (Geiser, 2011). In this model, we requested the modification indices (MI = all) for the direct effect of the covariates.

Criterion validity of the SEMOK-1-2 instrument was investigated by calculating associations between AMC and PMC of the children.

Model 2: In model 2, the relationship between the AMC and PMC factors was investigated to test concurrent validity. Therefore, we calculated a confirmatory factor analysis with the four factors AMC "object movement," AMC "self-movement," PMC "object-movement" and PMC "self-movement." Sex, age and BMI were integrated in the model as covariates.

Finally, the associations between AMC, PMC and PA were calculated.

Model 3: In Model 3 we investigated associations between AMC, PMC, and PA. Next to the latent AMC and PMC factors, the manifest factors of frequency of team sports and frequency of individual sports were included. Age, sex, and BMI were included as covariates in the model.

In all models, we treated the AMC and PMC as ordinal-scaled data. Accordingly, we used the mean- and variance-adjusted weighted least squares (WLSMV) estimator. We accounted for dependencies within the multilevel structure ($0.01 \leq \text{ICC} \leq 0.19$; Table 2) in all models by correcting the standard error with the "type = complex" function for nested datasets implemented in Mplus. The goodness of fit of the models was assessed using fit indices proposed in the literature (Schreiber et al., 2006). Effect sizes were interpreted as small ($r > 0.10$, $\beta > 0.05$), medium ($r > 0.30$, $\beta > 0.25$), or large ($r > 0.50$, $\beta > 0.45$) (Cohen, 1988; Peterson and Brown, 2005).

4 Results

Table 2 shows the descriptive values of AMC and PMC as well as the frequency of sport participation in team and/or individual sports. Boys showed better AMC in "object movement" ($d = 0.57$) than girls while girls had better AMC in "self-movement" ($d = -0.27$). Regarding PMC, boys rated themselves higher than girls in PMC "object movement" ($d = 0.97$). Most of the children whose parents filled out the questionnaire, were a member of a sports club (83.8%). Of the children, who participated in a sports club, 59.1% were active only in individual sports, 16.8% were participating only in team sports and 24.1% of the children were participating in both individual and team sports. Regarding the participation in organized sports, girls engaged more in individual sports ($d = -0.34$) than boys whereas boys engaged more in team sports ($d = 0.64$).

4.1 Factorial validity of the SEMOK-1-2 instrument

Model 1a: The CFA with the two factors PMC "object movement" and PMC "self-movement" showed a good model fit ($\chi^2 = 26.447$; df = 19; $p = 0.118$; CFI = 0.940; RMSEA = 0.032; $N = 391$). The factor loadings ranged from $\beta = 0.35$ to $\beta = 0.69$ (Figure 3). The correlation between the factors PMC "object movement" and PMC "self-movement" was $r = 0.66$ ($p < 0.001$).

Model 1b: Based on model 1a, the covariates sex, age and BMI were integrated to model 1b. The model showed a good model fit, whereby the model fit increased slightly in comparison to the model without the covariates. ($\chi^2 = 45.14$; df = 37; $p = 0.017$; CFI = 0.969; RMSEA = 0.023; $N = 377$). No modifications concerning the minimal value (MI > all) were suggested. Sex was found to have a significant effect on the factor PMC "object movement" ($r = -0.63$, $p < 0.001$), but not on the factor PMC "self-movement" ($r = 0.06$, $p = 0.457$). Age and BMI did not show significant effects on PMC factors. The correlation between PMC "object movement" and PMC "self-movement" was $r = 0.93$ ($p < 0.001$).

Both models and the resulting model fits showed that the assumed two-factor structure with the factors PMC "object movement" and PMC "self-movement" could be confirmed.

4.2 Criterion validity of the SEMOK-1-2 instrument

To investigate the criterion validity, the associations between the AMC and PMC factors were calculated. The four-factor confirmatory analysis with the factors AMC "object movement," AMC "self-movement," PMC "object movement" and PMC "self-movement" with the covariates resulted in a good model fit ($\chi^2 = 173.651$; df = 134; $p = 0.012$; CFI = 0.909; RMSEA = 0.027; $N = 404$). The correlation between the factors AMC "object movement" and PMC "object movement" was $r = 0.88$ ($p < 0.001$) and between the factors AMC "self-movement" and PMC "self-movement" $r = 0.85$ ($p < 0.001$). There was no correlation between PMC "object movement" and AMC "self-movement" ($r = 0.01$, $p = 0.953$) but a significant correlation between PMC "self-movement" and AMC "object movement" ($r = 0.50$, $p = 0.011$; Figure 4). The correlation between AMC "object movement" and AMC "self-movement" was $r = 0.74$ ($p < 0.001$) and between PMC "object movement" and "self-movement" $r = 0.95$ ($p < 0.001$).

4.3 Associations between AMC, PMC and PA

Model 3: Based on model 2, frequency of team sports and frequency of individual sports, were included as manifest variables in model 3 to investigate the associations between AMC, PMC and PA. Moreover, sex, age and BMI were included as covariates.

The model showed a good model fit ($\chi^2 = 200.149$; df = 158; $p = 0.013$; CFI = 0.914; RMSEA = 0.026; $N = 404$). The correlations are shown in Table 3 (below the diagonal).

Older children performed better in AMC "object movement" ($r = 0.56$, $p < 0.001$) and AMC "self-movement" ($r = 0.52$, $p < 0.001$) than younger children. Strong correlations were also found between sex and AMC and PMC as well as sport participation. Boys performed better in AMC "object movement" ($r = -0.36$, $p < 0.001$) than girls, whereas girls were better in AMC "self-movement" ($r = 20$, $p = 0.003$). Regarding PMC, boys rated themselves higher in "object movement" ($r = -0.65$, $p < 0.001$). Correlations between PA and sex were also found. Boys participated more often in team sports ($r = -0.30$, $p < 0.001$), whereas girls were more active in individual sports ($r = 0.17$, $p < 0.001$). The frequency of team and individual sports was also associated with PMC. Moreover, there were significant correlations between the frequency of team sport and AMC "object movement" ($r = 0.20$, $p < 0.001$), PMC "object movement" ($r = 0.53$, $p < 0.001$) and PMC

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TABLE 2 Descriptive values and interclass-correlations (ICC) of the actual (AMC) and perceived (PMC) motor competency domains and the frequencies of team and individual sports.

	Overall			Boys		Girls		*d*
	N	*M* CI 95%	ICC	*n*	*M* CI 95%	*n*	*M* CI 95%	
AMC object movement[a]	369	5.76 (5.60; 5.93)	0.11	179	6.23 (6.01; 6.45)	190	5.33 (5.09; 5.57)	0.57
AMCsSelf-movement[a]	352	5.70 (5.52; 5.89)	0.19	174	5.46 (5.18; 5.74)	178	5.94 (5.69; 6.19)	−0.27
PMC object movement[a]	383	6.33 (6.18; 6.48)	0.03	190	6.97 (6.80; 7.14)	193	5.70 (5.50; 5.90)	0.97
PMC self-movement[a]	383	7.23 (7.14; 7.33)	0.01	190	7.17 (7.02; 7.33)	193	7.30 (7.17; 7.42)	−0.12
Frequency team sports[b]	369	0.54 (0.45; 0.64)	0.04	182	0.84 (0.67; 1.00)	187	0.26 (0.17; 0.35)	0.64
Frequency individual sports[b]	369	1.08 (0.96; 1.19)	0.05	182	0.89 (0.75; 1.03)	187	1.25 (1.08; 1.42)	−0.34

[a]Range: 0–8.
[b]Days per week.

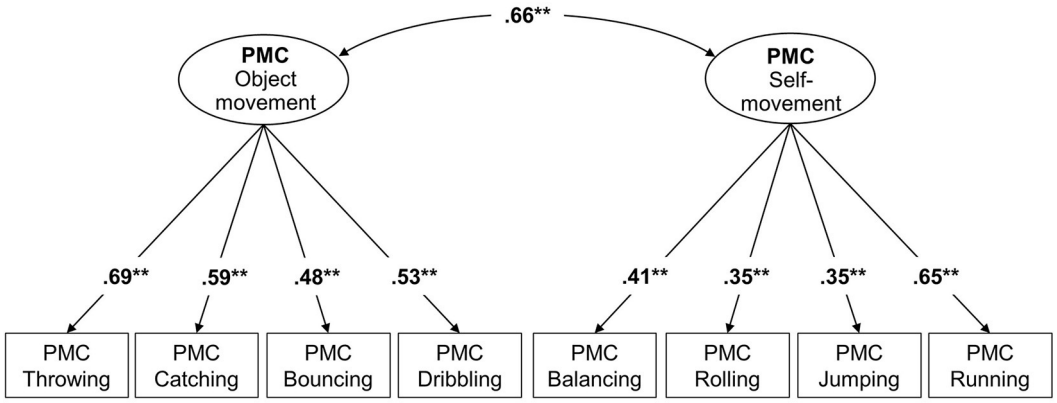

FIGURE 3
Two-factorial confirmatory factor analysis for the SEMOK instrument with the factors PMC "object movement" and PMC "self-movement" (Model 1a). $^{**}p < 0.01$.

"self-movement" ($r = 0.21$, $p = 0.037$). Associations with frequency of individual sports were found with PMC "self-movement" ($r = 0.39$, $p < 0.001$).

The partial Spearman correlations (Table 3, above the diagonal) also showed correlations between AMC and PMC in "object movement" ($r = 0.28$, $p < 0.001$) and "self-movement" ($r = 0.18$, $p < 0.001$). Moreover, correlations between PMC "object movement" and the frequency in team sport ($r = 0.22$, $p < 0.001$) as well as PMC "self-movement" and the frequency in individual sport ($r = 0.11$, $p = 0.048$) were found. The same correlations were found at the latent and manifest levels, although they were lower at the manifest level, as expected.

5 Discussion

PMC is seen as an important factor in the context of motor development. An instrument was developed to measure PMC in children in first and second grade, as there was no instrument to measure PMC aligned to the MOBAK-1-2 instrument. Because of the young age of the children and the poor reading skills, illustrated tasks were developed, supported by verbal instructions. The aim of this study was to test construct and criterion validity of the newly developed SEMOK-1-2 instrument and to investigate the associations between AMC, PMC and PA. In the following, the investigated construct and criterion validity are discussed.

Regarding the factorial validity the two-factorial structure with the two factors PMC "object movement" and PMC "self-movement" was confirmed, equivalent to the two-factor structure of the MOBAK instruments. Due to the high correlation between the PMC factors "object movement" and "self-movement" ($r = 0.95$, $p < 0.001$), a one-factor model was also tested, but this resulted in a poorer model fit than the two-factor solution. It is therefore assumed that the two-factor model is the better solution. Thus, it can be seen, that both the MOBAK and SEMOK instruments consistently show this two-factor structure with the factors "object movement" and "self-movement" (Herrmann et al., 2015; Herrmann and Seelig, 2017a,b,c; Strotmeyer et al., 2022).

Integrating sex, age and BMI as a covariate resulted in better model fits. Regarding the modification indices, no relaxation of the restrictions would lead to an improvement of the model and can be taken as an indication that there was no difference in the model regarding sex, age and BMI.

In terms of criterion validity, strong positive correlations between children's AMC and PMC were found, especially at the latent level (Model 2). These correlations indicate that the children's

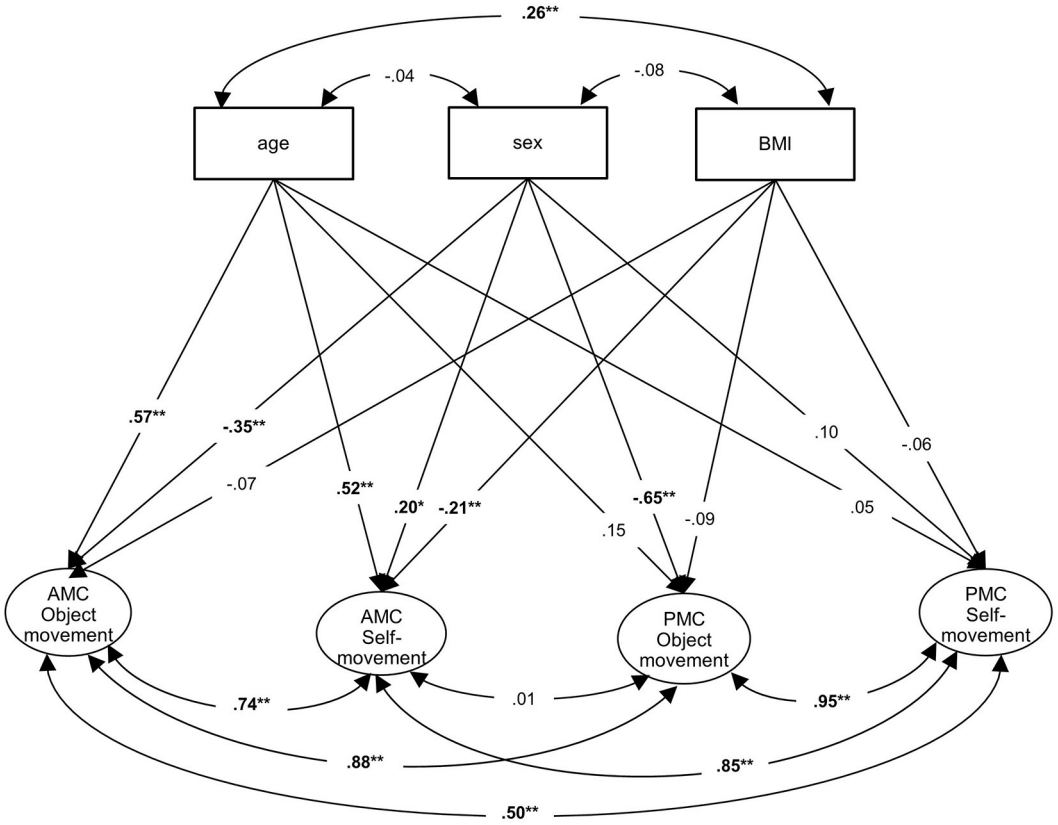

FIGURE 4
Structural equation model (SEM) with the factors AMC "object movement," AMC "self-movement," PMC "object movement" and PMC "self-movement" with the covariates age, sex and BMI (Model 2). *$p < 0.05$, **$p < 0.01$.

assessed PMC are related to the relevant criterion of children's AMC. The correlation between AMC and PMC was higher than in the study by Strotmeyer et al. (2022) ("object movement": $r = 0.45$, $p < 0.01$; "self-movement": $r = 37$, $p < 0.01$) and similar to the study by Herrmann and Seelig (2017b) ("object movement: $r = 0.70$, $p < 0.001$; "self-movement": $r = 0.76$, $p < 0.001$). The high correlation between the constructs could possibly be due to the high alignment between the AMC and PMC instruments. Other studies show low to moderate correlations between AMC and PMC in children (De Meester et al., 2020). However, it is possible that not only the alignment between the instruments but also the alignment between the scales is decisive for the strength of the correlation.

Differences between girls and boys appeared in model 1c, with boys rating themselves better than girls. That PMC in "object movement" was higher in boys than in girls, is also in line with the literature (De Meester et al., 2016; Herrmann and Seelig, 2017b; Niemistö et al., 2019; Martínez-González et al., 2022). In addition to PMC, differences in AMC were also found between boys and girls. Boys performed better in "object movement," whereas girls performed better in "self-movement." The result that boys are better in object movement and girls are better in self-movement has also been found in other studies with children from different age groups (Herrmann et al., 2019b; Wälti et al., 2022). Differences between boys and girls were also found regarding their sport participation. Boys participated more often in team sports (e.g., soccer), whereas girls participated in individual sports (e.g., gymnastics). The finding that boys prefer ball games while girls prefer sports such as dancing or gymnastics was also observed in other Swiss and international studies (Gramespacher et al., 2020; Peral-Suárez et al., 2020; Lamprecht et al., 2021).

The high correlation between sex and PMC "object movement" may be due to a link via the participation in sports club. Children, who participated in team sports showed a higher level in both PMC "object movement" ($r = 0.52$, $p < 0.001$) and PMC "self-movement" ($r = 0.21$, $p = 0.04$). Children who took part in individual sports showed higher levels only in PMC "self-movement" ($r = 0.39$, $p < 0.001$). A positive association between the organized sport activities and perceptions of "object movement" was also found by Niemistö et al. (2019). As boys participate more often in team sports and ball sports, they enhance their AMC in "object movement." Gramespacher et al. (2020) found that the differences between boys and girls in their AMC were mediated by club sport participation. Indirect effects of sex on "self-movement" were found through the frequency of individual sports and the frequency of team sports. An indirect effect on "object movement" was found via the frequency of team sports (Gramespacher et al., 2020). This would also be conceivable for PMC. It is also possible, that children who have a higher level of AMC and PMC, tend to participate more often in club sports than children with lower levels of AMC and PMC. As PMC in "object movement" is associated with

TABLE 3 Correlations between the AMC and PMC factors, frequency of team and individual sports and sex, age and BMI as covariates (Model 3).

	First-order correlations						Zero-order correlations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) AMC object movement		**0.27**	**0.28**	0.05	**0.12**	0.02	**−0.29**	**0.40**	0.08
(2) AMC self-movement	**0.75**		0.10	**0.18**	0.09	0.04	**0.16**	**0.32**	−0.02
(3) PMC object movement	**0.89**	<0.01		**0.22**	**0.22**	−0.02	**−0.45**	**0.13**	0.03
(4) PMC self-movement	**0.50**	**0.85**	**0.94**		0.04	**0.11**	−0.01	0.09	−0.02
(5) Frequency team sport	**0.20**	0.12	**0.53**	**0.21**		**−0.19**	**−0.35**	0.05	0.08
(6) Frequency individual sport	0.05	0.11	−0.05	**0.39**	**−0.21**		**0.18**	0.07	0.06
(7) Sex	**−0.36**	**0.20**	**−0.65**	0.10	**−0.30**	**0.17**		−0.05	−0.10
(8) Age	**0.56**	**0.52**	0.14	0.05	0.04	0.05	−0.04		**0.22**
(9) BMI	−0.08	**−0.21**	−0.09	−0.06	0.06	0.02	−0.08	**0.26**	

Correlations in bold are significant ($p < 0.05$). Latent correlations below the diagonal, manifest correlations above the diagonal; sex: 0 = boys, 1 = girls.

physical activity over time (Barnett et al., 2008), PMC in "object movement" should be promoted, especially in girls.

There are also some limitations in this study. As the children were interviewed in class, the possibility of mutual influence on the answers to the questions cannot be excluded. Although the test leader pointed out that the questions should be answered independently, a few children communicated their answers to the class. Another limitation is that the illustration shows the motor task in a simplified way. The operationalization into an illustration and a short instruction did not explain all the criteria for passing or failing the motor task. Regarding the item difficulty, ceiling effects could be observed, as the mean values in PMC were high, especially in PMC "self-movement." This could be due to the three-point-scale, as Estevan et al. (2019) mentioned this limitation also regarding the four-point-scale in the PMSC instrument. The high correlation between PMC "Object movement" und PMC "self-movement" ($r = 0.95$, $p < 0.001$) could also be due to these ceiling effects. It should be also considered that young children tend to overestimate their own abilities (Harter, 1999).

What should be considered in future studies is, that due to the study design, no retest for reliability analysis could be conducted. Because of the cross-sectional design of the study, no causal interpretations can be made. However, there is little evidence regarding the direction for preschool and primary school age children due to a lack of longitudinal studies (Dreiskämper et al., 2020). This might be due to the resources and time-consuming assessment of PMC in young children. With the SEMOK-1-2 instrument, the PMC of children can be assessed in a more efficient and economical way what might be an advantage for assessments in large samples.

Overall, it was found that the instrument is suitable for assessing PMC in first and second graders. The strength of the instrument is the economic assessment of PMC in a classroom setting facilitated by the illustrated motor tasks and the neutral gender and ethnic representation of the illustrations. Due to the illustration and the organization of questioning the children in their normal class setting the instrument can be used economically in a larger sample. Physical Education teachers could also use the instrument in class to identify children with low PMC and consequently encourage and support them to reflect on their PMC. These results are important for the diagnosis and identification of PMC to promote AMC and thus an active lifestyle.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of the University of Zurich. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

KB: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Conceptualization. AS: Writing – review & editing. HS: Data curation, Writing – review & editing. CH: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix B – Publication 2

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Article

Connection between Social Relationships and Basic Motor Competencies in Early Childhood

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Abstract: In preschool, children build new contacts and social relationships with other people. They learn to cooperate with their peers and communicate in groups. In addition to social relationships, basic motor competencies (in German: Motorische Basiskompetenzen (MOBAK)) are also seen as a central developmental goal in early childhood and are necessary for participation in the culture of sports and movement. The aim of this paper is to describe the connection between social relationships and basic motor competencies in early childhood. In this present study, the motor competencies of N = 548 preschool children (51% girls, M = 68.0 months, SD = 6.8) were tested in the competence areas of self-movement and object movement. The children's perceived social relationships were recorded from teacher and parent perspectives. The results clearly show a connection between social relationships and motor competencies in early childhood, with a stronger connection observed in boys. This finding is relevant both from a developmental and a health-oriented perspective, as it points to a link between physical and mental health, as well as technical and interdisciplinary competencies, in early childhood.

Keywords: preschool; kindergarten; sport; health; integration; fundamental movement skills; physical education

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1. Introduction

Preschoolers are seen as being at an important stage for physical, mental, and social development. In engaging with their environment, they constantly discover new connections, acquire new gross and fine motor skills, and build social relationships [1,2]. The development of motor competencies and social relationships with peers in early childhood is a core developmental task of this stage of life, whose mastery has a positive influence on children's mental and physical health [3,4].

In Switzerland, children from the age of four attend preschool, which is part of the mandatory schooling. There are cantonal and language-specific curricula that pursue the same goals in terms of physical and social development. The school career is divided into different stages. The first stage includes two years of preschool, as well as first and second grade. For all children, preschool is an expanded social environment with new tasks and challenges. Developmental goals are defined for subject-specific competencies, e.g., physical education (the pupils can balance on a narrow surface, e.g., walk along a long bench) [5]. In addition to subject-specific competencies, interdisciplinary competencies (e.g., interpersonal relationship skills and emotion regulation) should also be acquired in physical education [6]. Interdisciplinary competencies contribute to all health-related topics, such as well-being [7].

1.1. Social Interactions and Peer Relationships

Preschool plays an important role as a space for social interactions, as children between the ages of four and seven years spend a large part of the day there. The relationships children form in early childhood to their closest role models remain important during the preschool years and are supplemented by further role models. Some children go to a day nursery or play group before entering preschool and have already gained experience with other children in the absence of their parents. Other children experience themselves as independent and autonomous for the first time and learn to develop their own social strategies and to behave cooperatively and pro-socially toward their peers [8]. The social competencies they acquire are important for establishing and maintaining friendships in peer groups [9–11] and are related to executive functions such as cognitive flexibility [12]. Popular children participate more frequently in games, find resolutions to conflicts, and can agree on rules together [10]. For children who are rejected or neglected, in contrast, peer relationships can be a strain and can lead to problems resolving conflicts with peers, learning new skills, and coping with demands at school [13]. These children gain less social experience and are more rarely integrated into activities at and outside school.

1.2. Development of Motor Competencies

Preschoolers are at a stage of development in which they continually develop and extend their basic motor repertoire in contexts of social interactions (e.g., preschool, peer group, and sport groups) and differentiate it for use in different situations. Basic motor forms (e.g., throwing, jumping, running, and balancing) improve through regular practice. As children grow older, they learn and automate even more complex movement sequences [14] and can combine them with one another [15]. This forms the basis for the development in later childhood and adolescence of sport-specific motor skills, which constitute the basic techniques for individual sports (e.g., a power throw in handball) [16]. Within this connection, motor development is influenced by physical (e.g., body weight) and mental characteristics (e.g., self-assessed competency). Against this backdrop, childhood may be seen as a significant stage in the development of motor competencies [17].

Motor competencies that children need to participate in the culture of sports and movement are called basic motor competencies [18]. They guarantee a basic capacity to engage in sports and also form the basis for the development of higher competency levels required in specific, primarily extracurricular, fields of athletic activity [19]. For example, children can only participate in ball sports if they are sufficiently confident in controlling a ball.

Connections between physical activity and motor performance dispositions are increasingly becoming a topic of inquiry in the health sciences (for an overview, see [17]). Physical activity encourages motor development, whereas a low motor performance level can lead to lower physical activity [20]. A varied movement and sports behavior has a positive impact on physical health, fosters mental well-being, and contributes to social integration [21,22].

1.3. Peer Relationships and Motor Competencies

In preschool, friends are playmates who have similar interests and engage in similar activities. At this age, children mainly make friends with children of the same gender. Girls engage more frequently in cooperative forms of play, while boys engage more frequently in individual forms of play. With boys in particular, the circle of friends develops "competitive behavior" [23] and the resulting potential for conflict. Athletic ability plays a significant role in peer groups of boys [24].

Children with good motor performances are more popular and better-integrated into peer groups than those with poorer motor performances [25,26]. Low motor competencies can lead to negative interpersonal (problems with peers) and intrapersonal (low self-assessment) consequences at the psychosocial level, which, in turn, has an impact on mental

health in the form of a downward spiral, thus emphasizing the relationship between motor competence and metal health [27,28].

The connection between social relationships and motor development receives particularly little attention in preschoolers. As the majority of existing studies were conducted at the primary- and secondary-school levels, in the present study, we will shed light on the connection between friendships and motor competencies in early childhood. In doing so, we will examine the friendships of preschoolers as assessed by their parents and teachers. In addition, we will investigate potential gender differences.

2. Materials and Methods

In February/March 2020, we measured the basic motor competencies of preschoolers in the Swiss cantons Ticino and Nidwalden. In Switzerland, preschool is integrated into the school system as a two-year entrance stage for primary school. The educational and developmental goals of preschool, which is organized into homeroom and class lessons, are formulated in the curriculum Lehrplan 21 [5].

Parallel to this, we conducted a questionnaire among the children's parents or legal guardians and their teachers. In contrast to previous studies utilizing questionnaires among the children's classmates as a means of determining peer status, we measured the children's social integration and their interpersonal relationship skills via the assessments of their teachers and legal guardians.

Participation in the study was voluntary, and the legal guardians and teachers of the children concerned were informed about the study in advance. The legal guardians submitted written declarations of consent. The study was approved by the cantonal departments of education and the preschool principals.

Our study fully conforms to the Declaration of Helsinki. Ethical review and approval were partly waived for this study, as no medical parameters were collected in the study. As the study was conducted during regular physical education, the approval of the study was the responsibility of the cantonal school authorities. Therefore, the legal and school-relevant ethical requirements were approved by the Directorate of Education, Culture and Sport of the canton of Ticino (Repubblica e Cantone Ticino Dipartimento dell'educazione, della cultura e dello sport) and Cantonal School Authority of the canton of Nidwalden (Amt für Volksschulen und Sport) and the local school managements of the participating primary schools. The children and their parents were informed about the general purpose of the school project and the study, the voluntary nature of the participation, and the anonymous handling of the data. Furthermore, parents provided informed consent, and children assented to participate.

2.1. Sample

In total, we wrote to the parents or legal guardians of 956 preschoolers in the cantons of Ticino and Nidwalden, 701 of which (response rate: 73.3%) gave their written consent to participate in the study and sent back the parent questionnaire. In the present study, we admitted children in an age range of 55 to 80 months and were thus able to include N = 548 preschoolers (M = 68.0 months, SD = 6.8, 50.9% boys) from 52 classes (average class size, n = 10.5) and 16 preschools in the convenience sample. The subsample from Ticino contained 36 classes with n = 354 children (M = 66.5 months, SD = 6.5, 51.4% boys), and the subsample from Nidwalden contained 16 classes with n = 194 children (M = 70.7 months, SD = 6.4, 50.0% boys). In this total sample, we were able to collect data from n = 499 children (M = 68.1 months, SD = 6.9, 50.3% boys) on their basic motor competencies. In Switzerland, preschool classes are relatively small, with approximately 15 to 20 children per class. The low number of children per class is due to the exclusion of children without parental consent or children who were not present on the survey day. We received assessments from the teachers (M = 40.8 years, SD = 11.6, 95% female teachers) for n = 541 children (M = 68.0 months, SD = 6.8, 50.6% boys). We received assessments from

the parents (M = 37.1 years, SD = 8.2, 81% mothers) for n = 532 children (M = 68.0 months, SD = 6.8, 50.6% boys).

2.1.1. Test Instruments and Data Collection

Children: Basic Motor Competencies (In German: Motorische Basiskompetenzen (MOBAK))

To measure the basic motor competencies in the preschools, we used the MOBAK-KG test instrument, which enables curricular valid and age-specific measurements of the competencies in preschool physical education lessons [29]. The instrument measures the competency domains self-movement (4 items) and object movement (4 items) (Table 1; for details, see [29]) and contains the basic requirements emphasized explicitly in the field of sporting activity as the elementary learning goals of physical education (e.g., [5]). Each test item describes a standardized task with corresponding evaluation criteria. The children had two attempts to try to achieve the test item requirements (no trial run). The two single attempts were rated on a dichotomous scale (0 = failed, 1 = successful), and the individual results were added up to form the final item score (0 points = no successful attempts, 1 point = one successful attempt, 2 points = two successful attempts). The test items throwing and catching were an exception to this rule. In these cases the children had six attempts each, and the number of successful attempts was recorded. Afterwards, 0–2 successful attempts were scored as 0 points, 3–4 successful attempts as 1 point, and 5–6 successful attempts as 2 points. For each competency domain, it is possible to achieve a maximum sum value of eight points (for details, see [29]).

The validation study [30] succeeded in confirming the psychometric quality and the assignment of the test items into the two basic motor competencies of self-movement and object movement by means of confirmatory factor analyses (N = 403, Comparative Fit Index (CFI) = 0.98, Root Mean Square Error of Approximation (RMSEA) = 0.044 [30]).

Table 1. Description of the test items and their factor values (FV) in model 1. PIQ: perception of inclusion.

	Self-Movement [a] [29]	**FV**
Balancing	The child walks across an overturned long bench without stepping off the bench.	0.67
Rolling	The child performs a forward roll down an inclined mat and is able to land fluently in a standing position on his/her feet.	0.41
Jumping	The child continuously jumps a distance of 3.0 m on one foot, turns around, and jumps back 3.0 m on the other foot.	0.69
Running	The child runs forward along a corridor (0.6 m × 4.0 m) to a wall, touches it with his/her hand, and then runs back backwards.	0.67
	Object Movement [a] [29]	**FV**
Throwing	The child throws six juggling balls at a target of 1.1 m height at a distance of 1.5 m with overhead throws.	0.45
Catching	The tester drops a small basketball to the ground from a height of 1.5 m so that the ball bounces back up at least 1.1 m from the ground. The child catches the ball after it reaches the highest point.	0.75
Bouncing	The child bounces a small volleyball with both hands and catches it again without losing the ball.	0.71
Dribbling	The child dribbles a futsal ball through a marked corridor (2.8 m × 9.0 m) around two obstacles without stopping or losing the ball.	0.57
	Social Integration [b] **(from the Teacher's Perspective)** [31]	**FV**
PIQ 1	He/she has a lot of friends in his/her class.	0.81
PIQ 2	He/she gets along very well with his/her classmates.	0.70
PIQ 3	He/she feels alone in his/her class (-).	0.42
PIQ 4	He/she has very good relationships with his/her classmates.	0.48
	Interpersonal Relationship Skills [c] **(from the Parent's Perspective)** [32]	**FV**
KOMPIK 1	Your child plays with many different children (is not restricted to individual children).	0.65
KOMPIK 2	Your child is sought after as a playmate.	0.90
KOMPIK 3	Your child has close friendships with other children.	0.39
KOMPIK 4	Your child is important to other children, has influence in the group	0.69

Notes: KOMPIK: kompetenzen und interessen von kindern (in German); [a] 0 points, 1 point, 2 points; [b] 0 = strongly disagree, 1 = disagree, 2 = agree, and 3 = strongly agree, (-) = reversed coding; [c] 0 = disagree, 1 = somewhat disagree, 2 = somewhat agree, 3 = mostly agree, and 4 = agree.

The data were collected in classes during a regular 45-min lesson. The classes were split up into small groups of three to four children each and led through the eight test stations

by trained testers. The testers gave a standardized explanation and one demonstration of each test item.

Teachers: Social Integration (Perception of Inclusion (PIQ))

The children's social integration was measured via the assessment of their teachers. For this purpose, we used the corresponding subscale of the perception of inclusion (PIQ) questionnaire [31]. The teachers assessed the children individually via four items (Table 1) on a four-point scale. The teachers were sent a questionnaire for each child in advance, along with the information on the study. They were asked to complete it before the MOBAK testing and bring it with them on the day of the test. The internal consistency of the scale is satisfactory, with a Cronbach's alpha of 0.76.

Parents: Interpersonal Relationship Skills (In German: Kompetenzen und Interessen Von Kindern (KOMPIK))

The children's interpersonal relationship skills [32,33] were measured via four items (Table 1), which the parents responded to on a five-point scale in a questionnaire. Moreover, they were asked to provide the child's date of birth and gender. The parent questionnaire was handed out to the parents and collected again by the teachers in an envelope, along with the declaration of consent. The internal consistency of the scale is satisfactory, with a Cronbach's alpha of 0.75.

2.2. Data Analysis

The data editing and descriptive analyses were conducted with SPSS 25 (IBM Corp, Armonk, NY, USA) [34]. Influences of the multilevel structure (students from different classes) were tested with the help of interclass correlations (ICC). The multivariate analyses were calculated with Mplus 8.3 [35]. Three consecutive models were calculated.

Model 1: To test the factorial validity of the test instruments and calculate the latent correlations between the two MOBAK factors of self-movement and object movement, social integration, and interpersonal relationship skills, we calculated a four-factor confirmatory factor analysis.

Model 2: As the MOBAK factors in particular are closely associated with age [30], we integrated age in months into model 1 as a covariate.

Model 3: To test the differences between boys and girls, we calculated model 2 separately in a multigroup model for boys and girls. In doing so, we set the measurement model to be invariant between the genders (factorial invariance [36]) while allowing variations between the genders in the structural model.

In all models, we treated the MOBAK test items as ordinal-scaled data and the questionnaire items as interval-scaled data. Accordingly, we applied the means- and variance-adjusted weighted least squares (WLSMV) estimator, which allows for a robust estimation even of non-normally distributed data.

We considered the dependencies within the multilevel structure ($0.03 \leq ICC \leq 0.23$; Table 2) in all models by correcting the standard error with the "type = complex" function for nested datasets implemented in Mplus. The goodness of fit of the models was assessed with the help of the fit indices proposed in the literature [37]. Effect sizes were interpreted as small ($r > 0.10$, $\beta > 0.05$), medium ($r > 0.30$, $\beta > 0.25$), and large ($r > 0.50$, $\beta > 0.45$) [38,39].

Table 2. Descriptive sum values of the motor competency domains (0–8), social integration (0–12), and interpersonal relationship skills (0–16) by gender and age groups. ICC: interclass correlations.

Factors	Overall			Boys		Girls		55–67 Months		68–80 Months	
	M	95% CI	ICC	M	95% CI	M	95% CI	M	95% CI	M	95% CI
Self-movement	4.1	(3.9–4.3)	0.03	3.8	(3.5–4.1)	4.4	(4.1–4.7)	3.5	(3.2–3.8)	4.6	(4.3–4.8)
Object movement	4.2	(4.0–4.4)	0.13	4.7	(4.4–4.9)	3.8	(3.5–4.0)	3.1	(2.9–3.4)	5.1	(4.8–5.3)
Social integration	9.7	(9.6–9.9)	0.23	9.5	(9.3–9.7)	9.9	(9.7–10.2)	9.4	(9.2–9.7)	9.9	(9.7–10.2)
Relationship skills	11.0	(10.8–11.2)	0.06	10.9	(10.5–11.2)	11.1	(10.8–11.4)	10.5	(10.2–10.9)	11.3	(11.0–11.6)

Notes: M = Mean, 95% CI = 95% Confidence Interval.

The three data collection methods (MOBAK testing (n = 499 children), teacher surveys (n = 541 children), and parent surveys (n = 532 children)) led to missing values of an unsystematic nature (missing at random). For example, several children were sick when the MOBAK tests were conducted. On account of the age and gender distributions, however, it may be assumed that this did not lead to any biases in the overall sample (N = 548). Accordingly, we estimated the missing values via the full information maximum likelihood (FIML) algorithm. The FIML procedure is a conservative and well-established procedure in educational research. The FIML procedure prevents bias in the sample composition by preventing a reduction in the sample size [40].

3. Results

In a comparison between the age groups, older children showed much better performances in the basic motor competencies than younger children. Older children received better assessments on social integration and relationship skills. A consideration of the sum values (Table 2) shows that girls performed better on self-movement, while boys did better on object movement. Moreover, the teachers rated the girls as more socially integrated, while there were no significant gender differences with regards to the relationship skills assessed by the parents.

The calculated ICC values (Table 2) indicated that a significant portion of the total variances in object movement (13%) and in social integration (23%) as assessed by the teachers may be attributed to class membership, while class membership was less significant for self-movement and for interpersonal relationship skills as assessed by the parents.

Latent Structural Equation Models

Model 1: The four-factor confirmatory factor analysis to test for factorial validity achieved a good model fit (χ^2 =122.22; degrees of freedom (df) = 98; p = 0.049; CFI = 0.97; RMSEA = 0.021; N = 548). The individual factor values of the test items are listed in Table 1. This result confirmed the psychometric quality of the tests in this age group. The correlation between self-movement and object movement was r = 0.77 ($p < 0.001$) and, between social integration and interpersonal relationship skills, r = 0.21 ($p < 0.001$). The two motor competence areas were significantly correlated with social integration (self-movement: r = 0.20, $p < 0.01$ and object movement: r = 0.20, $p < 0.01$) and with interpersonal relationship skills (self-movement: r = 0.17, $p < 0.001$ and object movement: r = 0.20, $p < 0.001$).

Model 2: The four-factor confirmatory factor analyses with age as a covariate also achieved a good model fit (χ^2 =133.25; df = 110; p = 0.065; CFI = 0.971; RMSEA = 0.020; N = 548). Age showed clear correlations with the two basic motor competencies of self-movement and object movement. It showed weak correlations with social integration and interpersonal relationship skills.

When age was taken into account as a covariate, the partial intercorrelations between the latent factors were weaker but remained without exception at a significant level (Figure 1).

Model 3: Taking model 2 as a starting point, we tested for differences between boys and girls in a multigroup comparison. In doing so, we calculated the correlations between the latent factors, as well as with age as a covariate, for both genders separately. This multigroup model achieved a good fit (χ^2 = 255.14: girls: χ^2 =124.77, boys: χ^2 = 130.37, df = 244; p = 0.29; CFI = 0.987; RMSEA = 0.013; N = 548: girls = 279, boys = 269), demonstrating that the measurement models are invariant between the genders and, therefore, that no differential item functioning (DIF) is present (Table 3). Accordingly, gender comparisons are permissible at both the manifest and the latent levels.

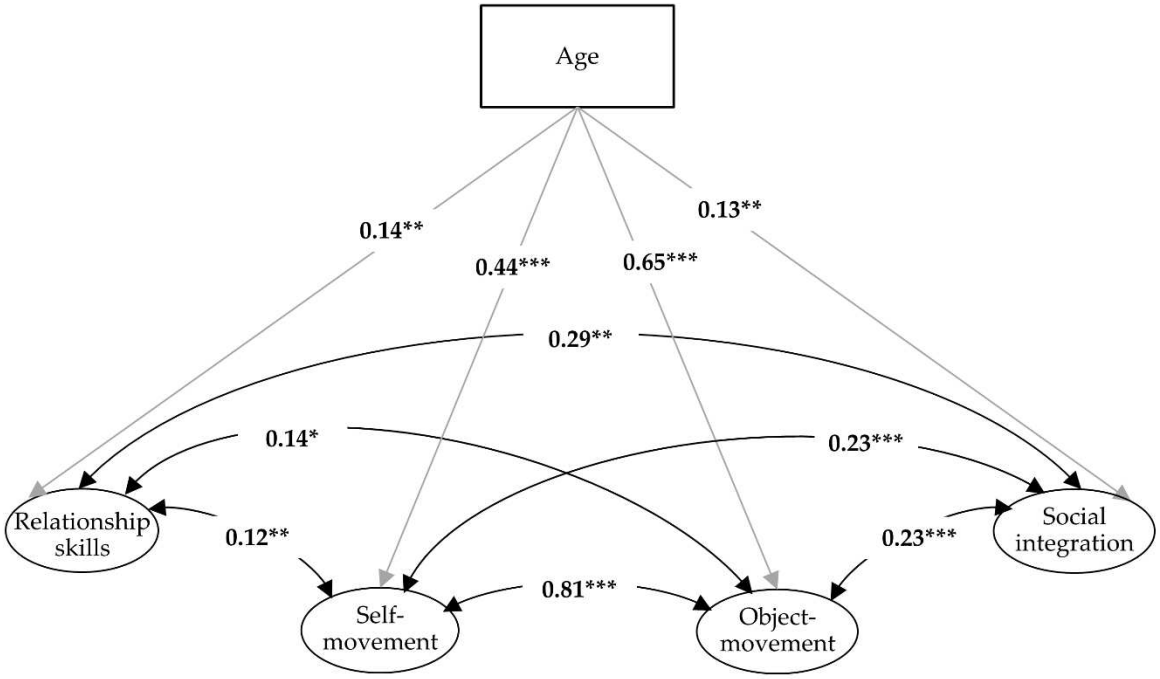

Figure 1. Four-factor confirmatory analyses with the covariate age (Model 2: * $p \leq 0.05$, ** $p \leq 0.01$, and *** $p < 0.001$).

Table 3. Intercorrelations between the latent factors and with age as a covariate (model 3).

Factors	Boys				Girls			
	(1)	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Self-movement	1				1			
Object movement	0.96 **	1			0.82 **	1		
Social integration	0.39 *	0.47 **	1		0.00	0.12	1	
Relationship skills	0.16 *	0.20 *	0.20 **	1	0.07	0.16	0.17 *	1
Age	0.44 *	0.71 **	0.12	0.13 *	0.43 **	0.64 **	0.15 **	0.15 *

Note: (1) Self-movement, (2) Object movement, (3) Social integration, (4) Relationship skills; * $p \leq 0.05$ and ** $p \leq 0.01$.

Table 3 shows that the correlation of the covariate age with the latent factors hardly differs between the genders. As already became clear in model 2, older children showed a higher level of motor performances and were assessed by their teachers and parents as being better socially integrated (cf. Table 2 and Figure 1).

By contrast, we did find gender-specific differences in the intercorrelations of the latent factors. The correlations between the basic motor competencies and social integration (as assessed by the teachers) or interpersonal relationship skills (as assessed by the parents) were only significant in the boys. The correlations of self-movement and object movement with social integration turned out to be high in the boys, at $r = 0.39$ ($p < 0.001$) and $r = 0.47$ ($p < 0.001$), respectively, whereas these correlations were not significant in the girls.

4. Discussion

The objective of the present study was to investigate the connection between basic motor competencies and social relationships in early childhood. To do so, we collected data on children's social relationships, both from the perspective of their parents and from the perspective of their preschool teachers, to obtain differentiated insights from various contexts.

The children already showed gender-specific differences in motor performance levels at the young ages of 4.5–6.5 years. Whereas the boys showed significantly better per-

formances on movements involving balls (object movement), the girls achieved better results on whole-body movements (self-movement) [30]. Moreover, the girls were assessed by the teachers as being better socially integrated than their male peers. As in previous studies [25,26], there were also significant correlations between the children's basic motor competencies and their social integration. Children with better motor competencies were assessed by their teachers and parents as being better socially integrated than children of the same age with poorer basic motor competencies. This correlation was more pronounced in the boys. This result can possibly be attributed to the relevance of athletic ability in peer relationships, especially among boys [24].

Since we did not directly interview the children regarding their social integration, biases by teachers or parents are possible. The girls were generally rated better in social relationships (see Table 2). These high values and the associated reduction in variance could explain the lower correlations. Whether the high ratings of the girls are partly due to the perceptions of the predominantly female teachers (95%) can unfortunately not be clarified at this point due to the lack of male teachers. However, the instruments for external assessment by parents (KOMPIK) and teachers (PIQ) are established and economical instruments. Correlations between the number of peer nominations and teachers' assessments have been demonstrated in various studies [31].

Due to the cross-sectional study design, however, it was not yet possible to identify the direction of causality. Accordingly, future longitudinal studies should focus on the extent to which a potential need for support in early childhood influences children's motor and mental developments. The current state of research provides indications that early experiences playing have an impact on children's later ability to integrate themselves into a community [41] and that persons with high motor competence are more likely to be able to participate in the culture of sports and movement during their lifespan and are, consequently, also more physically active than persons with low motor competence [19].

This also raises the pedagogical–didactic question of how to design a careful promotion of physical activity in preschool. Due to the intertwined nature of development and learning in early childhood, curricula like the Swiss Lehrplan 21 formulate a combination of subject-specific and general competencies as developmental goals of the first cycle [5]. In this way, great importance is attached to social actions in groups, which opens up diverse social interactions and takes into account the heterogeneous conditions and needs of individual children.

As for the teachers, their task is to implement a varied and age-appropriate promotion of basic motor competencies. In addition to targeted forms of play in which the children can make intensive and highly variable use of basic motor competencies in various learning environments, they need to develop competency-oriented tasks (learning tasks) that aim at cooperative problem solving and in which even children with poor motor competence can play an active and productive role [42]. The intention here is to prevent the exclusion of these children and, at the same time, to create a situation in which those children experience the joy of movement and take the opportunity to improve their motor competence without feeling ashamed. In this context, extracurricular measures should also be examined and developed, such as the design of schoolyards that promote physical activity or the organization of extracurricular sports-oriented activities that can, among other things, provide a meaningful rhythm to everyday school life.

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Institutional Review Board Statement: Our study fully conforms to the Declaration of Helsinki. Ethical review and approval were partly waived for this study, as no medical parameters were collected in the study. As the study was conducted during regular physical education, the approval of the study was the responsibility of the cantonal school authorities. Therefore, the legal and school-relevant ethical requirements were approved by the Directorate of Education, Culture and Sport of the canton of Ticino (Repubblica e Cantone Ticino Dipartimento dell'educazione, della cultura e dello sport) and Cantonal School Authority of the canton of Nidwalden (Amt für Volksschulen und Sport) and the local school managements of the participating primary schools.

Informed Consent Statement: The children and their parents were informed about the general purpose of the school project and the study, the voluntary nature of the participation, and the anonymous handling of the data. Furthermore, parents provided informed consent, and children assented to participate.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical guidelines of the Cantonal School Authorities.

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Appendix C – Publication 3

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Article

Basic Motor Competencies of (Pre)School Children: The Role of Social Integration and Health-Related Quality of Life

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Abstract: In (pre)school, children acquire and deepen their basic motor competencies (BMCs) and interact with peers and friends. BMCs are a central developmental goal in childhood and the prerequisite for participation in sportive aspects of social life. Both motor competencies and social integration are linked to children's health-related quality of life (HRQoL). The aim of the present study was to describe the connection between BMCs, social relationships, and aspects of HRQoL in (pre)school children. In this study, the BMCs of N = 1163 preschool children (M = 5.7 years, SD = 0.57, 52% boys) and N = 880 first and second graders (M = 7.5 years, SD = 0.58, 51% boys) were tested. The children's social integration was assessed by the teachers; the HRQoL was recorded from the parents' perspective. In both preschool and primary school, children with better BMCs also showed higher values in their social integration. Moreover, the results indicated a connection between BMCs and general HRQoL in primary school and BMCs and physical well-being in preschool. As BMCs, social integration, and HRQoL seem to be connected in (pre)school, this should be considered both from developmental and health-oriented perspectives, as well as for physical education (PE) lessons.

Keywords: kindergarten; sport; health; motor skills; physical education; well-being

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1. Introduction

Throughout childhood, children develop and extend their basic motor repertoire in contexts of social interaction (e.g., (pre)school, interactions with peers, sport clubs). Basic motor competencies (BMCs) are necessary for participation in the culture of sport and exercise [1,2]. They facilitate a basic capacity for the development of higher competency levels and further participation in sports and exercise [2]. BMCs are also the prerequisite for acquisition of sport-specific motor skills and positively influence a physically active lifestyle over an individual's lifespan [2]. BMCs further lead to the development of a large repertoire of movement skills [3]. This process is strongly influenced by opportunities for practice [4]. Preschools and primary schools should offer situations in which children can extend their BMCs [5]. Physical education (PE) classes with various movement situations are particularly suitable, as all children participate in them in contrast to extracurricular activities. The development of BMCs is a core development task in preschool and primary school and is also addressed in PE curricula [5].

For all children, school is an expanded social environment with new tasks and challenges [6]. Interpersonal relationship skills are addressed in the curricula and defined as a central life skill by the World Health Organization (WHO) [6,7]. Interpersonal relationship skills help children to relate to the people around them in a positive way. Moreover, they are acquired in contexts involving social interaction and are important for making friends

and getting involved in peer groups [6,8]. Social interactions and peer relationships are central to healthy child development [9,10]. Friendships are associated with a variety of positive psychological and behavioral outcomes for children, which continue into early adulthood [11]. Children choose friends and peers by participating in similar activities (e.g., sports, music, art) or interacting with those who behave similarly [12]. In early childhood, children are more likely to choose same-gender friendships and different genders show different play behavior, which can already be observed at preschool age [13]. While boys more often engage in physically active games, girls desire friendly closeness and cohesion more than boys [13]. Girls exert a lot of effort establishing and maintaining positive social relationships and spend time in smaller groups with closer friends [12,14].

In order to ensure adequate learning opportunities for every child, it is important to promote social integration in the class in addition to subject-specific competencies in PE [15]. This is particularly important in the context of sport and play situations, as this can only happen in the interplay between BMCs and social integration [9].

Positive associations between BMCs and social relationships have been found in preschool-aged children [16]. In addition, 9 to 12 year old children with poorer motor competencies have been found to be less preferred by their peers in both play and classroom settings [17]. Children with developmental coordination disorder, in particular, have been found to be less socially integrated and more likely to experience exclusion in class [18].

Integration with peers and interactions with friends are highly important for children's quality of life, as well as their well-being [19]. Health-related quality of life (HRQoL) is a multidimensional and complex construct described as an individual's perception of his or her position in life [20]. It includes physical, emotional, mental, social, and behavioral components of well-being and functioning from the subjective perspective [20]. The assessment of HRQoL in children has increasingly become the focus of health research [21]. An assessment of HRQoL can be used to identify subgroups or individuals who are at higher risk of health problems [22]. Therefore, HRQoL is especially examined in children with special needs or diseases, such as developmental coordination disorder or chronic illness [23,24].

Both BMCs and social integration have a positive influence on children's mental and physical health [25,26]. Studies investigating the determinants of HRQoL in (pre)school children show that children with higher motor competencies have better HRQoL levels [24,26–28]. Moreover, children with low motor competencies show a higher risk of negative interpersonal (peer problems) and intrapersonal (low self-assessment) consequences at the psychosocial level, which can result in worse mental health and well-being [18,29,30]. Integration with peers and interactions with friends are highly important for quality of life, as positive relationships with friends have a strong effect on children's subjective well-being [25,28].

However, little research has been conducted on the connections between (basic) motor competencies, social integration, and HRQoL in children, especially in preschoolers [26,31]. As previous studies have investigated the relationship between motor competencies and HRQoL mainly in children with DCD or special needs, there is a need to investigate this relationship in normally developing children as well. What should be taken into account in particular is the idea of participation, especially in PE. The aim of this study was to investigate the relationship between BMCs, social integration, and HRQoL in children in their first years of (pre)school.

2. Materials and Methods

The present study was a cross-sectional study based on the first measurement point for a longitudinal research project, funded by the Zurich University of Teacher Education and Health Promotion Switzerland (Gesundheitsförderung Schweiz, GFCH) and utilized convenience sampling. Although it was not a representative sample for Switzerland, we ensured that all three language regions, as well as urban and rural areas, were equally represented in the sample. In spring and summer 2021, we measured the BMCs of preschoolers

(4–6 years) and children from the first and second grades (6–8 years) in the German-, Italian-, and French-speaking parts of Switzerland. Preschool in Switzerland is part of mandatory schooling and includes a two-year entrance stage for primary school.

2.1. Participants

In total, we contacted the parents or legal guardians of 1840 preschoolers and 1163 children from the first two years of primary school in the German-, Italian-, and French-speaking parts of Switzerland. For preschoolers, 1334 parents (72.5%) gave their written consent for their children to participate in the study and sent back the questionnaire. Inclusion criteria were the presence of consent for the assessment of the BMC test and the parent questionnaire. Age ranges were formed based on the dates of entry to preschool (55–80 months) and primary school (77–105 months) in order to exclude much younger and older children from the study. We were thus able to include 1163 preschoolers (M = 5.7 years, SD = 0.57, 52% boys) from 95 classes (average class size, n = 13). In the first and second grades of primary school, 901 parents (77.5%) agreed to their children's participation in the study. We included 880 (M = 7.5 years, SD = 0.58, 51% boys) children from the first and second grades from 64 classes in the study (average class size, n = 14). We received assessments from the teachers (M = 39.7 years, SD = 10.2, 90% female teachers) and the parents (M = 38.5 years, SD = 5.9, 76% female).

2.2. Test Instruments and Data Collection

- Basic motor competencies (BMCs; children tests):

To measure BMCs, we used the MOBAK test instruments for preschool (MOBAK-KG) and the first two years of primary school (MOBAK-1-2). The MOBAK instrument is a curriculum-valid instrument that measures the level of BMC and can be used easily in PE lessons [1,32]. Moreover, it is oriented toward the elementary learning goals of PE (e.g., [5]). The BMCs in the two competence areas of self-movement and object movement (Table 1; for details, see [1,32]) are measured via four items each. A standardized task with corresponding evaluation criteria is described per item. The children performed two trials per test item (six trials for the throwing and catching items). Both attempts were rated dichotomously (0 = fail, 1 = successful). The individual results per test item were summed up to calculate the final item score (0 points = no successful attempts, 1 point = one successful attempt, 2 points = two successful attempts). The throwing and catching scores were calculated differently. In these cases, 0–2 successful attempts were scored as 0 points, 3–4 successful attempts as 1 point, and 5–6 successful attempts as 2 points. For each competency domain, a maximum sum score of eight points could be achieved (for details, see [1,32]). The data collection took 30–40 min and was carried out during a regular PE lesson of 45 min duration. The classes were split up and an examiner led three to four children through the eight test stations and gave a standardized explanation and one demonstration of each test item.

Table 1. Descriptions of the test items (see Herrmann, 2018 (p. 15) and 2020 (p. 8–9) [1,32]). Note: 0 = no attempt completed, 1 = task completed once, 2 = task completed twice.

	MOBAK-KG	MOBAK-1-2
	Object movement	
Throwing	The child throws six juggling balls at a target of 1.1 m height from a distance of 1.5 m with overhead throws.	The child throws six juggling balls at a target of 1.3 m height from a distance of 2.0 m.
Catching	The tester drops a small basketball to the ground from a height of 1.5 m so that the ball bounces back up at least 1.1 m from the ground. The child catches the ball after it has reached the highest point.	The tester drops a small ball to the ground from a height of 2.0 m so that the ball bounces back up at least 1.3 m from the ground. The child catches the ball after it has reached the highest point.

Table 1. *Cont.*

	MOBAK-KG	MOBAK-1-2
Bouncing	The child bounces a small volleyball with both hands and catches it again without losing the ball.	The child bounces a small basketball through a marked corridor (5.0 × 1.0 m) without losing the ball.
Dribbling	The child dribbles a futsal ball through a marked corridor (2.8 × 9.0 m) around two obstacles without stopping or losing the ball.	The child dribbles a futsal ball through a marked corridor (5.0 × 1.0 m) without losing the ball.
	Self-movement	
Balancing	The child walks across an overturned long bench without stepping off the bench.	The child walks across an overturned see-sawing long bench without stepping off the bench.
Rolling	The child performs a forward roll down an inclined mat and is able to land fluently in a standing position on his/her feet.	The child performs a forward roll on a mat and is able to land fluently in a standing position on his/her feet.
Jumping	The child jumps a distance of 3.0 m on one foot, turns around, and jumps back 3.0 m on the other foot.	The child jumps between and beneath carpet tiles fluently with one leg between the tiles and with straddled legs beneath the tiles.
Running	The child runs forward along a corridor (0.6 m × 4.0 m) to a wall, touches it with his/her hand, and then runs back backwards.	The child moves sideways from one cone to another placed at a distance of 3 m from each other.

The factorial validity of the MOBAK instruments for preschool and primary education has already been investigated and confirmed in various studies (e.g., [33,34]).

- Social integration (PIQ; teacher questionnaires):

The teachers measured the children's social integration using the subscale of the perception of inclusion (PIQ) questionnaire [15]. The teachers rated the children individually via four items (e.g., "He/she gets along very well with his/her classmates.") on a four-point scale. The teachers received the questionnaire for each child in advance along with the information on the study. We asked the teachers to complete the questionnaire and bring it with them on the day of the MOBAK test. The Cronbach's alpha of the scale was calculated for preschool (0.82) and primary school (0.83) and showed satisfactory internal consistency [35]. The factorial validity of the instrument was confirmed in a validation study by Venetz and colleagues. [15].

- General health-related quality of life (general HRQoL; parent questionnaires):

The low reading literacy of children, especially in early childhood, has led to the development of instruments that measure children's HRQoL via parental assessments [36]. General health-related quality of life (HRQoL) was measured via the KIDSCREEN-10 instrument [36,37] in a subsample of N = 943 preschool children and the total sample of N = 880 primary school children (subsample 1), with a short version used in one canton due to the construction of the questionnaire. This instrument contains ten items (e.g., "Has your child felt sad?") and provides a valid measure of a general HRQoL factor. Moreover, the parents filled out the children's date of birth and gender. The parents received the questionnaire along with the declaration of consent, both of which were collected by the teachers. The internal consistency of the KIDSCREEN-10 instrument was acceptable, with a Cronbach's alpha of 0.73 for preschool and 0.76 for primary school (overall 0.74) [35]. For the analyses, the sum score (10–50) was transformed into the t-value (mean: 50, standard deviation: 10). Higher values indicate a higher general HRQoL [36,37].

- Physical well-being (parent questionnaires):

In a subsample of N = 348 preschool children (subsample 2), the physical well-being subscale of the KIDSCREEN-27 instrument [36] was used exploratively. The subscale consists of five items (e.g., "Has your child felt fit and well?") and had an acceptable Cronbach's alpha of 0.71. For the analyses, the sum score (5–23) was transformed into the t-value (mean: 50, standard deviation: 10). Higher values indicate higher physical well-being [37].

2.3. Data Analysis

SPSS 28 was employed for the data editing, descriptive statistics, t-tests, and Cronbach's alpha estimations [38]. Descriptive statistics were calculated for all variables. T-tests were used to calculate differences between boys and girls in the variables of interest. In addition to the 95% confidence intervals, Cohen's d was calculated to examine the strength of the differences. Therefore, effect sizes were interpreted following Cohen (1988) as small (d = 0.10), medium (d = 0.50), and large (d = 0.80) [39]. We used Mplus 8.4 to perform multivariate analyses [40]. We calculated interclass correlations (ICCs) to test the influences of the multilevel structure (pupils from different classes) due to class associations. A high ICC value means that there are large differences between classes for the corresponding characteristics, the cause of which is to be sought at the class level (e.g., class composition). Raudenbush and Bryk (2002) recommend accounting for the multi-level structure of the data for advanced analyses with ICCs > 0.05 [41].

Model 1: In this first model, we used structural equation models to examine the relationships between the two MOBAK factors self-movement and object movement, social integration, and general HRQoL, with age as a covariate. Self-movement and object movement, as well as social integration, were included as latent factors.

Following Ravens-Sieberer and colleagues, we summed up general HRQoL, transformed it into the t-value, and included it as a manifest variable in the model [37] (Figure 1). This model was separately examined for both age groups of interest (MOBAK-KG, model 1a; MOBAK-1-2, model 1b). Since KIDSCREEN-10 was not used (in its entirety) at all study locations, model 1 was calculated for a subsample of N = 943 preschool children and N = 880 primary school children (subsample 1).

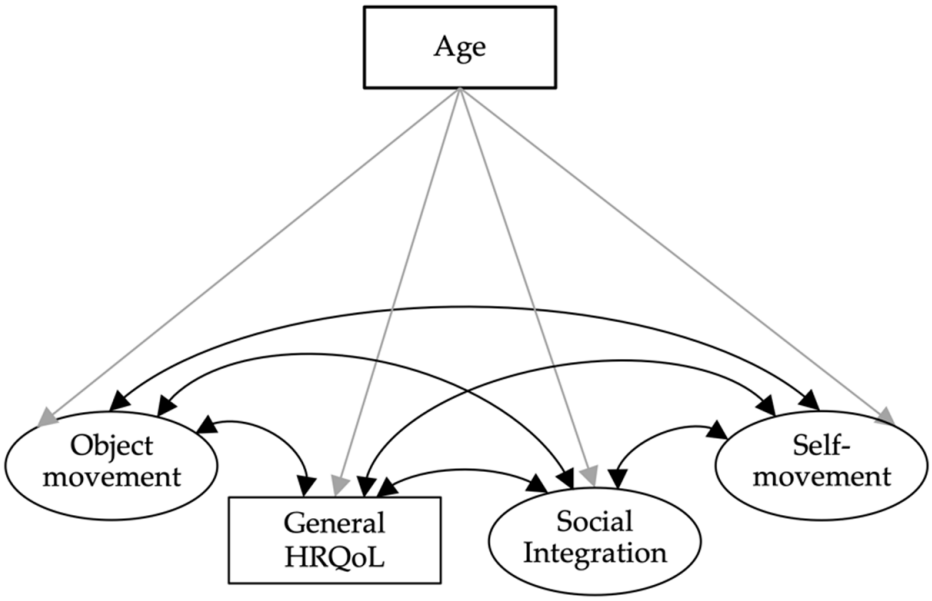

Figure 1. Model 1. Structural equation model with object movement, self-movement, general HRQoL, and social integration with the covariate age.

Model 2: Next, we re-calculated model 1 as a multigroup model to investigate the correlations between the model components separately for boys and girls. This allowed for a model test for boys and girls. All parameters were estimated freely. Only the factor structure was kept equal between boys and girls [42–44]. This served to ensure that the factor structure (numbers and types of latent factors and loadings) was the same for boys and girls. We calculated model 2 separately for both MOBAK-KG (model 2a) and MOBAK-1-2 (model 2b).

Model 3: In a subsample of N = 384 preschool children (subsample 2), we used the physical well-being subscale of the KIDSCREEN-27 instrument (5 items [36]) to assess the children's physical well-being from the parents' perspective. The sum score of the five

items was t-transformed into a manifest variable. We used structural equation models to calculate the relationship between the latent factors self-movement, object movement, and social integration and the manifest variable physical well-being. Age was included as a covariate (Figure 2).

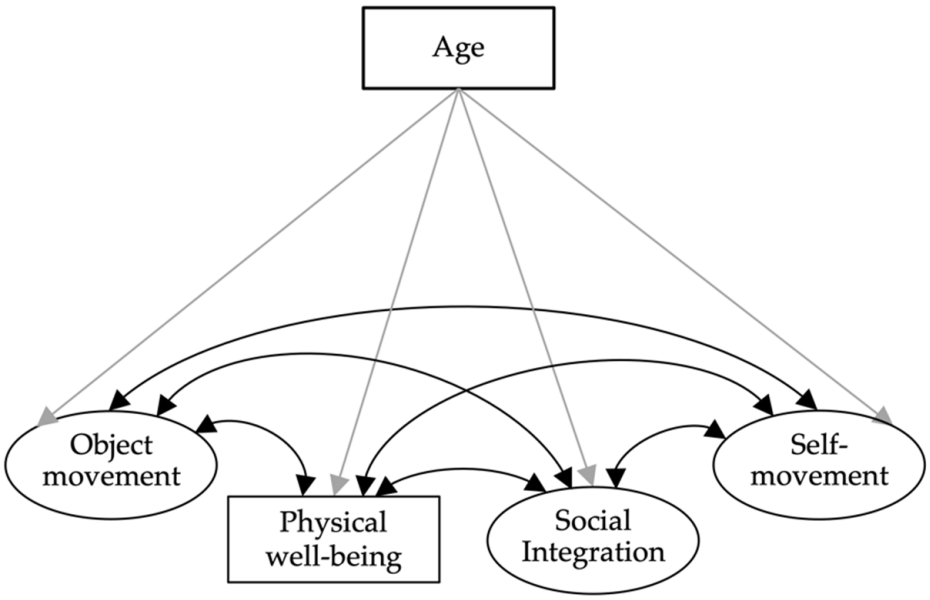

Figure 2. Model 3. Structural equation model showing object movement, self-movement, physical well-being, and social integration with the covariate age.

Model 4: We then re-calculated model 3 as a multigroup model for boys and girls. We examined the configural invariance in a multiple group model. This allowed for a model test for boys and girls simultaneously.

In all models, we treated the MOBAK test items as ordinal-scaled and the questionnaire items as interval-scaled data. Accordingly, we applied the mean- and variance-adjusted weighted least squares (WLSMV) estimator.

The "type = complex" function for nested datasets implemented in Mplus was needed to correct the standard error and ensure that dependencies within the multilevel structure ($0.01 \leq ICC \leq 0.19$; Table 2) were accounted for in all model estimations [41]. The goodness of fit of the models was assessed using fit indices proposed in the literature [45]. Effect sizes were interpreted as small ($r > 0.10$, $\beta > 0.05$), medium ($r > 0.30$, $\beta > 0.25$), and large ($r > 0.50$, $\beta > 0.45$) [39,46].

Table 2. Descriptive analyses of sum scores of the motor competency domains, social integration, general HRQoL, and physical well-being.

	Preschool					Primary School				
	Overall		Boys	Girls		Overall		Boys	Girls	
	M [95% CI]	ICC	M [95% CI]	M [95% CI]	d	M [95% CI]	ICC	M [95% CI]	M [95% CI]	d
Object movement [a]	4.0 [3.8; 4.1]	0.02	4.4 [4.2; 4.5]	3.5 [3.4; 3.7]	0.42	5.5 [5.4; 5.6]	0.12	5.9 [5.7; 6.0]	5.1 [5.0; 5.3]	0.43
Self-movement [a]	4.5 [4.4; 4.7]	0.05	4.3 [4.1; 4.5]	4.8 [4.6; 5.0]	0.21	4.9 [4.8; 5.1]	0.14	4.8 [4.6; 5.0]	5.1 [4.9; 5.3]	0.14
Social integration [a]	13.5 [13.4; 13.7]	0.19	13.4 [13.2; 13.5]	13.7 [13.6; 13.9]	0.17	13.7 [13.6; 13.8]	0.25	13.5 [13.3; 13.8]	13.9 [13.7; 14.1]	0.15
General HRQoL sum score [b]	41.5 [41.2; 41.7]	0.04	41.4 [41.1; 41.8]	41.5 [41.1; 41.8]	0.004	41.2 [40.9; 41.5]	0.03	40.8 [40.4; 41.2]	41.5 [41.2; 41.9]	0.18
General HRQoL *t*-value [1,b]	51.9 [51.4; 52.4]	0.02	51.8 [51.1; 52.5]	51.9 [51.2; 52.7]	0.02	51.7 [51.1; 52.2]	0.02	51.1 [50.3; 51.8]	52.3 [51.5; 53.1]	0.15

Table 2. *Cont.*

	Preschool					Primary School		
	Overall		Boys	Girls		Overall	Boys	Girls
Physical well-being sum score [c]	21.9 [21.7; 22.2]	0.04	22.3 [21.9; 22.6]	21.6 [21.1; 22.0]	0.27			
Physical well-being *t*-value [1,c]	53.2 [52.6; 53.8]	0.003	54.1 [53.3; 54.8]	52.2 [51.3; 53.1]	0.33			

Note: M = mean, 95% CI = 95% confidence interval. Point ranges: object movement (0–8), self-movement (0–8), social integration (5–20), KIDSCREEN-10 sum score (10–50), KIDSCREEN physical well-being (5–25). [1] The sum score (range: 10–50) was transformed into t-values (mean: 50, standard deviation: 10). Higher values indicate better general health-related quality of life or physical well-being [37]. [a] Complete sample (preschool: N = 1163, primary school N = 880), [b] subsample 1 (preschool: N = 943, primary school N = 880), [c] subsample 2 (preschool: N = 384).

We accounted for missing values by generating model estimates using the full information maximum likelihood (FIML) procedure. This procedure prevents bias in the sample composition by preventing a reduction in the sample size [47].

3. Results

As the descriptive analyses (Table 2) show, there were already gender-specific differences in motor performance levels. Girls were better in self-movement, while boys performed better in object movement. Girls were rated as more socially integrated by their teachers in both preschool and primary school. In preschool, there were no gender differences regarding general HRQoL, whereas boys showed higher physical well-being than girls. In primary school, general HRQoL was higher in girls than in boys. The ICC values for BMCs, general HRQoL, and physical well-being were low (ICC < 0.05). The ICC value for social integration was 0.19. This means that there were large differences between the classes due to the assessment of social integration by the teacher at the class level.

Latent Structural Equation Models

Model 1: Both model 1a (preschool) and model 1b (primary school) fit the data well (Table 3).

Table 3. Data fit of the calculated models.

Model	Analysis	Sample	*n*	χ^2	*df*	*p*	CFI	RMSEA
1a	MIMIC	SS 1 preschool	943	115.947	69	<0.001	0.961	0.027
1b	MIMIC	SS 1 primary school	880	92.865	69	0.029	0.967	0.020
2a	MGM	SS 1 preschool	943	201.069	160	0.015	0.971	0.023
2b	MGM	SS 1 primary school	880	180.123	160	0.132	0.977	0.017
3	MIMIC	SS 2 preschool	384	88.459	69	0.057	0.962	0.027
4	MGM	SS 2 preschool	384	175.645	160	0.188	0.971	0.023

Note: CFI = comparative fit index; RMSEA = root mean square error of approximation; MIMIC = structural equation model with covariate age; MGM = multigroup model; SS = subsample.

Table 4 shows that the associations of the latent constructs of BMC and social integration with general HRQoL differed between preschool and primary school children. A positive small to moderate association between children's BMCs and their social integration (assessed by the teachers) was found in both preschool and primary school. In preschool, no correlations were found between general HRQoL (assessed by the parents) and BMCs or between general HRQoL and social integration.

Table 4. Intercorrelations between variables in model 1 (subsample 1).

Factors	Preschool (Model 1a)				Primary School (Model 1b)			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
(1) Object movement								
(2) Self-movement	0.74 ***				0.56 ***			
(3) Social integration	0.27 ***	0.26 ***			0.22 ***	0.18 **		
(4) General HRQoL	0.01	0.04	0.04		0.003	0.14 **	0.13 ***	
(5) Age	0.59 ***	0.47 ***	0.15 ***	−0.01	0.49 ***	0.33 ***	0.10	<0.01

Note: (1) object movement, (2) self-movement, (3) social integration, (4) general HRQoL. ** $p < 0.01$, *** $p < 0.001$.

In primary school, positive significant associations were found between general HRQoL and self-movement ($r = 0.14$, $p = 0.005$), as well as general HRQoL and social integration ($r = 0.13$, $p < 0.001$), whereas no correlations were found between general HRQoL and object movement. The results show that children who were better with self-movement and children who were better socially integrated obtained higher values for general HRQoL. The correlations with age show that older children had better BMCs and seemed to be better socially integrated than younger children. No correlation with age was found for general HRQoL.

Model 2: Taking model 1 as a starting point, the correlations between the latent factors, as well as with age as a covariate, were calculated for both genders separately in a multigroup model (Table 5). This model achieved a good fit for preschool (model 2a, Table 3) and primary school (model 2b, Table 3). Deviation estimates for boys and girls appeared to be comparable in preschool (boys: $\chi^2 = 106.924$, $n = 484$; girls: $\chi^2 = 94.146$, $n = 459$) and within primary school (boys: $\chi^2 = 62.191$, $n = 450$; girls: $\chi^2 = 117.932$, $n = 430$).

Table 5. Intercorrelations between the variables in model 2 (subsample 1).

Factors	Preschool (Model 2a)					Primary School (Model 2b)				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
(1) Object movement		0.85 ***	0.34 ***	−0.01	0.53 ***		0.64 ***	0.21 **	0.11	0.44 ***
(2) Self-movement	0.84 ***		0.22 *	0.01	0.44 ***	0.68 ***		0.12	0.12	0.26 ***
(3) Social integration	0.26 ***	0.27 ***		0.07	0.15 ***	0.32 ***	0.24 **		0.16 **	0.09
(4) General HRQoL	0.06	0.05	0.01		−0.02	−0.03	0.18 **	0.10		−0.001
(5) Age	0.71 ***	0.52 ***	0.15 ***	−0.02		0.58 ***	0.44 ***	0.10	−0.001	

Note: (1) object movement, (2) self-movement, (3) social integration, (4) general HRQoL. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Girls below the diagonal, boys above the diagonal

In model 2, the results were similar for boys and girls. Boys and girls with better BMCs were rated higher for their social integration by their teachers in both preschool and primary school. Regarding general HRQoL, there were no associations with BMCs or social integration for either boys or girls in preschool. For primary school, significant relationships with general HRQoL, as assessed by the parents, were only found for self-movement among girls ($r = 0.18$, $p = 0.007$) and social integration among boys ($r = 0.16$, $p = 0.004$). The finding that age was positively associated with BMCs and social integration was evident for girls and boys.

Model 3: The structural equation model with object movement, self-movement, social integration, and the subscale physical well-being (t-value of subscale sum score) achieved a good model fit (Table 3). A high correlation between object movement and self-movement was found ($r = 0.79$, $p < 0.001$). As already became clear from model 1 and model 2, older children showed higher BMCs and were assessed as being better socially integrated. Moreover social integration was significantly correlated with object movement ($r = 0.29$, $p < 0.001$) and self-movement ($r = 0.40$, $p < 0.001$). No significant correlation was found between social integration and physical well-being. The BMCs of the children were positively

correlated with both object movement ($r = 0.20$, $p = 0.004$) and self-movement ($r = 0.29$, $p < 0.001$) (Table 6).

Table 6. Intercorrelations between the variables in model 3 (subsample 2).

Factors	(1)	(2)	(3)	(4)
(1) Object movement				
(2) Self-movement	0.79 ***			
(3) Social integration	0.29 ***	0.40 ***		
(4) Physical well-being	0.20 **	0.29 ***	0.07	
(5) Age	0.54 ***	0.39 ***	0.17 **	−0.04

Note: (1) object movement, (2) self-movement, (3) social integration, (4) physical well-being. ** $p < 0.01$, *** $p < 0.001$.

Model 4: Taking model 3 as a starting point, the correlations between the factors, as well as with age as a covariate, were calculated for both genders separately. This multigroup model achieved a good fit (Table 3). Separate deviation estimates were $\chi^2 = 67.209$, $n = 198$ for boys and $\chi^2 = 108.436$, $n = 186$ for girls. For both genders, the children's social integration, as assessed by their teachers, was moderately related to BMCs. Correlations with BMCs could also be found for physical well-being. Both boys and girls showed high correlations between self-movement and physical well-being ($r = 0.35/0.34$, $p < 0.001$). In the competency domain of object movement, a significant correlation was only observed for boys ($r = 0.21$, $p = 0.009$). No significant correlation was found between physical well-being and social integration (Table 7).

Table 7. Intercorrelations between the variables in model 4 (subsample 2).

Factors	Boys				Girls			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
(1) Object movement								
(2) Self-movement	0.83 ***				0.88 ***			
(3) Social integration	0.40 ***	0.26 **			0.24 **	0.48 ***		
(4) Physical well-being	0.21 **	0.35 ***	0.05		0.15	0.34 **	0.18	
(5) Age	0.45 ***	0.29 ***	0.19 ***	−0.05	0.68 ***	0.58 ***	0.20 ***	−0.04

(1) Object movement, (2) self-movement, (3) social integration, (4) physical well-being. ** $p < 0.01$, *** $p < 0.001$.

4. Discussion

The objective of the present study was to investigate the relationship between BMCs, social integration, and health-related quality of life in (pre)school children. The results of this study support earlier findings that children with poor BMCs are less integrated socially and show poorer general HRQoL in primary school and physical well-being in preschool.

Moreover, girls' general HRQoL was rated higher than boys' general HRQoL in primary school, whereas there were no gender differences in preschool. Physical well-being, on the other hand, was rated higher for boys than for girls. Differences in HRQoL between age and gender have only previously been studied from eight years onwards [48].

The findings of this study are consistent with previous studies indicating that children with lower motor competencies show lower HRQoL and are less integrated socially [16,26]. The relationship between motor competence and HRQoL has mostly been investigated in children with developmental coordination disorder, as these children are more likely to have psychological issues, which may result from poor social skills or decreased quality of life [18,24,49,50]. Moreover, children with DCD show lower scores in HRQoL than typically developing children [24]. Redondo-Tébar and colleagues (2021) studied the relationship between motor competence and HRQoL in a sample of typically developing children and found a positive association between HRQoL and motor competence [26]. In contrast to previous studies in which motor competence instruments were used in a clinical context

(e.g., MABC-2 [24]), our study used curriculum-valid instruments that examine BMCs in self-movement and object movement.

Children with better BMCs seemed to be better integrated in both preschool and primary school, although this correlation was higher in preschool. This could have been due to the fact that activities other than play and sports become more important for friendships in primary school. From primary school onwards, extracurricular activities, such as musical or artistic activities, are increasingly offered, and these activities could become more important for friendships with increasing age. The increasing importance of academic achievement in school could also be a reason for the lower correlations.

Differences in the association between BMCs and general HRQoL were found between preschool and primary school. Whereas no correlations between BMCs and general HRQoL were found in preschool, primary school children with better performance in self-movement also showed higher values in general HRQoL. No connection with object movement was found. It is possible that general HRQoL in preschool is more strongly influenced by other factors, such as family factors (e.g., parents, siblings). Moreover, it could be that BMC is related to general HRQoL in more informal play settings (e.g., outside, with friends or siblings).

Due to the fact that motor competencies may be important for children's physical well-being, we additionally used the physical well-being subscale of KIDSCREEN-27 in a subsample of N = 384 preschool children [26,36]. Physical well-being was higher in children with better BMCs, with a stronger association for self-movement than for object movement. The results indicate a significant relationship between BMCs and physical well-being, which has already been demonstrated in other studies [26,50].

Social integration and interaction with friends and peers are important factors for children's well-being, since popularity, mutual friendships, and engagement in social play are positively associated with children's quality of life [19,28]. In the present study, primary school children who were assessed to be better integrated socially also showed higher values in general HRQoL, although the association was stronger in boys. In accordance with previous studies, it appears that children who seem to be better socially integrated show higher general HRQoL.

One strength of the study was that the investigated constructs (BMCs (motor competence test [1,32]), social integration (teacher perspective [15]), and general HRQoL or physical well-being (parent perspective [36,51])) were examined from different perspectives. Thus, we took into account the perspective of the child but also those of the parents and teachers, as home and school are important environments in children's everyday lives. Another strength was the high sample size achieved in this study. Nevertheless, a few limitations should be pointed out. While the KIDSCREEN-10 instrument is a valid measurement tool for general HRQoL and is especially useful in identifying subgroups of children who are at risk for health problems, it does not represent most of the dimensions captured in KIDSCREEN-27 [51]. This suggests that the different dimensions of the multidimensional construct of health-related quality of life should be considered in further studies. As was evident in the subsample, physical well-being is related to both BMCs and social integration. It should also be taken into account that the KIDSCREEN instrument is a validated instrument for children above eight years, and a validation study in a younger cohort has yet to be conducted [51]. Moreover, we used the teacher and parent perspective to assess social integration, general HRQoL, and physical well-being because of the young age of the children. Factors that influence HRQoL, such as socioeconomic status [52], should also be considered in future studies.

Due to the cross-sectional study design, it was not possible to identify the direction of causality. Accordingly, future longitudinal studies should examine the extent to which (basic) motor competencies influence children's social integration and HRQoL and vice versa and how (basic) motor competencies can be targeted.

The findings of the study raise the pedagogical–didactic question of how to design a careful and effective setting for PE in (pre)school. As early as preschool, there are differences

between boys and girls regarding BMCs that cannot be attributed to gender alone [53,54]. Teachers should be aware of gender-specific sports socialization and try to remove gender-specific role models (boys play with the ball, girls do gymnastics) in PE. This can happen, for example, through a polysportive approach or the inclusion of different combinations of movement, balls, or equipment in PE.

As PE addresses both BMCs and interdisciplinary competencies, such as interpersonal relationship skills, it should be held in an inclusive setting that promotes not only learning outcomes but also interpersonal relationship skills. Both BMCs and interpersonal relationship skills seem to be important for children's social integration. For this purpose, PE classes should promote BMCs in social situations (e.g., open learning tasks that can be solved in a group and that do not reward the individual's performance), as well as interaction with classmates. This could involve the creation of learning tasks for children with different levels of BMCs in which children can vary the difficulty, find different ways of solving the tasks, and cooperate with other children. This could help children to integrate better and feel more comfortable in the class setting. Teachers and practitioners should be aware of the connections between BMCs, social integration, and HRQoL in children. Children with poor motor competencies in particular should be encouraged to participate in sport activities and play interaction to improve both social integration and BMCs.

5. Conclusions

This study showed a positive association between BMCs, social integration, and HRQoL. In both preschool and primary school, children with better BMCs seemed to be better integrated socially in the class. Children with better BMCs showed better general HRQoL in primary school and better physical well-being in preschool. The improvement of BMCs and social integration in the class could contribute to higher HRQoL. Furthermore, additional opportunities for movement with an integrative character and opportunities for co-determination could be implemented both in PE and in extracurricular activities. Since both BMCs and social integration are linked to better HRQoL, we recommend creating inclusive situations in physical settings in which it is possible to improve both BMCs and social integration. Consequently, BMCs should be considered to improve both social integration and HRQoL.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study or their parents.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the ethical guidelines of the Cantonal School Authorities.

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Appendix D – Publication 4

Bretz, K., Kress, J., & Herrmann, C. (2025). *The interplay of actual and perceived motor competencies, physical activity and well-being: A child-centered approach* [Manuscript submitted for publication].

This manuscript has been submitted for publication in a scientific journal. The manuscript has not been accepted for publication at the time of the dissertation's publication and will, thus, not be included in the publication of this dissertation.

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Declaration of Independence

Eidesstattliche Erklärung nach

☒ **§ 7 (4) der Promotionsordnung des Instituts für Bewegungswissenschaft der Universität Hamburg vom 18.08.2010**

☐ **§ 9 (1c und 1d) der Promotionsordnung des Instituts für Psychologie der Universität Hamburg vom 20.08.2003**

Hiermit erkläre ich an Eides statt,

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