This is the accepted version of the publication Eguia, K. F., Ng, S. S. M., & Wong, T. W. L. (2023). Attentional Focus Strategies for Promoting Children's Motor Learning: A Scoping Review With a Learner-Task-Environment Framework. Perceptual and Motor Skills, 130(6), 2700-2722. DOI: 10.1177/00315125231210150

Attentional Focus Strategies for Promoting Children's Motor Learning: A Scoping Review with a Learner-Task-Environment Framework

Kathlynne F. Eguia[1, 2], Shamay S.M. Ng[1], and Thomson W.L. Wong[1]

[1]*Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong SAR*

[2]*Therapeutic Intervention for Kids, Inc., Quezon City, Philippines*

Running title: Attentional focus strategies for children's motor learning

Corresponding author:

Thomson W.L. Wong

Department of Rehabilitation Sciences

The Hong Kong Polytechnic University

Hong Kong SAR, China

thomson.wong@polyu.edu.hk

Attentional Focus Strategies for Promoting Children's Motor Learning:

A Scoping Review with a Learner-Task-Environment Framework

Abstract

There is emerging evidence that attentional focus instructions and feedback may help children with motor learning. However, information relevant to learner characteristics, settings, and contexts in which attentional focus strategies can be used has not been synthesized. Therefore, in this review, we adopted a learner-task-environment framework to map the evidence to date related to attentional focus strategies in children's motor learning. We adapted the framework for scoping reviews put forth by Arksey and O'Malley (2005) and the enhanced protocol recommended by the Joanna Briggs Institute (Peters et al., 2021). Two researchers (a) identified the research question, (b) identified relevant studies, (c) selected studies, (d) charted the data, and (e) collated, summarized and reported these results. We included 30 papers, all of which used an experimental or quasi-experimental design. Most studies have focused on typically developing children and those in middle childhood as learners. The movement tasks in these studies included isolated fundamental movement skills and sport-related tasks. All but one study were situated in non-clinical settings (i.e., school, laboratory). We found limited use of attentional focus strategies for learning movement tasks in early childhood, especially among children with neurodevelopmental disorders. Movement tasks were mostly isolated skills, and there was extremely limited application to clinical settings.

Keywords: attentional focus, instructions, feedback, movement learning, children

Introduction

Instructions form a critical component of movement skill acquisition and may be presented through demonstration, verbal instructions, or tactile cues (Palisano et al., 2018). Access to feedback also contributes to the motor learning process by providing learners with information that can improve future performance (Schmidt & Lee, 2020). Motor learning strategies related to providing instructions and feedback include directing the learner's focus of attention externally or internally during practice (Wulf et al., 2010). An external focus directs the learner's attention to some end-product of the action or to the external effects of one's movement on an object or to the environment. An internal focus directs attention to the learner's own body movements or to how these movements are being produced while performing the task (Schmidt & Lee, 2020). For example, an external focus instruction for throwing would be, *"Hit the center of the target,"* while an internal focus instruction for the same task would be, *"Start the throw with a wind-up where your hand is behind your head."*

Strategies that direct attentional focus are founded on McNevin et al.'s (2003) Constrained Action Hypothesis (CAH), which proposed that an external focus promotes automatic control of movement, while an internal focus leads to a heightened consciousness that can disrupt automatic control of movement. Wulf and Lewthwaite (2016) further proposed that an external focus directs attention to an actual goal (i.e., the outcome or result), explaining that emphasis on the end result enhances the learner's

satisfaction and confidence in their ability to achieve the desired goals. An extension of the CAH is referred to as optimizing performance through intrinsic motivation and attention for learning (OPTIMAL) theory. Lewthwaite and Wulf (2017) further elaborated that an external focus of attention enables skill learning through mechanisms that involve learning and memory associated with enhanced expectancies.

In other research, strategies such as implicit motor learning, quiet eye, mindfulness training, and self-talk have also been related to attentional focus (Wulf & Lewthwaite, 2016). For instance, a quiet eye, defined as visual fixation lasting at least 100 ms on a specific target just before movement (Vickers, 1996), is believed to promote an external focus of attention through a visual focus on a relevant aspect of the task (Vine et al., 2015). Evidence of enhanced performance associated with the quiet eye has grown over recent years (e.g., Moore et al., 2013).

Experimental studies with young adults have shown that adopting an external focus is more advantageous than adopting an internal focus in functions that include balance, movement accuracy and form and to enhance muscular activity and force production (Lohse et al., 2012). Supportive studies for external focus have included both novice and skilled performers of tasks such as long jumping and dynamic ski simulation. A recent meta-analysis showed that external focus tends to be more effective than internal focus for the performance, retention, and transfer of movement skills across children, adults, and older adults (Chua et al., 2021). Such findings were

based on both behavioral and electromyogram outcomes, which were consistent regardless of age, health status, or skill level. Specific to older adults, a review by Ziv and Lidor (2015) concluded that external focus instructions were more advantageous than internal focus instructions. Studies in controlled experimental settings have also shown similar advantages of external focus instructions on older adults' balance, gait, and fall-related psychological outcomes (e.g., Law & Wong, 2021; Mak et al., 2021). The promotion of automatic control through external focus appears sensible for older adults because typical cognitive decline in late adulthood leads to limitations in cognitive capacities. We might expect similar cognitive limitations among young children who have yet to reach full cognitive development. Indeed, experimental studies with young children have also shown advantages of external focus instructions in motor skill acquisition (e.g., Brocken et al., 2016; van Cappellen – van Maldegem et al., 2018).

Of note, however, a recent review of children's overall motor learning strategies found inconclusive evidence with regard to attentional focus instructions, with a number of studies showing no differences in the effects of internal and external focus on learning and performance (van Abswoude et al., 2021). On the other hand, another review by van der Veer et al. (2022) examined the effectiveness of attentional focus in relation to the frequency, timing, and form (i.e., visual or auditory) of instructions and feedback and found moderate evidence that self-controlled external focus feedback

during practice was most effective for children's retention of gross motor tasks. In still another review, Simpson and colleagues (2021), guided by the OPTIMAL theory, examined the impact of attentional focus together with motivational mechanisms on children's fundamental movement skills (FMS) and found emerging evidence that external focus is particularly beneficial for object control skills, with the effects moderated by the children's stage of development. Collectively, these past reviews suggest that there is still evolving evidence related to attentional focus instructions and feedback for children's motor learning, with information to date still to be synthesized.

Current Review

Gordon and Magill (2017) described an important framework for understanding how children learn movement skills. This framework particularly attends to the characteristics of (a) the learner, (b) the task, and (c) the environmental context in which the task is to be performed. This framework is consistent with a developmental perspective in which individual characteristics of a child (e.g., age, disability) transact with the demands of learning a specific movement task in the environmental context (e.g., instructional cue, practice opportunity) (Goodway et al., 2021). Instructions can be catered to a specific learner's needs for information about the task and the prevailing environment, while feedback facilitates improved performance and motivation. From a developmental perspective, we believe there is value in examining attentional focus

instructions and feedback in children by using the learner-task-environment framework. While synthesized evidence to date (i.e., Simpson et al., 2021; van der Veer et al., 2022) suggests that external focus instructions and feedback may be beneficial to children (i.e., learners) who are learning gross motor and fundamental movement skills, recent reviews have been concerned with quantifying the effectiveness of attentional focus strategies; however, because they have not mapped data regarding the focus of instructions in relation to learner characteristics, movement tasks, and learning environments, there is not yet a full understanding of the conditions in which instructions and feedback can be enhanced by directing attentional focus (externally or internally). Such understanding is crucial if instructional strategies are to be deployed in a developmentally appropriate manner in varied applied contexts.

Evidence has yet to be synthesized about ways that learner characteristics (e.g., developmental stage, disability), a range of suitable tasks (e.g., complexity, novelty), and environmental settings (e.g., school, clinic) affect the application of attentional focus instructions and feedback. For instance, childhood is further divided into developmental phases during which learning processes vary with children's cognitive development (Donnelly et al., 2017). In early childhood (i.e., 5-10 years of age), sensory and motor development are accelerated, while logic becomes prominent at approximately 10 years of age (Piaget, 1963). Thus, the use and effects of attentional focus instructions and feedback are apt to be different at the varied developmental

stages of learners. Learners' environments may also vary as in, for example, whether learning settings are clinical or non-clinical. Clarifying the learner-task-environment aspects of using attentional focus strategies is crucial in designing future learning paradigms that can integrate developmentally appropriate instructions and feedback for specific groups of children, tasks, and environments.

We sought to perform a scoping review that would be appropriate for exploring the nature and diversity of current evidence (Tricco et al., 2018). Scoping reviews have been considered suitable for mapping the characteristics of prior research, as scoping reviews strive to identify and analyze knowledge gaps and inform future work (Peters et al., 2021). To check whether a scoping review that met our purpose was currently being conducted, we conducted a preliminary search of the Cochrane Database of Systematic Reviews (sources including PubMed, Embase, CINAHL, ICTRP), Prospective Register of Systematic Reviews (PROSPERO), and the Joanna Briggs Institute (JBI) Evidence Synthesis. Since we found no current systematic reviews or scoping reviews that matched our research aims to be ongoing, we undertook the present review.

Method

We followed the framework for scoping reviews originally proposed by Arksey and O'Malley (2005) and used the enhanced protocol endorsed by JBI for guidance (Peters et al., 2021). The first five steps of the framework consisted of (a) identifying

the research question, (b) identifying relevant studies, (c) selecting the study, (d) charting the data, and (e) collating, summarizing and reporting the results. We did not deem the sixth step (i.e., consultation of experts) to be necessary. As scoping reviews are not designed to assess the quality of evidence (Munn et al., 2018; Pollock et al., 2022), we did not engage in a critical appraisal or assessment of the risk of bias in the studies we examined.

Identifying the Research Question

Using the Population, Concept, and Context (PCC) format for scoping reviews (Kao et al., 2017), we posed the following review question: *What are the developmental characteristics of children (population; aged 3-17 years), movement tasks, and settings (context) where attentional focus strategies have been examined (concept)?* The specific objectives of this review are further defined below:

1. To describe the developmental characteristics of children for whom attentional focus instructions and/or feedback had been applied and examined.
2. To identify the breadth of movement tasks that were learned by children with attentional focus instructions and feedback.
3. To map the settings in which children learned movement tasks with attentional focus strategies.

Identifying and Selecting Studies

We aimed to locate published studies that included mixed-methods (quantitative and qualitative data) designs. We conducted the search in March 2023 and applied no date of publication restrictions on the papers selected. We searched the following electronic databases: PubMed, Scopus, EBSCO, ProQuest, JSTOR, and Web of Science. We used the Boolean operators "AND", "OR", and "*" with multiple combinations of keywords. Based on the PCC elements outlined in the review question, we constructed the following search phrase: ("child*" OR "early child*" OR "young child*" OR "adolescen*" OR youth) AND (((("motor" OR "movement") AND ("skill" OR "task" OR "development")) OR "skill acquisition" OR "locomotor" OR "manipulative" OR "stability") AND (("focus" AND ("attention*" OR "external" OR "internal" OR "mixed")) AND ("instruction" OR "feedback"). We reviewed the reference lists of the selected papers to find any further published studies that might meet selection criteria but found no additional studies in this way.

Two reviewers selected studies independently; their selection results were compared, and any inconsistency was resolved through discussion and consensus. Studies were selected if they met the following criteria: (a) utilized attentional focus instruction and/or feedback, (b) participants were aged 3 to 17 years, (c) involved learning or re-learning movement tasks, (d) reported on original research (i.e., not a

review), and (e) written in English. Studies were excluded when they did not include a learning phase and/or involved only movement performance following instructions.

Our electronic search initially yielded 1,220 articles that were uploaded into Zotero 6.0.15 (Digital Scholar, VA, USA). The study selection process followed the Preferred Reporting of Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021) and the PRISMA extension for scoping reviews (PRISMA-ScR; Tricco et al., 2018), as shown in Figure 1. After removal of duplicates, the titles were screened, and those that were irrelevant to the review question were excluded, reducing the number of studies to 161 articles for the next stage (review of abstracts). We excluded articles in which participants did not include children, tasks did not focus on learning movement skills (e.g., language acquisition, reading skills), and observation of movement performance was limited to following instructions at a single point in time (i.e., no learning phase). We also removed published reviews and study protocols, conference abstracts, and dissertations. Our final selections totaled 30 articles for this current review.

Charting the Data

Following the JBI protocol for scoping reviews (Peters et al., 2021), we charted the following data: author(s), title, year of publication, study design, aim(s) of the study, participants, attentional focus strategies used (including detailed descriptions of

instructions and/or feedback), settings, measures and outcomes, and main findings. Data extraction was performed by one reviewer and verified by a second reviewer for accuracy. The results are summarized and reported in the next section.

(Insert Figure 1 about here)

Results

Overview of the Studies

All the studies we reviewed used either an experimental or a quasi-experimental research design. The key information from each of the studies is summarized in the supplementary table. A descriptive summary of the number of studies, according to the learner-task-environment framework, is presented in Table 1.

Learner

While we were willing to accept studies in which participants were aged 3-17 years old, the actual age of participants in the reviewed studies ranged from 4-15 years old. Most studies (n = 20) involved children in middle childhood (i.e., 6-11 years). One study each involved young teens (i.e., 12-15 years) and children in early childhood (i.e., 4-5 years). Five studies involved a combination of children in early and middle childhood, and three studies used a combination of participants from middle childhood and young teens (n = 3).

Most studies involved typically developing children (n = 23). The few studies that involved clinical populations consisted of those with intellectual disability (ID; n = 2), developmental coordination disorder (DCD; n = 2), attention deficit-hyperactive disorder (ADHD; n = 2), and autism spectrum disorder (ASD; n = 1).

Task

The most frequently trained task in the reviewed studies was the fundamental movement skill of throwing (n = 10), including two studies that specified the task to include a preliminary swing before throwing (i.e., referred to as slinger ball). Three other fundamental movement skills were targeted in other studies: kicking (n = 1), jumping (n = 1) and balancing (n = 1). Sport-related tasks were trained in many studies, including basketball skills (n = 3), golf putting (n = 2), soccer (n = 2), darts (n = 2), tennis (n = 1), and volleyball passing (n = 1). Other tasks were functional, such as using a Pedalo (n = 2), which is for training coordination and balance. Other functional/game tasks included using a shuffle board (n = 1), playing band instruments (n = 1), pirouettes (n = 1), yoga (n = 1), and a fine motor tracking task (n = 1).

Most studies (n = 23) examined the use of attentional focus only for instructions. A few studies included both instructions and feedback (n = 3) or only feedback (n = 4). Most studies reported verbatim instructions and feedback (n = 25), and they can be found in the supplementary table.

Environment

Most studies were conducted in school settings (n = 20), followed by research laboratories (n = 9). Even when seven studies involved populations with developmental conditions, only one was conducted in a clinical setting and delivered by physiotherapists.

(Insert Table 1 about here)

Study Designs and Outcomes

The study designs for which the outcomes were measured varied across these reviewed studies. Among the experimental studies, the most frequent design measured outcomes during the learning phase, at retention, and with a transfer task (n = 9). An almost equal number of studies measured outcomes at pretest, during the learning phase, and at retention (n = 7). Four studies used a simpler design consisting of outcomes at pretest and retention. On the other hand, some other studies adopted the most complex design consisting of outcomes at pretest, during the learning phase, at retention, and with transfer tasks (n = 3). A few studies looked at only the learning and retention phases (n = 2) or the learning and transfer phases (n = 2). One study each measured outcomes at pretest, retention, and transfer, only at the learning phase, or only at retention.

Table 2 summarizes the differential outcomes between external and internal focus relative to the learner-task-environment framework. Most studies (n = 18) showed that external focus instructions and feedback were more advantageous than internal focus. Among these studies, 15 involved typically developing children whose ages ranged from early childhood to adolescence. Two studies involved children with ADHD, and one study involved children with ID. Most of the tasks where external focus led to greater improvements in performance (n = 13) involved object manipulation (e.g., ball, stick). Three other studies showed benefits for complex tasks (i.e., pedaling, ballet pirouette), while one study each showed benefits to a locomotion (i.e., jumping) and balancing task (i.e., jumping). Evidence supporting the advantages of external focus was generated by 12 (out of 20) school-based studies and six (out of nine) laboratory-based studies.

A substantial number of studies (n = 10) found no significant differences in the outcomes between external and internal focus instructions and feedback. Seven of these studies involved typically developing children, while one study involved children with ID. Two studies were of children with DCD, one of which found concurrently no difference between external and internal focus for children and advantages associated with external focus only for typically developing children (Jarus et al. 2015). Nearly all studies involved object manipulation tasks (n = 8), while one study involved a balancing task (i.e., slackline) and another involved playing a variety of instruments. Six studies

were school-based, three were laboratory-based, and one study was in a physiotherapy clinic.

Three studies showed that internal focus instructions were more advantageous – two of these were with typically developing children and one was with children with ASD. These studies showed greater improvements in the performance of tasks that involved object manipulation. The studies of typically developing children were conducted in schools, while the study of children with ASD was conducted in the laboratory.

The common limitations cited by the studies suggest the need to address ecological validity. Several laboratory-based studies acknowledged that the findings from a controlled environment and protocol may have limited transferability to the real world. On the other hand, some school-based studies were noted to have relatively short learning phases, which may not reflect the length of time that children might need to acquire complex motor skills. Other studies also acknowledged the lack of an effective manipulation check, through which it can be verified whether the children in fact followed the specified instructions or feedback that directed their focus.

(Insert Table 2 about here)

Discussion

This review was guided by the learner-task-environment framework for motor learning (Gordon & Magill, 2017), in which we aimed to map the conditions in which attentional focus instructions and feedback have been examined in research with children. Particularly, we focused on children's developmental characteristics, the nature of movement tasks that were learned, and the settings in which motor skill acquisition took place. Prior reviews of evidence related to attentional focus strategies in children have focused on quantifying the effectiveness and the relative advantages associated with type of instructional focus, highlighting an external focus of attention specifically (Simpson et al., 2021; van der Veer et al., 2022). In the studies we reviewed, most showed that an external focus may be advantageous for children, including those with ADHD. Nevertheless, there were a substantial number of studies that showed no differences between the effects of external and internal attentional focus strategies, and this group included children with DCD. Studies that showed equivocal results suggested that individual differences must be considered in children's learning, meaning that future investigators should account for individual learning trajectories (Perreault & French, 2016; van Cappellen – van Maldegem et al., 2018). This suggestion is highlighted by the apparent different responses among children with ADHD and DCD, perhaps indicating the importance of the learner's distinct characteristics as matched with the learning conditions.

In general, our findings concurred with those of previous reviews that provided support for the use of external focus instructions and feedback for children (van der Veer et al., 2022; Simpson et al., 2021). However, the details we provided using the learner-task-environment framework elicited further considerations, as follows below.

Learner

In terms of the learner, studies of attentional focus strategies with children appear to have predominantly focused on typically developing children in middle childhood (i.e., 6-11 years of age). In this developmental period, fundamental movement skills are mastered, and concrete operational thinking (i.e., reasoning and problem solving) is developed (Del Giudice, 2018). It can be assumed that the characteristics of children at this stage enable research on movement skill acquisition. For instance, newly developed problem-solving abilities allow middle childhood learners to process instructions and feedback in relation to motor skills. In contrast, very few studies have examined children in early childhood, even though this is a crucial stage when fundamental movement skills first emerge (Donnelly et al., 2017). Fundamental movement skills, particularly object control skills, were the most frequently targeted movement task in the reviewed studies. Fundamental movement skills consist of locomotor, object control, and balance skills (Goodway, Ozmun, & Gallahue, 2021), the development of which is often targeted in early childhood education and care settings. Teachers may be able to promote these skills better by

utilizing appropriate attentional focus instructions and feedback. However, only one study specifically focused on early childhood and targeted the object control skill of throwing (Lola et al., 2022). While these authors' findings showed that external focus instructions and feedback were more beneficial, there is a pressing need for more research in this age group.

While the overwhelming majority of available evidence has been drawn from samples of typically developing children, effective motor learning strategies are especially important to address in children with neurodevelopmental disorders (NDDs). According to the Diagnostic and Statistical Manual of Psychiatric Disorders (DSM-5; American Psychiatric Association, 2022), NDDs include ID, ADHD, communication disorders, ASD, specific learning disorders, and motor disorders that may include DCD. Many children with NDDs are known to have motor issues and therefore constitute groups of children who need to be supported by effective motor learning strategies. For instance, in the physiotherapy of children with NDDs, the use of instructions and feedback is especially crucial due to potential physical constraints and sensory impairments that may affect the processing of movement-related information (Gordon & Magill, 2017). However, very few studies have applied attentional focus strategies for children with NDDs, and this should be a direction for future investigators to take.

The advantages associated with external focus instructions and feedback were found to be evident in children with ADHD, but only in two studies (Ghorbani et al.,

2020; Saemi et al., 2013). External focus instructions encourage learners to direct attention toward the task's goal. This approach has been advantageous for children with ADHD, who contend with heightened distractibility. The external focus method enables them to visualize and work toward achieving a tangible endpoint. In children with DCD, two studies showed no differences in the effects of external and internal focus instructions (Jarus et al., 2015; van Cappellen – van Maldegem et al., 2018). As discussed earlier, children with DCD tend to have difficulty learning from their mistakes and persist with incorrect movement patterns (Biotteau et al., 2016). Thus, they might be better attuned to identifying and correcting erroneous movements when they focus internally and monitor their own performances. In other research, however, "quiet eye" has been found to effectively improve visuomotor task performance in children with DCD by facilitating their ability to focus, anticipate, and track the target object (Miles et al., 2015). These quiet eye mechanisms appear to be aligned with an external focus (i.e., focusing on the target object). Thus, future researchers should examine the contexts in which attentional focus instructions and feedback are delivered (i.e., in addition to quiet eye) to identify the ways in which children with DCD process and execute movement skills.

Two further studies involved children with ID, but only one of these studies found external focus to be advantageous (Chiviacowsky et al., 2013), while the other found no differences in learning effects (Kok et al., 2021). An external focus is assumed

to be associated with reduced attentional demands (Wulf et al., 2001), perhaps making this strategy advantageous for children with ID who have cognitive limitations. Kok and colleagues (2021) offered the nuanced suggestion that the choice of instructions for these children should be dependent on those cognitive resources.

Finally, one study showed that internal focus instructions were better suited for children with ASD, and the authors proposed that this was due to these children being more attuned to relying on proprioception (Tse, 2019). This explanation was drawn, in part, from previous research that showed that children with ASD tend to rely on proprioception rather than vision when learning a movement skill (Marko et al., 2015). However, this single study of attentional focus in children with ASD, limited to those with high-functioning ASD who were aged 9-12 years, is too limited in scope for drawing definitive inferences about children with ASD generally. Clearly, there is a need for further research of this kind for children with NDDs and particularly for those with ASD.

Task

The most commonly targeted tasks in these reviewed studies were fundamental movement skills, which are considered to form the foundations of more complex tasks (Donnelly et al., 2017). Crucially, fundamental movement skills enable exploration of the environment and interaction with peers, which are important contributors to cognitive and socioemotional development (Cameron et al., 2016; Veldman et al.,

2019). Many of these reviewed studies targeted isolated object control skills in particular; however, in the real world, physical play and other activities require that children use a coordinated combination of fundamental movement skills. Indeed, many authors of studies we reviewed acknowledged that the ecological validity of movement tasks and training conditions should be enhanced in future research (e.g., Bahmani et al., 2021; Ghorbani et al., 2020). It has also been emphasized in recent research that fundamental movement skills should not be viewed as discrete isolated tasks (Ng & Button, 2023). While the importance of fundamental movement skills is well established, future research regarding attentional focus instructions and feedback with children should consider play- or game-based contexts rather than studying movement skills in isolation.

Many studies we reviewed involved sport-related and functional tasks that are more complex than fundamental movement skills and more consistent with actual contexts of children's play. For instance, tasks related to basketball, golf, and soccer were trained, and it appears that an external focus of attention was more advantageous in these studies (e.g., Brocken et al., 2016; Gredin & Williams, 2016; Perreault & French). However, as most studies have focused on only specific tasks (e.g., throwing, putting), future research on attentional focus instruction might train a combination of sport-related and functional tasks.

Environment

A large portion of the studies we reviewed were conducted in laboratory settings, which is generally consistent with the trend of motor learning research (Kleynen et al., 2015). Interestingly, most of these laboratory studies showed advantages with an external attentional focus. Possibly, the controlled settings helped elicit these findings, in which case these data should be interpreted cautiously, given the limited ecological validity of laboratory conditions. Compared to studies of adults, field-based settings in schools have made better progress with children. Studies that were conducted in schools might have had a better likelihood of facilitating a potential for knowledge translation in physical education and sports coaching contexts. As most of these reviewed studies reported the actual instructions used in school settings, teachers and coaches may refer to them when considering how to structure and deliver the instructions and feedback for their own contexts.

Considering the importance of effective motor learning strategies for children with NDDs, future investigators should further explore clinical settings. We reviewed only one study in a physiotherapy clinic setting. In physiotherapy for children with NDDs, instructions and feedback are especially crucial due to potential physical constraints and/or sensory impairments that might affect these children's processing of movement-related information (Gordon & Magill, 2017). There is potential for integrating attentional focus instructions and feedback systematically in pediatric

physiotherapy practice, but there is simply insufficient research at this time to inform practice in these clinical settings or for different diagnostic groups.

Limitations of this Review

We followed the established protocols for scoping reviews, but by excluding non-English papers, we might have missed some evidence. We summarized the findings in terms of the advantages associated with external and internal focus, but given the nature of a scoping review (Munn et al., 2018), **we did not conduct a quality assessment of the reviewed studies; hence, we do not offer insights into the quality and strength of available evidence. This limitation should be considered when considering the synthesized evidence in this review.** Additionally, in considering learner-task-environment factors, we examined only a few limited descriptors in each category (e.g., children's developmental characteristics, fundamental movement skills and sports-related tasks, and laboratory, school-based, and clinical settings). There may be other relevant descriptors in each category that would be valuable for future researchers to examine.

Conclusion

In this scoping review, we determined the extent of research conducted to date on the use of attentional focus strategies to facilitate children's learning of movement tasks. While more studies have shown the advantages of an external attentional focus in these motor learning applications, some studies we reviewed showed no differences

between an external and internal focus, highlighting the need to consider children's individual differences. Regarding tasks, attentional focus strategies are evidently useful for tasks that range from isolated fundamental movement skills to functional and sport-related tasks and in school-based or laboratory settings. Future work is needed to examine attentional focus strategies among children in early childhood and those with NDDs. Further task applications might involve combinations of fundamental movement skills and sport-related tasks. Finally, the potential benefits associated with attentional focus instructions and feedback should be tested more frequently in clinical settings.

Declaration of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Agar, C., Humphries, C. A., Naquin, M., Hebert, E., & Wood, R. (2016). Does varying attentional focus affect skill acquisition in children? A comparison of internal and external focus instructions and feedback. *Physical Educator, 73*(4), 639. https://doi.org/10.18666/TPE-2016-V73-I4-6883

American Psychiatric Association. (2022). *Diagnostic and Statistical Manual of Mental Disorders* (5th, Text Revised Ed.). https://dsm.psychiatryonline.org/doi/book/10.1176/appi.books.9780890425787

Arksey, H., & O'Malley, L. (2005). Scoping studies: Toward a methodological framework. *International Journal of Social Research Methodology*, *8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Asadi, A., Aiken, C. A., Heidari, S., & Kochackpour, F. (2021). The effect of attentional instructions during modeling on gaze behavior and throwing accuracy in 7 to 10-year-old children. *Human Movement Science, 78*, 102825. https://doi.org/10.1016/j.humov.2021.102825.

Bahmani, M., Babak, M., Land, W. M., Howard, J. T., Diekfuss, J. A., & Abdollahipour, R. (2021). Children's motor imagery modality dominance modulates the role of attentional focus in motor skill learning. *Human Movement Science, 75*, 102742. https://doi.org/10.1016/j.humov.2020.102742

Biotteau, M., Chaix, Y., & Albaret, J.-M. (2016). What do we really know about motor learning in children with Developmental Coordination Disorder? *Current Developmental Disorders Reports*, *3*(2), 152–160. https://doi.org/10.1007/s40474-016-0084-8

Brocken, J. E. A., Kal, E. C., & van der Kamp, J. (2016). Focus of Attention in Children's Motor Learning: Examining the Role of Age and Working Memory.

Journal of Motor Behavior, *48*(6), 527–534. https://doi.org/10.1080/00222895.2016.1152224

Cameron, C. E., Cottone, E. A., Murrah, W. M., & Grissmer, D. W. (2016). How are motor skills linked to children's school performance and academic achievement? *Child Development Perspectives*, *10*(2), 93–98. https://doi.org/10.1111/cdep.12168

Chiviacowsky, S., Wulf, G., & Avila, L. T. G. (2013). An external focus of attention enhances motor learning in children with intellectual disabilities. *Journal of Intellectual Disability Research: JIDR*, *57*(7), 627–634. https://doi.org/10.1111/j.1365-2788.2012.01569.x

Chow, J. Y., Koh, M., Davids, K., Button, C., & Rein, R. (2014). Effects of different instructional constraints on task performance and emergence of coordination in children. *European Journal of Sport Science*, *14*(3), 224-232. https://doi.org/10.1080/17461391.2013.780097

Chua, L.-K., Jimenez-Diaz, J., Lewthwaite, R., Kim, T., & Wulf, G. (2021). Superiority of external attentional focus for motor performance and learning: Systematic reviews and meta-analyses. *Psychological Bulletin*, *147*(6), 618–645. pdh. https://doi.org/10.1037/bul0000335

Del Giudice, M. (2018). Middle childhood: An evolutionary-developmental synthesis. In *Handbook of life course health development* (pp. 95–107). Springer Nature.

Donnelly, F. C., Mueller, S. S., & Gallahue, D. L. (2017). *Developmental physical education for all children: Theory into practice*. Human Kinetics.

Emanuel, M., Jarus, T., & Bart, O. (2008). Effect of focus of attention and age on motor acquisition, retention, and transfer: a randomized trial. *Physical Therapy, 88*(2), 251-260. https://doi.org/10.2522/ptj.20060174

Flôres, F. S., Menezes, K. M., & Katzer, J. I. (2016). Influences of gender on attention and learning of motor skills. *Journal of Physical Education, 27*, e2706. https://doi.org/10.4025/jphyseduc.v27i1.2706

Flôres, F. S., Schild, J. G., & Chiviacowsky, S. (2015). Benefits of external focus instructions on the learning of a balance task in children of different ages. *International Journal of Sport Psychology*, *46*(4), 311-320. https://doi.org/10.7352/IJSP.2015.46.31

Ghorbani, S., Amir, D., & Christodoulides, E. (2020). Effects of external focus of attention on learning static balance among girls with ADHD. *Biomedical Human Kinetics*, *12*(1), 69–74. https://doi.org/10.2478/bhk-2020-0009

Gordon, A. M., & Magill, R. (2017). Motor learning: Application of principles to pediatric rehabilitation. In *Campbell's Physical Therapy for Children* (5th ed., pp. 78–97). Elsevier.

Goodway, J.D., Ozmun, J.C., & Gallahue, D.L. (2021). *Understanding motor development: infants, children, adolescents, adults* (8th ed.). John & Bartlett Learning.

Gredin, V., & Williams, A. M. (2016). The relative effectiveness of various instructional approaches during the performance and learning of motor skills. *Journal of Motor Behavior, 48*(1), 86-97. https://doi.org/10.1080/00222895.2015.1046544

Hadler, R., Chiviacowsky, S., Wulf, G., & Schild, J. F. G. (2014). Children's learning of tennis skills is facilitated by external focus instructions. *Motriz: Revista de Educação Física, 20*, 418-422. https://doi.org/10.1590/S1980-65742014000400008

Jarus, T., Ghanouni, P., Abel, R. L., Fomenoff, S. L., Lundberg, J., Davidson, S., Caswell, S., Bickerton, L., & Zwicker, J. G. (2015). Effect of internal versus external focus of attention on implicit motor learning in children with developmental coordination disorder. *Research in Developmental Disabilities*, *37*, 119–126. https://doi.org/10.1016/j.ridd.2014.11.009

Kao, S. S.-T., Peters, M. D. J., Dharmawardana, N., Stew, B., & Ooi, E. H. (2017). Scoping review of pediatric tonsillectomy quality of life assessment instruments. *The Laryngoscope*, *127*(10), 2399–2406. https://doi.org/10.1002/lary.26522

Kleynen, M., Braun, S. M., Rasquin, S. M. C., Bleijlevens, M. H. C., Lexis, M. A. S., Halfens, J., Wilson, M. R., Masters, R. S. W., & Beurskens, A. J. (2015). Multidisciplinary views on applying explicit and implicit motor learning in practice: An international survey. *PLOS One*, *10*(8), e0135522. https://doi.org/10.1371/journal.pone.0135522

Kok, M., Kal, E., van Doodewaard, C., Savelsbergh, G., & van der Kamp, J. (2021). Tailoring explicit and implicit instruction methods to the verbal working memory capacity of students with special needs can benefit motor learning outcomes in physical education. *Learning and Individual Differences 89*. https://doi.org/10.1016/j.lindif.2021.102019

Krajenbrink, H., van Abswoude, F., Vermeulen, S., van Cappellen, S., & Steenbergen, B. (2018). Motor learning and movement automatization in typically developing children: The role of instructions with an external or internal focus of attention. *Human Movement Science, 60*, 183-190. https://doi.org/10.1016/j.humov.2018.06.010

Law, J. C. L., & Wong, T. W. L. (2021). Internal focus instruction increases psychological stress with conscious motor processing and deteriorates motor performance in dart throwing. *Cognitive Processing*, *22*(1), 57–64. https://doi.org/10.1007/s10339-020-00991-7

Lohse, K. R., Wulf, G., & Lewthwaite, R. (2012). Attentional focus affects movement efficiency. In Hodges, N. J. and Williams, A. M., eds. *Skill Acquisition in Sport*. Routledge.

Lola, A., Koutsomarkou, A., & Tzetzis, G. (2021). Influence of different focus of attention instructions on learning volleyball skills for young novices. *Journal of Human Sport and Exercise, 17*(4), 867-881. https://doi.org/10.14198/jhse.2022.174.14

Lola, A., Tzetzis, G., Manou, V., & Alexandropoulou, S. (2022). Attentional focus on learning fundamental movement skills in children. *Physical Activity Review, 10*(1), 60–67. Scopus. https://doi.org/10.16926/PAR.2022.10.07

Mak, T. C. T., Young, W. R., & Wong, T. W. L. (2021). Conscious control of gait increases with task difficulty and can be mitigated by external focus instruction. *Experimental Aging Research, 47*(3), 288–301. https://doi.org/10.1080/0361073X.2021.1891811

Marko, M.K., Crocetti, D., Hulst, T., Donchin, O., Shadmehr, R., & Mostofsky, S.H. (2015) Behavioural and neural basis of anomalous motor learning in children with autism. *Brain 138,* 784–797.

McNevin, N. H., Shea, C. H., & Wulf, G. (2003). Increasing the distance of an external focus of attention enhances learning. *Psychological Research, 67*(1), 22–29. https://doi.org/10.1007/s00426-002-0093-6

Miçooğulları, B., Kirazcı, S., & Altunsöz, Ö. (2012). Effects of internal, external and preference of attentional focus feedback instructions on learning soccer “Head Kick”. *Montenegrin Journal of Sports Science and Medicine, 1*(1), 21-26.

Miles, C., Wood, G., Vine, S., Vickers, J., & Wilson, M. (2015). Quiet eye training facilitates visuomotor coordination in children with developmental coordination disorder. *Research in Developmental Disabilities*, *40*, 31–41. https://doi.org/10.1016/j.ridd.2015.01.005

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Palisano, R. J., Orlin, M., & Schreiber, J. (2018). *Campbell’s Physical Therapy for Children* (5th ed.). Elsevier. https://evolve.elsevier.com/cs/product/9780323390187?role=student

Perreault, M. E., & French, K. E. (2015). External-focus feedback benefits free-throw learning in children. *Research Quarterly for Exercise and Sport, 86*(4), 422-427. https://doi.org/10.1080/02701367.2015.1051613

Perreault, M. E., & French, K. E. (2016). Differences in children's thinking and learning during attentional focus instruction. *Human Movement Science, 45*, 154-160. https://doi.org/10.1016/j.humov.2015.11.013

Peters, M. D. J., Marnie, C., Colquhoun, H., Garritty, C. M., Hempel, S., Horsley, T., Langlois, E. V., Lillie, E., O'Brien, K. K., Tunçalp, Özge, Wilson, M. G., Zarin, W., & Tricco, A. C. (2021). Scoping reviews: Reinforcing and advancing the methodology and application. *Systematic Reviews, 10*(1), 263. https://doi.org/10.1186/s13643-021-01821-3

Petranek, L. J., Bolter, N. D., & Bell, K. (2019). Attentional focus and feedback frequency among first graders in physical education. *Journal of Teaching in Physical Education*, *38*(3), 199-206. https://doi.org/10.1123/jtpe.2018-0080

Piaget, J. (1963). *The origins of intelligence in children.* W.W. Norton.

Saemi, E., Porter, J., Wulf, G., Ghotbi-Varzaneh, A., & Bakhtiari, S. (2013). Adopting an external focus of attention facilitates motor learning in children with attention deficit hyperactivity disorder. *Kinesiology*, *45*(2), 179–185. Scopus.

Schmidt, R.A., & Lee, T.D. (2020). *Motor learning and performance: from principles to applications,* Human Kinetics.

Schwab, S., Rein, R., & Memmert, D. (2019). "Kick it like Ronaldo": a cross-sectional study of focus of attention effects during learning of a soccer knuckle ball free

kick technique. *German Journal of Exercise and Sport Research, 49*(1), 91-96. https://doi.org/10.1007/s12662-018-0558-4

Simpson, T., Ellison, P., Carnegie, E., & Marchant, D. (2021). A systematic review of motivational and attentional variables on children's fundamental movement skill development: The OPTIMAL theory. *International Review of Sport and Exercise Psychology*, *14*(1), 312–358. Scopus. https://doi.org/10.1080/1750984X.2020.1809007

Stambaugh, L. A. (2019). Effects of focus of attention on performance by second-year band students. *Journal of Research in Music Education, 67*(2), 233-246. https://doi.org/10.1177/0022429419835841

Teixeira da Silva, M., Thofehrn Lessa, H., & Chiviacowsky, S. (2017). External focus of attention enhances children's learning of a classical ballet pirouette. *Journal of Dance Medicine & Science, 21*(4), 179-184. https://doi.org/10.12678/1089-313X.21.4.179

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, *169*(7), 467–473. https://doi.org/10.7326/M18-0850

Tse, A. C. (2019). Effects of attentional focus on motor learning in children with autism spectrum disorder. *Autism*, 23(2), 405–412. https://doi.org/10.1177/1362361317738393

Tse, A. C. & van Ginneken, W. F. (2017). Children's conscious control propensity moderates the role of attentional focus in motor skill acquisition. *Psychology of Sport and Exercise, 31*, 35-39. https://doi.org/10.1016/j.psychsport.2017.03.015

van Abswoude, F., Mombarg, R., de Groot, W., Spruijtenburg, G., & Steenbergen, B. (2021). Implicit motor learning in primary school children: A systematic review. *Journal of Sports Sciences*, *39*(22), 2577–2595. https://doi.org/10.1080/02640414.2021.1947010

van Abswoude, F., Nuijen, N. B., van der Kamp, J., & Steenbergen, B. (2018). Individual differences influencing immediate effects of internal and external focus instructions on children's motor performance. *Research Quarterly for Exercise and Sport, 89*(2), 190-199. https://doi.org/10.1080/02701367.2018.1442915

van Cappellen – van Maldegem, S. J. M., van Abswoude, F., Krajenbrink, H., & Steenbergen, B. (2018). Motor learning in children with developmental coordination disorder: The role of focus of attention and working memory. *Human Movement Science*, *62*, 211–220. https://doi.org/10.1016/j.humov.2018.11.001

van der Veer, I. P. A., Verbecque, E., Rameckers, E. A. A., Bastiaenen, C. H. G., & Klingels, K. (2022). How can instructions and feedback with external focus be shaped to enhance motor learning in children? A systematic review. *PLOS One*, *17*(8), e0264873. https://doi.org/10.1371/journal.pone.0264873

Veldman, S. L. C., Santos, R., Jones, R. A., Sousa-Sá, E., & Okely, A. D. (2019). Associations between gross motor skills and cognitive development in toddlers. *Early Human Development*, *132*, 39–44. https://doi.org/10.1016/j.earlhumdev.2019.04.005

Wulf, G., McNevin, N., & Shea, C. H. (2001). The automaticity of complex motor skill learning as a function of attentional focus. The Quarterly Journal of Experimental Psychology Section A, 54(4), 1143-1154.

Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin & Review*, *23*(5), 1382–1414. https://doi.org/10.3758/s13423-015-0999-9

Wulf, G., Chiviacowsky, S., Schiller, E., & Ávila, L. T. G. (2010). Frequent external-focus feedback enhances motor learning. *Frontiers in Psychology*, *1*, 190. https://doi.org/10.3389/fpsyg.2010.00190

Wulf, G., Shea, C., & Lewthwaite, R. (2010), Motor skill learning and performance: a review of influential factors. *Medical Education, 44*, 75-84. https://doi.org/10.1111/j.1365-2923.2009.03421.x

Ziv, G., & Lidor, R. (2015). Attentional focus and motor learning in clinical settings and in older age: A review. *Journal of Motor Learning and Development*, *3*(2), 123–139. https://doi.org/10.1123/jmld.2015-0014

Figure

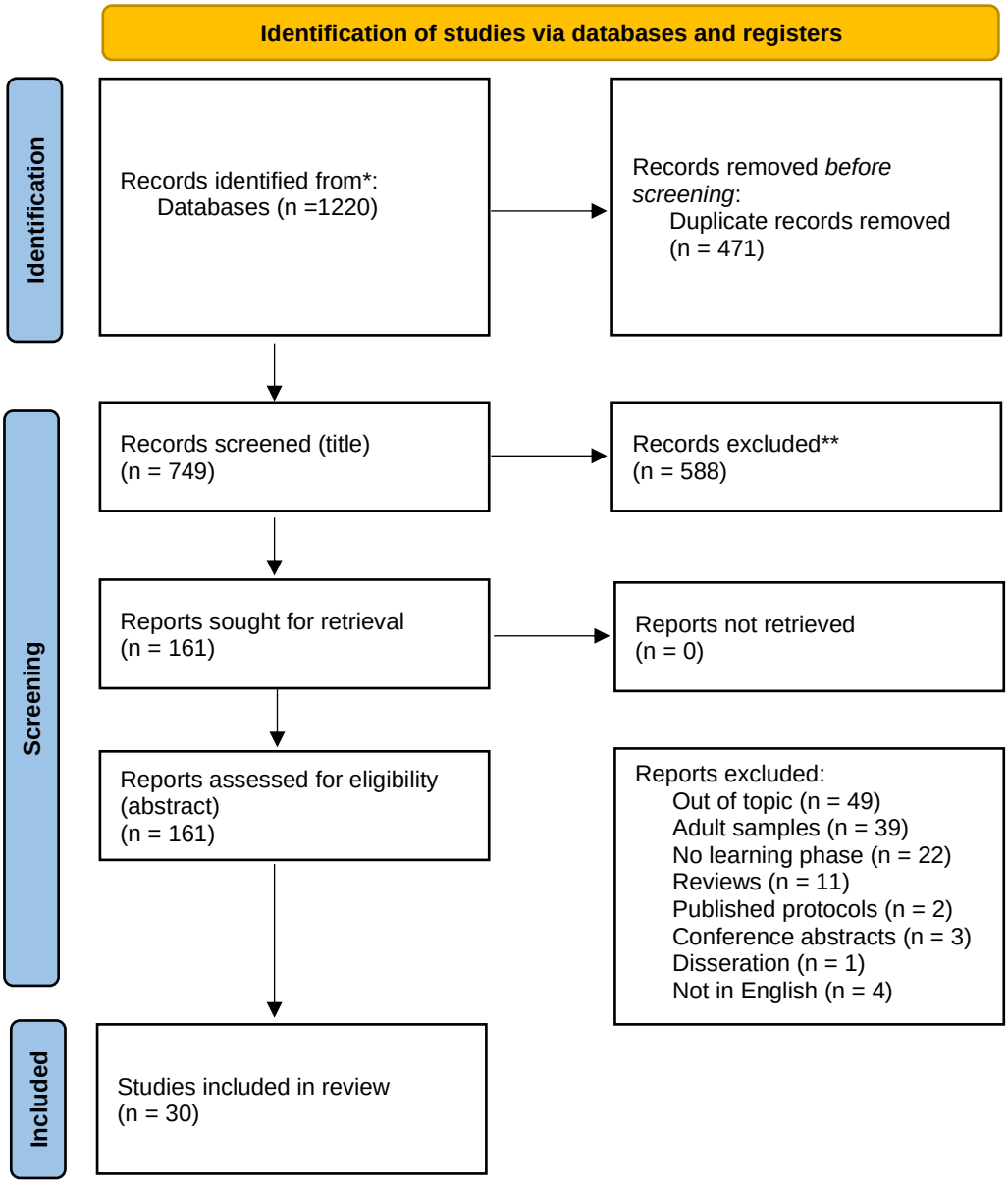

Figure 1. PRISMA Flow Diagram (Page et al, 2021) for Article Selection.

Table

Table 1. Summary of the Numbers of Reviewd Studies that Focused on Different Subgroups of Learners, Tasks, and Environmental Settings.

Learner	Task	Environment
Age	Fundamental movement skills	Field-based (school): n = 20
Early childhood: n = 1	Throwing: n = 10	Research laboratory: n = 9
Middle childhood: n = 20	Kicking: n = 1	Clinic (physiotherapy): n = 1
Teens: n = 1	Balancing: n = 1	
Combination: n = 8	Jumping: n=1	
Development	Sport-related tasks	
Typically, developed: n = 23	Basketball: n = 3	
Intellectual disability (ID): n = 2	Golf putting: n = 2	
Developmental coordination disorder (DCD): n = 2	Soccer: n = 2	
	Darts: n = 2	
Attention deficit-hyperactivity disorder (ADHD): n = 2	Tennis: n = 1	
	Volleyball: n = 1	
Autism spectrum disorder (ASD): n = 1	Functional tasks	
	Pedalo: n = 2	
	Shuffle board: n = 1	
	Band instrument: n = 1	
	Pirouette: n = 1	
	Yoga: n = 1	
	Tracking: n = 1	

Table 2. The Advantageous Effects of External versus Internal Attentional Focus Instructions/Feedback with Reference to the Learner, Task, and Environment.

Author/Year	Learner	Task	Environment	Advantageous effect		
				External	Internal	None
Agar et al. 2016	Typically developing children; 5-12 years old	Shooting task using a shuffleboard, stick and pucks	Laboratory			+
Asadi et al. 2021	Typically developing children; 7-10 years old	Overarm tossing task using a ball toward a target on the wall	Laboratory	+		
Bahmani et al. 2021	Typically developing children; 9-11 years old	Overarm tossing task using a ball toward a target on the wall	Laboratory	+		
Brocken et al. 2016	Typically developing children; 8-12 years old	Golf putting task	Laboratory	+		
Chiviacowsky et al. 2013	Children with ID; 10-14 years old	Throwing task using a beanbag toward a vertical target	School	+		
Chow et al. 2014	Typically developing children; 9-10 years old	Long jumping task on a standing board	School	+		
Emanuel et al. 2008	Typically developing children; 8-9 years old	Darts throwing task	Laboratory			+
Flôres et al. 2016	Typically developing children; 6-10 years old	Pedaling task	School	+		
Flôres et al. 2015	Typically developing children; 6-10 years old	Pedaling task	School	+		
Ghorbani et al. 2020	Children with ADHD; 7-11 years old	Yoga posing task	School	+		

Author/Year	Learner	Task	Environment	Advantageous effect		
				External	Internal	None
Gredin & Williams 2016	Typically developing children; 9-10 years old	Kicking task using a stationary ball toward a target on the floor	School		+	
Hadler et al. 2014	Typically developing children; 10-12 years old	Forehand tennis striking task	Laboratory	+		
Jarus et al. 2015	Typically developing children; 9-12 years old	Computer tracking task	Laboratory	+		
	Children with DCD; 9-12 years old					+
Kok et al. 2021	Children with ID; 9-13 years old	Balancing task using a slackline	School			+
Krajenbrink et al. 2018	Typically developing children; 8-12 years old	Throwing task using a slinger toward a horizontal target	School			+
Lola et al. 2022	Typically developing children; 9-10 years old	Volleyball passing task	School	+		
Lola et al. 2021	Typically developing children; 5-6 years old	Throwing task using a beanbag toward a horizontal target	School	+		
Miçooğulları et al. 2012	Typically developing children; 12-15 years old	Soccer head kicking task	School	+		
Perreault & French 2016	Typically developing children; 9-11 years old	Basketball free throwing task	School			+
Perreault & French 2015	Typically developing children; 9-11 years old	Basketball free throwing task	School	+		
Petranek et al. 2019	Typically developing children; 6-7 years old	Overhand throwing task using a foamball toward a vertical target	School		+	

Author/Year	Learner	Task	Environment	Advantageous effect		
				External	Internal	None
Saemi et al. 2013	Children with ADHD; 8-11 years old	Throwing task using a ball toward a horizontal target	School	+		
Schwab et al. 2019	Adolescents; age not specified	Soccer free kicking task	Laboratory	+		
Stambaugh 2019	Typically developing children; 12 years old	Playing a variety of band instruments	School			+
Texeira-da Silva et al. 2017	Typically developing children; 9-10 years old	Performing a ballet pirouette	Dance school	+		
Tse 2019	Children with autism; 9-12 years old	Throwing task using a beanbag toward a vertical target	Laboratory		+	
Tse & van Ginneken 2017	Typically developing children; 8-12 years old	Darts throwing task	School			+
van Abswoude et al. 2018	Typically developing children; 8-12 years old	Golf putting task	School			+
van Cappellen-van Maldegem et al. 2018	Children with DCD; 4-12 years old	Throwing task using a slinger toward a horizontal target	Physiotherapy clinic			+
Wulf et al. 2010	Typically developing children; 10-12 years old	Throwing task using a ball toward a horizontal target	School	+		

Supplementary Files

Supplement: Extracted data