

## **Physical Activity and Literacy Interventions for Children with Developmental Coordination Disorder: Present and Future Preferences**

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### **Abstract**

Children with Developmental Coordination Disorder (DCD) experience limitations in motor skills learning and performance. Impact of limitations can be minimized through involvement in Physical Activities (PA) and development of Physical Literacy (PL). The purpose of this study is to search available literature published in last ten years purely based on physical activity interventions to determine current preferences and provide direction for future preferences in designing interventions for children with DCD. Search was made by using three key terms on four databases to explore articles published since 2013 that applied only physical activity interventions to study effect either on physical activity or physical literacy of children with DCD. Screening of available data revealed that there were only 05 studies which met the already defined inclusion criterion. Screening of articles also disclosed absence of interventional researches targeting physical literacy of children with DCD. Since DCD is a motor learning disorder more researches should be based on physical activity and target the same being the core area requiring amelioration. Moreover, a shift from physical activity to physical literacy is also needed as being more appropriate and broader concept for physical learning and growth of children with DCD.

**Keywords:** Developmental Coordination Disorder (DCD), Physical Activity (PA), Physical Literacy (PL)

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**Introduction:**

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder hampering motor development and learning, causing difficulties in performing and mastering motor related tasks and skills in 5% to 6 % school going children (Edition, 2013). Fine and gross motor skills are typically weaker than peers (Zwicker, Missiuna, Harris, & Boyd, 2012). Difficulties in motor coordination and learning may cause limitations in academic progress and daily life activities (Bo, & Lee, 2013) and restrict social grooming of children which may lead to social aloofness and withdrawing behavior (Preston, Magallon, Hill, Andrews, Ahern, & Mon-Williams, 2017). DCD may impact multiple areas of development and education achievement is no exception. Available research evidence discloses DCD contributing in enhancing difficulties in education (Harrowell, Hollén, Lingam, & Emond, 2018). Graphomotoricity is one of the many dominant areas found affected in children with DCD. Grapho-motor skills help children in manual movements. These skills are considered essential for enabling a child to write (Huau, Velay, & Jover, 2015). DCD may also increase the risk of additional physical and mental health problems (Chiricoet al.2012). Physical Activity (PA) has vital implication for public health and is considered crucial to manage and prevent mental illnesses (Marconcin et al. 2022). PA refers to the movement of body generated from skeletal muscles and ending up in expenditure of bodily energy. It may include exercising, walking, running or performing any task that involved body movement (Caspersen, Powell, & Christenson, 1985). The alarming fact about PA is that most of the children and adults are unable to perform required amount of PA (Myers, Kokkinos, Arena, & LaMonte, 2021). The reason can be lack of motor competence or lack of interest. This is why Physical Literacy (PL) is rapidly gaining attention of researchers especially in public health field (Cairney, Dudley, Kwan, Bulten, & Kriellaars, 2019). Origins of PL are found in existential and phonological philosophies. It is considered integral to human existence and inevitable to dwelling a healthy life. Foreseeing the multifaceted role of PL developed countries like New Zealand, Australia, Canada and UK have taken concrete initiatives to promote PL (Giblin, Collins, & Button, 2014). PL is a wholesome concept encompassing four very integral domains of human development and explains how lifelong learning is associated with individual and social processes. Each of its domain is closely linked with a specific human developmental domain as Physical (physical competence), cognitive (knowledge & understanding), affective (motivation & confidence) and behavioral (daily behavior) domain (Cornish, Fox, Fyfe, Koopmans, Pousette, & Pelletier, 2020). Amelioration in physical competency and engagement in physical activity (PA) alone hardly guarantees lifelong behavioral alteration. Within school context, interventions that girdle around PA exhibit either minor or no significant impact on PL. This scenario offers a whole new realm for

interventions and investigations that contribute towards enhancing overall PA competence and lifelong predilections of children towards PA (Elsborg, Melby, Kurtzhals, Tremblay, Nielsen, & Bentsen, 2021).

Trends of utilizing interventions based on or with technological assistance are increasing. The adopted strategies of interactive games based on virtual reality technology provide instant feedback and increase chances of providing more movement repetitions (Adams, Ferguson, Lust, Steenbergen, & Smits-Engelsman, 2016) but still lack the level of evidence necessary to prove them parallel or better than physical interventions in volume and effect for children with DCD (Cavalcante Neto, Steenbergen, & Tudella, 2019). So far efficacy of conventional physical activity interventions is more evident and acceptable in comparison with the technology based interventions for children with DCD (Ashkenazi, Weiss, Orian, & Laufer, 2013). Therefore occupational or pediatric physical therapist has a crucial role to play in improving physical competence and life skills of children with DCD. Children with DCD are normally referred to physical rehabilitation service providers for learning and enhancing motor skills. For this purpose normally task-oriented or process-oriented interventions are applied. Task-oriented approach is used to enhance competence in a particular task whereas process-oriented interventions aim at overall body function and motor process (Zwicker, Missiuna, Harris, & Boyd, 2012). Application of different types of interventions is different ways of approaching solution for motor related problems of children with DCD. Interventions based on therapeutic approaches, process-oriented approaches and task-oriented approaches serve the same broader goal (Smits-Engelsman et al. 2013). Moreover, disability oriented approaches and sport specific training have also been used. All intervention in one way or the other eventually aimed at overcoming motor limitations of children with DCD. Though the trends of introducing varied types of interventions for DCD is growing yet the need for motor skills interventions for improving motor competence and functional abilities of children with DCD is immense (Au, Chan, Lee, Chen, Chau, & Pang, 2014). In comparison with the typically growing peers group of 7 year old, children with DCD show less level of perceived athletic competence (Poulsen, Ziviani, & Cuskelly, 2008). Difference in physical activity in children with and with DCD of the same age group largely depends upon differences in perceived athletic competence between the groups (Noordstar, Net, Voerman, Helders, & Jongmans, 2017).

Variety and a large available number of interventions encourage to search out evidence for already conducted studies applying any particular type of intervention and unveil its effectiveness for children with DCD. Considering the importance of interventions based on physical activities this review endeavors to trace out researches which were designed to use physical activities only to overcome motor limitations of children with DCD and also to highlight the shift of interventions occurred in last ten

years (if any) from PA to the broader area of PL for children with DCD. Therefore, this study intends to find answers of two questions. How many interventional studies based on physical activities with reliable designs are available targeting improvement level in physical activity or physical literacy of children with DCD? Do findings of available studies exhibit positive treatment effect?

### **Methodology**

#### ***Selection of Studies***

A review of literature was systematically conducted for the identification of researches focusing on PA interventions aimed at improving level of physical competence as well as development of PL in children with DCD. Children with any other diagnosis were not made part of the review. Similar terminologies used in literature like dyspraxia were also not considered. Studies which involved children with DCD but have some allied conditions (like ADHD) were kept out of the search. For selection interventions had to be designed for children purely and only having DCD. Step one involved the identification of titles and abstract of articles appeared against the search that matched the purpose of this study. Any abstract, article, thesis, dissertation, book chapter, commentary and letter to editors written in any other language except English were excluded. No age limit was proposed for articles involving interventions for developing PA or PL in children with DCD. Hence no article was excluded on the basis of age of the participants. Full articles of the relevant abstract were studied for better understanding and determining the correct inclusion. Step two involved the exclusion of review articles, meta-analysis, scoping reviews, brief reports, short communications, replication studies, conference abstracts, comparative studies, articles designing sports specific interventions and including children with any allied condition intervening with the diagnosis of DCD based on DSM-V. Researches on children at risk of DCD are also excluded. Studies focusing on assessments, validations and reliability of tools, co-morbidities, were also not included. Moreover, interventions based on technology or electronic gadgets like video games, Exergames, Wii Fit, Nintendo, virtual reality games etc were also excluded. Interventions based on physiotherapy methods like Kinesio taping and motor imagery were also excluded. Studies involving therapeutic exercises as interventions were included in the search. Pilot studies were allowed for selection increasing number of studies for review but no compromise was done on design of the study.

#### ***Search Strategy***

A systematic search was made using four electronic databases (PubMed, Eric, Science Direct, Springer) from January 2013 to March, 2022 (last ten years) by two reviewers. The search strategy included finding literature through three different types of combinations. Each combination involved two terminologies which were combined with the help of Boolean Operators (AND). The combination of terms included were

developmental coordination disorder AND physical activity intervention, developmental coordination disorder AND motor skills intervention, developmental coordination disorder AND physical literacy intervention. Three different combinations were searched. Each combination comprised two key terms. No key term was separately used in any database. One by one all three combinations were separately applied for search on each database and the appeared articles were reviewed according the selection criterion. In general six types of studies were found based on type of intervention being applied; general physical activities, sports specific activities, activities based on electronic interactive games and technology, process oriented, deficit oriented and task oriented interventions. These studies were carefully screened against the selection criterion. Studies meeting the inclusion criterion were selected for the review and rests were removed as per steps proposed in the study.

**Table 1**  
*Steps Involved in Article Selection and Screening*

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Searching of three key terms in four databases	Title reading and selection of apparently relevant looking articles	Deleting automatically generated duplicate items by Zotero.	Manually deleting remaining duplicate items.	Abstract and full article reading in detailed	Final selection of article for review

**Table 2**  
*Summary of Key terms, Databases, Steps of article screening and selection*

Key Terms	PubM ed	Er ic	Scien ce Direct	Sprin ger	Total Articles	After Title Reading	After Removing Duplicate by Software & Manually	After Abstract/Article Reading (Finally Selected for Review)
“Developmental	122	22	511	205	860	89	72	03

Coordinatio n Disorder” AND Physical Activity Interventio n								
“Developm ental Coordinatio n Disorder” AND Motor Skills Interventio n	361	38	638	239	1276	75	52	02
"Developm ental Coordinatio n Disorder" AND Physical Literacy Interventio n	01	22	60	34	117	03	02	Nil
Total number of articles of all three terms in each database	484	82	1209	478	2253	167	126	05

## Results

Altogether 2253 articles appeared on four databases against search with three different key terms. These articles were screened by the titles appeared in the searches that brought down the number of articles to 167. Data was compiled and managed by using Zotero software. Using Zotero’s duplicate item search option 33 articles were found as

duplicates and were immediately removed to further narrow down the search. A quick reading was then given to article titles for ensuring absence of any duplicate item and found 08 more duplicate articles which were manually removed, hence further shortening the number of articles to 126. In next step, further screening was done and all other studies were removed that didn't match the inclusion criteria by consulting abstract and reading full articles. At this stage assessments, proof of concept studies, all comparative studies in which comparison was made between children with and without DCD and studies focusing on task-oriented interventions including handwriting, having participants above 12 were removed. Moreover studies which either used designs other than randomized pretest posttest control group design or not clearly specified the type of design used in the study were also removed. Intervention inclined towards medical and psychological domains were also excluded (effect on bone mineral, stress etc). Interventions based on particular sports specific trainings, motor imagery and involving neurological element were also removed. Studies finding relationships, determining personal and environmental factors for participation in physical activities, aiming at skeletal improvements, incorporating subgroups of children with DCD based on intensity of disorder, focusing children at risk of DCD were also not included. Furthermore, studies that designed interventions based on technology like exergames, video games etc were removed. On completion of detailed reading of abstract and articles and close monitoring of set criterion total 05 studies were left which eventually met the set criterion. Consequently, these 05 studies were finally selected for review.

All the studies used randomized pretest/posttest designs to ensure removing all biases in selection of sample as evidence of effect weakens when selection of sample is not bias free. None of the studies used weak design to ensure reliable level of evidence for authenticating and generalizing the outcomes of the study. Duration of interventions vary and range from minimum 08 weeks to 12 weeks and from minimum 08 sessions to maximum 36 sessions. Sessions wise detail of interventions reveals two studies using interventions based on 08 sessions, one used 20 sessions, one used 24 sessions and one used 36 sessions. No study except one used a relatively a bigger sample size (60). Range of sample size lasts from maximum 60 participants to minimum 20 participants. Rest of the three studies selected 30, 24 and 22 participants. Gender ratio of participants was not equal as the study with maximum number of participants (60) incorporated 43 male and 17 females. All studies except one mentioned the male/female ration in participants of control and experimental groups. More number of male participants is proportioned with the male/female prevalence ration of children with DCD (4:2). Reliable protocols and tools were used by all studies to determine the level of physical competence among participants as Movement Assessment Battery for Children (MABC) was commonly used by all researches for diagnosis of DCD except one which used Body Coordination Test for Children (BCTC). One of the most important elements prior to designing interventions is to ensure correct diagnosis of the disorder. DCD is relatively new disorder gaining rapid attention and consideration among researchers and other

professional. So a strict diagnosis was followed in all the studies. Separate balance test was used in all studies to complete the diagnosis. It was ensured that participants had similar level of DCD so that the ability level doesn't affect the results. Consideration of the determining current level of DCD is a prerequisite for acquiring reliable results and evidence for generalization. Most appropriate and correct analysis of data helps in computing and presenting reliable results. Two studies used ANOVA for analysis. Other studies used multiple tests like MANOVA and Mauchly's test of Sphericity, Mann-Whitney U, Chi-square and Wilcoxon Signed Ranks tests and lastly Shapiro Wilk, independent and paired t-test. Results revealed that every research ended up in leaving positive impact on the motor functioning of children with DCD. Two studies attempted to check effect on particularly single area of physical development i.e balance and two studied studies effect on overall motor competence whereas one research focused on motor functioning and daily life skills both. One study was severely affected by Covid-19 causing reduction of sample size from 63 to only 17 participants. Parents were not interested to send their wards to the institutes due to rapidly increasing spread of Covid-19. This study was conducted in small kindergarten, used both genders without specifying the exact ratio of male/female participants. Small number of participants may weaken the evidence for effectiveness of the proposed intervention. Overall, all studies were designed and conducted abiding by reliable research norms and hence evidence and authenticity can be claimed.

**Table 3**

*Summary of Finally Selected Research Articles for Review*

S.No	Research Title	Design	Intervention	Sample	Analysis	Results
1	Does a physiotherapy programme of gross motor training influence motor function and activities of daily living in children presenting	Randomized Pretest/post test	8 week intervention based on physiotherapy. Once a week 30 minute session.	60 children with DCD (43 M & 17 F), 6 – 12 years of age equally divided in control and experimental group	An unpaired t-test and analysis of variance (ANOVA) were used to compare the control and intervention groups	8 weeks of gross motor training which can be a beneficial intervention for physiotherapists to improve gross motor function for DCD. An improvement

					with developmental coordination disorder?	by comparing the scores of ball and balance skills to determine the impact of the intervention.	t of 6.46% in MABC score, 4.80% balance score and 3.54% ball skills score have been observed. Improvement in DCDQ score was significant at (p < 0.05).
2	A Ten-Week Motor Skills Training Program Increases Motor Competence in Children with Developmental Coordination Disorder	Randomized Pretest/post test	10 weeks intervention, twice a week 45 min session	24 children with DCD, 4 - 6 years old, with DCD unequally divided in control (07)and experimental group(17)	Use of ANOVA highlighted the difference.	After involvement in 10 week motor skills program improvement in balance, manual dexterity, aiming and catching and in total MABC-2 score has been observed.	
3	Can balance trampoline training promote motor	Randomized Pretest/post test	12 weeks intervention, 3 days a week 45 minute session	20 children with DCD (13 M & 07 F), 8-9 years old,	Mauchly's Test of Sphericity and MANOVA were	Use of trampoline for improving balance and functional	

<p>coordination and balance performance in children with developmental coordination disorder?</p>			<p>equally divided in control and experimental groups</p>	<p>used.</p>	<p>outcomes can be an effective intervention for children with DCD.</p>
<p>4 Core stability exercise is as effective as task-oriented motor training in improving motor proficiency in children with developmental coordination disorder: a randomized controlled pilot study</p>	<p>Randomized Pretest/post test</p>	<p>08 week intervention, once a week 1 hour session</p>	<p>22 children with DCD (15 M &amp; 07 F) with 6-9 years of age, divided in control and experimental groups</p>	<p>Mann-Whitney U Tests and Chi-square tests were used for continuous variables and nominal variables, respectively. The pre-test and post-test data of each of the two treatment groups were compared using Wilcoxon Signed Ranks</p>	<p>Program of core stability exercise can be considered as good and impactful as any task-oriented training program for bringing improvement in motor proficiency of children with DCD.</p>

				Tests.		
5	The effect of strength training based on process approach intervention on balance of children with developmental coordination disorder	Randomized Pretest/post test	12 week intervention, total 12 sessions. Flexible duration of session according to task repetition.	30 children with DCD(22 M & 08 F) with 7-9 years of age, divided in control and experimental groups. EG: 10 M / 05F CG: 12 M / 03F	The collected data was analyzed through descriptive statistic (mean and standard deviation), ensuring data normal distribution by Shapiro Wilk Test and then independent and paired sample t-test with ( $\alpha= 0.05$ ) as well as SPSS software version 18.	Significant improvement in muscular strength ( $P < 0.001$ ) and static balance performance ( $P < 0.05$ ) has been observed whereas no such improvement in dynamic balance ( $P > 0.05$ ) has been observed.

## Discussion

Despite the fact that an immense amount of literature is available on interventions designed for children with DCD, there has been a relatively lesser tendency of interventions in near past that focused to ameliorate motor performance of children with DCD by using particularly physical or motor oriented activities. There was an

abundance of literature offering mixed interventions e.g based on technological devices, video games and neurological and psychological elements. Comparative studies are also available in which comparison is made between children with and with DCD in achieving physical competence through physical activity interventions. Studies with application of varied approaches of physical interventional were also found. Though limited but intervention based on specific sports training could also be found. Among huge number of interventional researches for children with DCD, finding physical activity based interventions was the task. Within this scarce availability of studies using physical activities as interventions apart from one study, rest followed reliable procedure and interventions. The studies would be more credible and generalizable if the volume would have been slight broader and bigger. Results of all the reviewed interventions reveal positive treatment effects which are supported by other reviews conducted by Jane, Burnett, & Sit, (2018) and Offor, Williamson, & Caçola, (2016).

Doubtlessly, correct diagnosis ensures efficacy of intervention. This is so true in case of DCD as being disorder not to mix with any disability. DCD is relatively new term for many and conceptually it is in its infancy in many countries of the world. This is why diagnosis of children with DCD requires special concern and strict abiding by standardized procedure. DSM-V in this regard provides clear and strict diagnostic criterion. All five studies included in this review used standardized procedure of diagnosing children with DCD. Special consideration was given to ensure absence of anyco-morbid medical problem which is essential to diagnosis of DCD. Presence of co-morbidity or any other disorder excludes an individual from being purely suffering from DCD.

On one hand there was a serious dearth of interventions based on physical activities without involving assistive technological, neurological or psychological element while designing interventions, on the other hand much worse and aggravated scenario has been observed for physical literacy. Complete absences of such interventions that aim at physical literacy succeed in tracing a huge gap to be filled in by researchers. This alarming fact of unavailability of interventions aimed at developing or enhancing physical literacy in children with DCD not only encourages researchers for paying serious heed to the matter but also motivate them to find out the reasons of this gap. Designing interventions for the development of physical literacy can be fruitful shift. This will help children with DCD to become physically literate, quit sedentary habits and chose a better lifestyle for themselves.

## **Limitations**

The selection criterion was strict and narrow because of which small number of researches was included in final selection. The reason behind selecting a strict and

narrow criterion was population and area this review has targeted. Children with DCD have limitations in learning and performing physical tasks. Hence, only those interventions were studied which were designed purely on the basis of physical activities. Moreover, this review was targeted on unveiling the current trends and preferences of researchers when it comes to designing interventions on either PA or PL for children with DCD. Without determining current preferences it was not possible to propose what and why future researches should be based on for children with DCD.

Study was limited to select articles published within last ten years only. Since, the review aimed at not only tracing out present trends and latest trends which would have not been possible if older researches were selected. Moreover, based on current scenarios, future directions were also to be given. Current scenarios and directions needed to be synched for the time they are respectively being studied and proposed.

## **Conclusion**

Review of all available studies exhibit positive treatment effect. These results provide reliable evidence that interventions based on physical activities are effective medium of overcoming motor skill learning and performance limitations in children with DCD. These outcomes are aligned with outcomes proposed by already available literature and hence make the evidence even stronger. Apart from proven effectiveness of physical activity interventions, this search also reveals that available literature published in last ten years aiming at designing motor interventions to increase motor competence of children with DCD is scarce. Not only this, area of PL in relation to children with DCD is still in its infancy. Reasons of being an understudied area are still unknown but the search verified that studies intending to target PL of children with DCD were hardly available as no such study was found during the search which has identified a gap to be filled in by the researchers.

## **Recommendations**

More experimental and interventional researches should be designed to improve conditions of children with DCD. Since DCD is a lifelong limitation, researchers should be encouraged to design interventions for bigger age group and adults. This is how present condition of individuals in elder age groups with DCD can be understood and new interventional directions can be unveiled and experimented. An urgent shift is also direly needed in which centre of attention should be PL instead of PA. PL being latest and broader concept can prepare children with DCD more aptly and propose better understanding for coping with lifelong motor limitations. This shift can increase the possibilities of providing most appropriate intervention for improving motor performance and overcoming motor limitations of children with DCD.

Present study uses three combinations of terms on four databases for the selection of relevant studies. Future researchers may include more term combinations and increase the number of databases for the search to broaden the area and increase the chances of finding articles more in number and better in aptness.

## Implications

This review will be highly beneficial for the researchers interested in exploring new realms of research for children with DCD. The scarcity of researches revealed by this review will provide researchers with a new area for research and experimentation. Researchers may also tend to endeavor for creating and using better protocols for interventions based on interactive technology and put effort to increase the interventional evidence of such studies. This will eventually help children with DCD to gain motor competence. Moreover, development of physical literacy in typically developing children has started gaining importance among researchers. The reason behind this rapidly growing trend of physical literacy is the larger, broader and lifelong scope of this newly emerging concept. This review will contribute in bringing researchers' heed towards designing interventions aimed at improving physical literacy of children with DCD which so far has not been experimented and apparently deemed most appropriate for this population.

## References

- Adams, I. L., Ferguson, G. D., Lust, J. M., Steenbergen, B., & Smits-Engelsman, B. C. (2016). Action planning and position sense in children with developmental coordination disorder. *Human movement science, 46*(1), 196-208.
- Ashkenazi, T., Weiss, P. L., Orian, D., & Laufer, Y. (2013). Low-cost virtual reality intervention program for children with developmental coordination disorder: a pilot feasibility study. *Pediatric Physical Therapy, 25*(4), 467-473.
- Au, M. K., Chan, W. M., Lee, L., Chen, T. M., Chau, R. M., & Pang, M. Y. (2014). Core stability exercise is as effective as task-oriented motor training in improving motor proficiency in children with developmental coordination disorder: a randomized controlled pilot study. *Clinical rehabilitation, 28*(10), 992-1003.
- Bo, J., & Lee, C. M. (2013). Motor skill learning in children with developmental coordination disorder. *Research in developmental disabilities, 34*(6), 2047-2055.

- Cairney, J., Dudley, D., Kwan, M., Bulten, R., & Kriellaars, D. (2019). Physical literacy, physical activity and health: Toward an evidence-informed conceptual model. *Sports Medicine*, *49*(3), 371-383.
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports*, *100*(2), 126-131.
- Cavalcante Neto, J. L., Steenbergen, B., & Tudella, E. (2019). Motor intervention with and without Nintendo® Wii for children with developmental coordination disorder: protocol for a randomized clinical trial. *Trials*, *20*(1), 1-12.
- Chirico, D., O'Leary, D., Cairney, J., Haluka, K., Coverdale, N. S., Klentrou, P., & Faught, B. E. (2012). Longitudinal assessment of left ventricular structure and function in adolescents with developmental coordination disorder. *Research in developmental disabilities*, *33*(2), 717-725.
- Cornish, K., Fox, G., Fyfe, T., Koopmans, E., Pousette, A., & Pelletier, C. A. (2020). Understanding physical literacy in the context of health: a rapid scoping review. *BMC public health*, *20*(1), 1-19.
- Edition, F. (2013). Diagnostic and statistical manual of mental disorders. *Am Psychiatric Assoc*, *21*(1), 591-643.
- Elsborg, P., Melby, P. S., Kurtzhals, M., Tremblay, M. S., Nielsen, G., & Bentsen, P. (2021). Translation and validation of the Canadian assessment of physical literacy-2 in a Danish sample. *BMC public health*, *21*(1), 1-9.
- Giblin, S., Collins, D., & Button, C. (2014). Physical literacy: importance, assessment and future directions. *Sports Medicine*, *44*(9), 1177-1184.
- Harrowell, I., Hollén, L., Lingam, R., & Emond, A. (2018). The impact of developmental coordination disorder on educational achievement in secondary school. *Research in developmental disabilities*, *72*(1), 13-22.
- Huau, A., Velay, J. L., & Jover, M. (2015). Graphomotor skills in children with developmental coordination disorder (DCD): Handwriting and learning a new letter. *Human movement science*, *42*(1), 318-332.
- Jane, J. Y., Burnett, A. F., & Sit, C. H. (2018). Motor skill interventions in children with developmental coordination disorder: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, *99*(10), 2076-2099.
- Marconcin, P., Werneck, A. O., Peralta, M., Ihle, A., Gouveia, É. R., Ferrari, G., & Marques, A. (2022). The association between physical activity and mental

- health during the first year of the COVID-19 pandemic: a systematic review. *BMC Public Health*, 22(1), 1-14.
- Myers, J., Kokkinos, P., Arena, R., & LaMonte, M. J. (2021). The impact of moving more, physical activity, and cardiorespiratory fitness: Why we should strive to measure and improve fitness. *Progress in cardiovascular diseases*, 64(1), 77-82.
- Noordstar, J. J., van der Net, J., Voerman, L., Helders, P. J., & Jongmans, M. J. (2017). The effect of an integrated perceived competence and motor intervention in children with developmental coordination disorder. *Research in developmental disabilities*, 60(1), 162-175.
- Offor, N., Williamson, P. O., & Caçola, P. (2016). Effectiveness of interventions for children with developmental coordination disorder in physical therapy contexts: a systematic literature review and meta-analysis. *Journal of Motor Learning and Development*, 4(2), 169-196.
- Poulsen, A. A., Ziviani, J. M., & Cuskelly, M. (2008). Leisure time physical activity energy expenditure in boys with developmental coordination disorder: The role of peer relations self-concept perceptions. *OTJR: Occupation, Participation and Health*, 28(1), 30-39.
- Preston, N., Magallon, S., Hill, L. J., Andrews, E., Ahern, S. M., & Mon-Williams, M. (2017). A systematic review of high quality randomized controlled trials investigating motor skill programmes for children with developmental coordination disorder. *Clinical rehabilitation*, 31(7), 857-870.
- Smits-Engelsman, B. C., Blank, R., Van Der Kaay, A. C., Mosterd-Van Der Meijs, R. I. A. N. N. E., Vlugt-Van Den Brand, E. L. L. E. N., Polatajko, H. J., & Wilson, P. H. (2013). Efficacy of interventions to improve motor performance in children with developmental coordination disorder: a combined systematic review and meta-analysis. *Developmental Medicine & Child Neurology*, 55(3), 229-237.
- Zwicker, J. G., Missiuna, C., Harris, S. R., & Boyd, L. A. (2012). Developmental coordination disorder: a review and update. *European Journal of Paediatric Neurology*, 16(6), 573-581.