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Motor Imagery Training through Action Observation and Imitation of Rhythmical Actions in Indian Children with Developmental Coordination Disorder

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Abstract

Developmental coordination disorder is characterized by clumsiness and awkwardness. Children with developmental coordination disorder (DCD) experiences difficulty in performing activities of daily living and any other tasks that demands motor coordination. Difficulty in executing activities of daily living is due to the underlying deficits both in imitation and motor imagery (MI). Observation of actions performed and motor imagery can be coupled to enhance the imitation of tasks to be executed in ADL. In the current study, the effects of motor imagery with action observation in children with and without developmental coordination disorder are evaluated. On each training phase, participants observed or asked to imagine a familiar rhythmical action. The actions perceived were either fast or slow and they can be habitual too. Tooth brushing, window wiping, paint brushing, face washing. The direction of movement can be vertical and horizontal. The speed of the habitual tasks was manipulated across each trials. 3 levels of manipulations across trials were listed and the level 1 task was to observe and imitate the targets action, level 2 was to instruct the child to observe the habitual task and imagine how to execute it from imitating and the third level was to observe and imagine at the same time before performing it. This evaluation of the kinematics declared that the typically developing children executed and imitated the task in many cycles with significant sequence than children with developmental coordination disorder. It has been proved that subsequent instructions at each phase of the trial improved the AO and MI execution capability among children with DCD. There is a significant improvement in DCD children for action observation and motor imagery training in observe and imagine component than execution. However in typically developing children, imitation of task was improved significantly. AO + MI instructions and approach is a promising approach to refining performance of everyday activities among children with and without DCD.

Keywords: Motor imagery, Action observation, DCD, kinematics, Indian children

Introduction

Developmental coordination disorder (DCD) is a persistent neuro-developmental disorder which is characterized by the difficulties in activities of daily living skills. It is a lifelong condition

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where the children exhibit difficulties in movement acquisition and difficulties relative to pertaining their age matched skills. The skills where the children found difficulties demands coordination, balance and integration of gross motor and fine motor skills[1].

Difficulties in these major domains were having a major impact on academic performance and social skill development. Secondary impact was predominant among children who left unattended with their primary consequences. School teachers who spend maximum time with these children reported that they were inactive and isolate themselves from other children in class and in physical education classes they appear clumsy and inactive[2].

If these loneliness and isolation were not considered at the early stage, it can leads to psychosocial complications. To enhance their coordination skill and movement skill, there is a need to incorporate physical practices and they are recommended at higher doses. Neuromotor task training and cognitive orientation were best to incorporate and previous researchers were also suggests the same techniques. A mental pacing technique which needs practice includes MI-Motor imagery technique which enhances the motor coordination and movement skill acquisition among children with developmental coordination disorder[3].

Motor imagery is the rehearsal of physical execution of action and it is an alternative form of mental rehearsal. Action observation is considered as an effective tool on motor training and movement skill training for children with developmental coordination disorder. To imitate the activity of daily living skill like brushing, combing, buttoning the shirt and unbuttoning it there is a need to support the combined action of observation and motor imagery[4].

Human movement requires support imitation of task. For children with developmental coordination disorder combing the action observation and motor imagery training facilitates automatic imitation of tasks that demands motor coordination. Previous researchers have documented the isolated effects of action observation and motor imagery training. In the current study the effects of action observation and motor imagery were used in combination to enhance the imitation of actions and transfer of observed actions to intentional imitation[5]. When analyzing the instructions delivered to imitation strategy in children with DCD, we have compared to when they initiate observation then imitation to observe, imagination before imitation.

Methodology

Twenty children of age group 5- 10 years were included in the study and in that ten children met the DSM-V (American Psychiatric Association,2013) diagnostic criteria for DCD and the other

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ten children m met the inclusion criteria for control group typically developing children. The volunteered children were right hand dominant and they had normal vision and found to have free from physical injury. Informed consent form was signed from parent or guardian. Ethical clearance was obtained from SRM medical college hospital and research institute.

Initial evaluation of the children's motor ability was conducted through Movement Assessment Battery for Children-2. If the child scored ≥20th percentile, they will be included under the typically developing children group and if the scores lies at the range of $\leq 16^{th}$ Percentile, the children will be included to the DCD group (Table 1). But for the allocation of children in DCD group, the Developmental Coordination Disorder Questionnaire was used to confirm the disruption in activities of daily living skills. Additional questionnaires were used to confirm the presence of any other neurological or visual defects that hinder movement acquisition. The health questionnaire and Vanderbilt ADHD Diagnostic Parent Rating Scale were used to confirmed the absence of additional defects.A repeated measures with between factors ANOVA was used to test the assumptions with alpha level of 0.05. The total sample used for the study (n=20) was considered adequate to scrutinize such an effect (Table 2).

Children were instructed to view the picture or video of target action to be followed. The actions displayed were consisted of rhythmical pantomime actions consecutively added at either a fast and slow pace. Everyday's activities like brushing, combing were displayed as target actions where the children instructed to perform the same through observation of actions. These movements were performed at slow as well as fast pace. Through observation, children were asked to perform the action as accurately as possible. The experiment composed of 16 trials executed in 3 blocks.

When performing each trial in different blocks the action speed and the habitual speed were manipulated. Face washing and paint brushing were habitual actions and instructed to execute the task slowly. However the window washing and tooth bushing actions need to be performed fast and they can be done in both vertical and horizontal plane. Therapist performs the action and the child should perform the mirror image of the actions executed by the therapist with dominant hand. To execute the task, the child needs spatial compatibility over the displayed action and performed actions.

During the performance of fast and slow habitual actions, the speed of the performance was paced with a metronome at the speed of 60 to 90 beats per minute (BPM) for slow actions and the metronome was timed at 120 to 180 BPM for fast actions. The experiments to be imitated by the children were displayed without any added sound effects in the main experimentation. The participants were instructed to copy the displayed action by ensuring them to verbally represent the action they viewed and going to observe as well as imitate. Intentional imitation of the presented task must be represented within 4 seconds. Practice trial was allowed once for all the children in the experimental and control group. Child is allowed to visualize the task for 1.5 seconds.

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Table 1: Movement assessment battery for children- 2 mean Scores of children with and without Developmental Coordination Disorder

Group	Manual dexterity	Aiming and catching	Balance	Mean standardized score	Mean Percentile score
DCD	7.2	16.3	24.5	54.4	7
Typically developing children	32.4	37.5	55.9	78.4	43
(p) value	.008	.012	.002	<.001	<.001

Table 2: Motor imagery Questionnaire-C subcategory mean score for children with and without DCD

Group	Internal Visual imagery	External Visual imagery	Kinesthetic imagery
DCD	4	4.3	4.2
Typically developing children	5.5	5.8	5.6
(p) value	.723	.056	.022

Results

By using the mean cycle time data, ANOVA was conducted for each group. This evaluated the within group factors of training and habitual speed. The major analyses were conducted using SPSS Statistics 25 (IBM). Alpha levels were set to 0.05, and effect sizes were calculated as partial eta squared values .To reduce type I error rates, Fisher's least significant difference (LSD) contrasts were used in all pairwise comparisons.

Discussion

The children with DCD experiences reduced capacity for planning the actions and sequencing it in order. There is now a body of research displaying the incapability of children with a reduced speed for action planning among Indian children with developmental coordination disorder. Internal modeling consists of forward model and inverse model[6]. The inverse model displays a motor composite of tasks to be performed to achieve the desired action in the sequence and it helps in moving towards the goal[7].

The forward model depicts the feedback from a copy of motor commands. This kind of predictive feedback will be compared to feedback from the environment. If the in congruency lies between predicted and sensory feedback from external environment generates the internal models[8]. These internal models will enhance future learning and helps in sequencing the movement pattern and planning the motor skills in real time.

Wilson et al in 2013, evaluated the internal model deficit in children with developmental

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coordination disorder elaborated that there is an overlap between neural mechanics involved in motor planning , motor imagery and action planning as well as observation[9]. Wilson, Maruff et al in 2015 concludes that there is a consistent difficulty in motor imagery ability in children wit developmental coordination disorder compared to other typically developing peers.

When there is biomechanical and temporal constraints this Motor imagery training will enhance the action planning and if the sequence was repeated through repeated practice, it further facilitates and improves the action planning[10]. Further prolonged training will enhance the movement skill acquisition in children with developmental coordination disorder. Licari et al in 2015, suggested that functional magnetic resonance imagining (fMRI) studies suggests that action observation network (AON) may be impaired in this population and they concluded in through the findings of whole-brain analyses that there is a reduced activation of precentral gyrus and inferior frontal gyrus during tasks that demands observation and imitation in children with developmental coordination disorder[11].

Behavioral research in children with developmental coordination disorder shows there are limitation in imitation of gestures and there are intentional difficulty in responding to task that demands equivocal responses[12]. There is a remarkable enhancement in the neurophysiologic research that suggests there is a increased activation of neurons and that simultaneously facilitates the AON involvement in children with developmental coordination disorder by following the combination techniques of action observation and motor imagery training. When comparing the children with typical development, children with developmental coordination disorder shows enhanced motor improvements through regular interventions that combines motor imagery training and action observation[13].

Riach, Holmes, & Wright in 2016 involve kinesthetic imagining of actions and sensations that demands visual display of same action at the time. The instructions were designed in a way that involves imaging a task more rather than executing it. Previous researchers experimented the automatic imitation paradigm using AO and MI[14]. but the combination techniques were not tested among Indian children with developmental coordination disorder. For the imitation of automatic task there is a need for stimulus response compatibility and the child have to impede execution of actions in a synchronized way to facilitate the motor neurons[15].

The instructions were delivered in a way to synchronize the actions in a rhythmical way for example face washing and painting. In the current study, the combined instructions with AO and MI commands significantly improved the initiation of automatic movement in children with developmental coordination disorder[16]. The combined therapeutic interventions and commands delivered will enhance the sensorimotor activation that further supports the representation if internal motor neurons and finally the forward planning mechanism are activated. Behmer et al in 2016, had more or less used the same paradigm but calibrated the report using electroencephalography recordings[17].

These combined techniques were suggested to enhance the action Observation behavior of children with developmental coordination disorder. The current study evaluated the intentional imitation of familiar actions using the previous researcher’s paradigms but by combing the two

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paradigms as combined approach[18]. There was a significant difference between two groups in their motor ability and it was assessed through MABC-2. The study adds evidence that mechanism of neurocognitive input which underlies the automatic imitation task was intact among Indian children with developmental coordination disorder.

The findings were in contrasts with the previous researchers findings on behavioral deficits in DCD. Molnar at al in 2007 stated a dominant explanation on imitation of familiar task and he insisted that intentional imitation is more complex task that engages action planning mechanics which is impaired for children with DCD[19].

Intentional imitation is mandatory component used by the researchers to facilitate movement skill acquisition and the research findings concludes that demonstration of movement task enhances the motor learning in typically developing children and children with developmental coordination disorder. However there is limited research in the area of observational learning among Indian children with developmental coordination disorder[20].

Conclusion

Combined AO+MI interventions improved the replication ability in children with and without DCD. When compared their natural imitation ability, instructions followed by AO and MI were suggested as an efficient method to improve the imitation ability in children with and without DCD. The current research further suggests that AO and MI training were efficient for training children with DCD. Further studies were required to support the findings. This AO+MI interventions were easy to administer and low cost to be incorporated in clinical practices to facilitate the movement acquisition among children with developmental coordination disorder.

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Availability of data and other materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Please mail and reach us in monisha_ravikumar@srmuniv.edu.in

Ethics approval and consent to participation

The study was approved by the Institutional Ethics Committee (Human Studies) of the SRM Institute of Science and Technology, Kattankulathur with Approval No. 1755/IEC/2019. Written informed consent for interviews was obtained from all participants. The privacy and confidentiality of all the participants was strictly maintained.

Competing interests
Authors declare no conflict of interest

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