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An individual’s ability to perform a task depends on several factors which could be intrinsic or extrinsic in nature. Most tasks in our everyday settings rely on our ability to generate the desired response when we perceive a certain stimulus. This ability to respond to various stimuli differs among individuals, amid situations, and across lifespan.

The ability to solve problems that we face every day requires interaction between multiple neural systems in a coordinated manner to achieve the desired goal, which is known as the executive function (EF) of an individual. Executive function is a set of cognitive skills which allows an individual to produce the desired motor response. The prefrontal cortex plays an important role in EF by controlling the integration of information from multiple neural systems in the cortical and subcortical areas. Deficits in EF impairs the cognitive and motor abilities of individuals leading to difficulties in performing daily activities. The efficiency with which a response is generated relies on the executive functions and motor control abilities of an individual.

This ability to efficiently respond is as essential for individuals with intellectual disabilities as it is for general population. “Intellectual disability” which was previously referred to as “mental retardation” was given a new name i.e. “intellectual developmental disorders” which is defined as “a group of developmental conditions characterized by significant impairment of cognitive functions, which are associated with limitations in learning, adaptive behaviour and skills”. Individuals with IDD of different etiologies are known to be impaired in their cognitive ability especially
executive functions.\textsuperscript{4,5} Individuals with Down Syndrome (DS), the most common cause of IDD, are more impaired in their EF, especially working memory (i.e., a component of EF which functions as a unit which temporarily stores, processes and manipulates information) as compared to those with other causes of IDD.\textsuperscript{6,7} The prefrontal cortex, which plays a major role in executive functions\textsuperscript{1}, is said to have a disrupted functioning in individuals with DS\textsuperscript{8}, which may be responsible for their poor performance in an array of cognitive tasks.\textsuperscript{9}

Deficits in EF influences adaptive behavior and ability to learn, which leads to lower levels of adaptive functioning resulting in reduced capacity to perform daily activities commonly seen in individuals with IDD and DS.\textsuperscript{2,5,6,10} An impaired ability in adaptive functions alters the performance of tasks especially in terms of the time taken i.e., response time (RT), and the force with which the task is performed i.e., response force (RF). Both RT and RF influence how a task is performed and therefore form important aspects of our daily activities\textsuperscript{11} as they aid in the smooth execution of tasks.

Apart from EF, individuals with ID especially DS have deficits in motor control\textsuperscript{12–14} and perceptual-motor deficits which are said to be due to poor perceptual motor coupling (the interaction of perceptual and motor processes to produce the desired action).\textsuperscript{15,16} Impairments in perceptual motor coupling are seen in children with DS when they perform actions like catching a ball or avoiding obstacles while walking, both require the integration of visual i.e. perceptual and motor systems.\textsuperscript{16} The impaired functional connectivity and integration of information between the cortical networks required for motor processing i.e., planning and coordination of
movements, could be the basis of impaired motor control and sensorimotor integration in individuals with DS.\textsuperscript{17}

In most areas of motor functions children with DS display poor motor control, fine and gross motor skills.\textsuperscript{18,19} Evidence suggests that while performing the same task, RT is slower among DS as compared to those individuals with IDD or healthy controls.\textsuperscript{7,20–23} Among children with ID, those with DS have a slower and more variable RT.\textsuperscript{20,21,24} Response force, on the other hand, has been studied predominantly in healthy individuals and in the elderly individuals.\textsuperscript{25,26} Masumoto et al compared TDC and adolescents with DS for their timing and force components while performing a unimanual and bimanual tapping task and found a difference in their abilities with regard to the magnitude of errors for force and delay in onset of movements, which was attributed to the difference in the motor unit recruitment among individuals with DS.\textsuperscript{27} Variable force output and lower ability to anticipate modifications in force or to modulate force by making appropriate adjustments have been observed in those with DS among others.\textsuperscript{28,29}

The baseline functional deficits in terms of responding may be amplified among individuals with DS and IDD when they are performing more than two tasks at the same time or dual-task. Dual-task abilities have said to increase the time taken to respond, however, the changes in the response force are not well known. A similar scenario may be generated if they are asked to modulate the force with which they respond or to respond specifically based on the stimulus provided like in a choice response task. Under such situations, the amount of time taken to respond and the force with which the response is produced may undergo further alteration. Dual-task
impairments are seen in children with DS as compared to TDC\textsuperscript{30} and the ability to dual-task is more impaired in DS as compared to individuals with William Syndrome and Intellectual Disabilities of unknown etiologies.\textsuperscript{31}

Although important aspects of motor control, RT and RF have been collectively studied only by a few. Hence, the present study aimed at understanding the response abilities in terms of RT and RF of individuals with DS and IDD across task conditions in a series of experiments. We hypothesized that there exists a difference in the RT and RF abilities of children with DS, IDD and those who are typically developing; which are more pronounced when they are examined under different task constraints and conditions. The task conditions that we chose to explore were routine task situations which included simple task, dual-task, choice response task and their ability to modulate the force required for performing a task. Performance of tasks across these conditions has been studied in healthy controls. Studying response abilities across these task conditions collectively and comparing them among a cohort of children who are healthy and have pre-existing cognitive motor impairments, is worthy to be explored.

Over the year’s studies have addressed training to improve function in individuals with IDD and DS. Training in this population had major emphasis on motor skills\textsuperscript{32} or motor performance\textsuperscript{33} and encompasses areas like early intervention programs,\textsuperscript{34} strength,\textsuperscript{35} balance,\textsuperscript{33} aerobic conditioning,\textsuperscript{36} physical fitness,\textsuperscript{37,38} etc., to name a few. The shift of focus from purely motor and function based training to cognitive and the finer aspects of motor control is gaining recent considerations as cognitive functions are just as important as training gross motor functions.\textsuperscript{39} EF and motor ability in
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individuals with ID have a high correlation,\textsuperscript{4,39} one influencing the other and both resulting in greater time in performing complex EF tasks.\textsuperscript{4} Interventions which aim at improving motor skills, anticipatory and motor sequencing abilities can contribute towards reducing motor impairment and improving EF resulting in better ability to respond to complex situations.\textsuperscript{4} Practice and training ranging from computerized training to aerobic training are said to improve EF in any age group.\textsuperscript{40} Various methods have been used to improve cognitive functions including gaming based interventions in Paediatric population.\textsuperscript{41}

Response time has been used for understanding an individual’s cognitive motor ability and is considered as the simplest tool for assessing cognitive function;\textsuperscript{42} whereas RF has been used for understanding the mechanisms for generating motor responses.\textsuperscript{43–45} Training to improve RT has been primarily targeted among individuals participating in sports. Various forms of training like neuromuscular training and plyometrics, are known to have a positive effect on RT among normal healthy individuals.\textsuperscript{46} However, the magnitude or focus of training RT among individuals with disability is not similar to that seen among able individuals. Training to improve RT can infact serve more significance among individuals with disability as it can enable them to perform their regular tasks faster, with more precision and efficiency.

Training of RT may have significance in the light of literature suggesting increased risk for all-cause mortality among young and healthy older adults.\textsuperscript{47,48} Over the years studies have shown that training has brought an improvement in RT among children with DS and IDD.\textsuperscript{49–51} Recent studies among children with IDD and DS have shown a similar improvement in RT with training.\textsuperscript{52–54} In children with DS, it was observed that
practice of tasks improved the total force control and accuracy while variability of practice improved control and coordination while performing finger tasks. RF has been studied solely in lab setting and it’s unclear whether training can influence the RF abilities and if it does in what way does it help the individuals. Training in home and community-based settings without use of laboratory facilities or complicated equipment is gaining momentum to allow replicability of training methods in countries with resource limited settings.

Training the identified motor control deficits with regard to the ability to respond with the help of simple exercise programs and video games to target a change in RT and RF will help us understand how an exercise program can influence the outcome on these basic tasks which form an essence of our everyday lives. Changes in these variables could influence the daily living abilities of individuals with DS and IDD.

1.1 NEED FOR THE STUDY

Components of responses i.e. ability to modulate force, respond to variable stimuli and respond in presence of distraction, are elements essential for good motor control; all of which have not been collectively looked at among children with IDD.

How performing a simple task, dual-task, choice response task and force modulation task influence both the RT and RF abilities among children with DS and IDD when compared to TDC will provide us a basic understanding of the influence of task on their underlying dysfunctions and motor control abilities.

The influence of these tasks on RT and RF and the impact of therapeutic interventions on response abilities in children with IDD has not been explored until now.
1.2 **AIM OF THE STUDY**

1. To assess the response abilities in terms of response time and response force across various task conditions among children with DS and IDD as compared to children who are typically developing.

2. To compare the effect of training with object control skills or video game based training interventions on response abilities in terms of response time and response force among children with IDD.

1.3 **OBJECTIVES OF THE STUDY**

The study was divided into two phases to meet the aims of the study.

**PHASE 1**

To compare the response time and response force of children with intellectual developmental disorders, Down Syndrome and typically developing children across tasks such as

- Simple response task
- Dual-task – Passive and Active dual-task
- Force modulation task
- Choice response task
PHASE 2

Primary objective

- To compare the effect of object control skills training and video game based training against no training, on response time and response force across task conditions among children with IDD

Secondary objective

- To compare the effects of object control skills training and video game based training against no training on response time using the ruler drop test among children with IDD
- To compare the effects object control skills training and video game based training against no training on upper limb speed and dexterity among children with IDD