Cognitive Abilities In Children With Different Muscle Tone Disorders

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Abstract:

Background: Cognition is the ability of the central nervous system to acquire, process, and act on information from the environment. Children with neuromotor disorders have multidisplinary disabilities, so it is important to investigatehow can the muscle tone disorders affect the cognitive abilities including attention / concentration level, maximum reaction time and figural memory level and its deviation from normal.**Methods:** Thirty one child ranged in age between five and eight years with muscle tone disorder (15 hypotonic), (16 hypertonic) and 17 age matched normal child participated in this study.They were selected from outpatient clinic of Faculty of Physical Therapy, Cairo University, and National Research Center. Cognitive abilities including attention /concentration, maximum reaction time and figural memory were evaluated by using Rehacom system for each child participated in this study and the results were compared to those of normal age matched individuals. **Results:** the results revealed a statistically significance difference in attention / concentration and figural memory levels between groups while no significance difference in maximum reaction time. **Conclusion**: ultimately the study revealed that children with hypertonia and hypotonia have impairment and delayed development of their cognitive abilities and theywere highly deviated from normal.

Key Words: Muscle Tone disorders; Children; Cognition; Rehacom system

Introduction:

Muscle tone can be defined as the continuous and passive tension in the muscles, or the resistance offered by the muscles to passive elongation during resting state[1)]. Muscle tone is needed to maintain proper posture and decline during sleeping[2)]. Tone abnormalities may be manifested by either increased tone (called hypertonia) or decreased tone (called hypotonia/ atonia), these abnormalities are commonly combined by other motor disturbances in several neurological diseases[3)].

Hypertonia is defined as “abnormally increased resistance to movement about a joint. That can be caused by spasticity, dystonia, or rigidity. Spasticity is defined as hypertonia occurring in response to passive muscle stretch that meets one of two criteria: either

increases with increasing speed of muscle stretch, or increases beyond a certain critical angle of joint motion**.**It may be associated with sustained muscle contractions (dystonia), involuntary muscle spasms, and exaggerated deep tendon reflexes that make movement difficult or uncontrollable[4)].

Hypotonia is abnormal decreased muscle tone or floppiness. It may be progressive or static, acute or chronic, isolated or part of a complex clinical situation affecting children of all ages. It may or may not be associated with weakness. Functionally, it may be characterized as decreased resistance to movement as a limb is passively moved through a range of motion about a joint[5)].Hypotonia can be classified as central or peripheral. Central hypotonia results from the central nervous system, while peripheral hypotonia is linked to problems within the skeletal muscle, spinal cord and/or peripheralnerves[6)].

Cognition is the acquisition and manipulation of knowledge. It includes conscious, effortful processes, such as those involved in making important decisions, and unconscious, automatic processes, such as those involved in recognizing a familiar face, word or object[7)].The aspects of cognitive abilities include memory, attention, representational competence, and processing speed. Successful cognitive development requires progress in all these domains. Memory involves the proper encoding, storing, and retrieving of information[8)]. Cognitive deficits in school age children with spasticity are not merely a function of an early brain lesion; they are also the result of dynamic, ongoing interaction between the child and his environment, where the child participates in learning situations and interacts with his or her peers[9)].Hypotonic children have cognitive and perceptual problems which limit functional improvement[10)]. The aim of this study was to evaluate how muscle tone disorders affect cognitive abilities in children.

- **Materialand Methods:**

Study design: The research design of this study was a cross- section study. Ethical committee approval was obtained from the institutional review board at Faculty of Physical Therapy, Cairo University before study commencement with number (No. P.T. REC/ 012/001862). Informed written consent was signed from each child caregivers after explaining the nature and purpose of the study.

Participants:Fourty one children of both sexes (ranged in age from 5-8 years) participated in this study,seventeen normally age matched children of the patient's relatives and friends represented group (A),sixteen spastic children were considered as group (B) ,and fifteen hypotonic children were considered as group (C), they were selected from outpatient clinic of Faculty of Physical Therapy, Cairo University. Patients were selected based on the following inclusion criteria: (1) their IQ score more than 70 according to Stanford-Binet Intelligence test as referred from the psychiatrist, (2) Level II or III on the Gross Motor Function Classification System (GMFCS)[11], (3) grade 1 to 2 of spasticity on Modified Ashworth Scale (MAS)[12]for group (B) and (4) They were abled to use the key panel. the criteria for exclusion were as follows: children with visual or auditory problems, children with fixed deformities, contractures or fractures in the upper limbs, children who take medications that affect muscle tone.

Measurement Procedures: Rehacom system (manufactured by **Schuhfred,** model No. 454V, D-14482 potsd am, **Karl-Liepknecht, Austria**) was used in the current study for all children to assess their cognitive functions. It contains several modules with different levels of difficulty. Rehacom system is composed of special input panel, the computer keyboard, the mouse for entering the child personal data, screen and central processing unit (CPU). A special input panel was used with very simple keyboard which has six big keys; four large white keys expressing up, down, right and left directions to move towards the direction of the chosen answer and two large green keys (OK) to confirm the choice, two special keys: red

key for emergent stop and yellow key for more information about the procedures and one joystick. Attention and concentration and figural memory were chosen to be evaluated in this study.

Evaluation Procedures: The procedures of the Rehacomsystem according to**Hasomed**[13)]were as follows:Every child sat on a chair with back supported and feet supported on the ground in front of a table that suit his/ her height to enable him/ her to use the keyboard and computer's mouse correctly and comfortably.Evaluation was performed in less distraction, suitable light and temperature environment, the personal data of the child (name, date of birth and sex) were introduced to the system. Every child was given explanatory instruction and was asked to do the task, starting from level one in each domain of cognitive function. When the first level was successfully finished, the test progress to the next level of difficulties. At the end of the session, a printed results sheet was obtained to detect performance of the child. Evaluation in different domainswas performed as follows: **1- Attention and concentration domain:** The child was asked to recognize the picture shown separately and select the one that resemble it in every detail from the matrix by means of the big buttons on the child panel. When use the big buttons of the panel, a yellow frame marked a picture in the matrix then the selection would confirmed by pressing OK button on the panel. After selection a picture the procedure evaluated the choice and lighted up a green sign "CORRECT" OR a red sign "INCORRECT". The test stopped when the child did three incorrect trials in the level. At the end of attention and concentration test, a report about the results were obtained and this report included maximum reaction time and the domain level. **2- Figural memory domain:** Each task consisted of acquisition phase and a reproduction phase. In acquisition phase, pictures of concrete objects were presented on the screen. the acquisition phase was determined by the child. The child end this phase by pressing "OK" key. In the reproduction phase, the child recognized the pictures of the concrete objects that

would be presented on the screen during the acquisition phase, the child was pick out from a number of pictures moving over the screen from right to left. The child was asked to press "OK" button when the picture is inside the red marked area. If the two tasks solved incorrectly, the same pictures presented for up to two times. It gave the child the chance to memorize the same pictures. after two incorrect reproductions, the program progressed to the previous level. At this time, the test stopped and results obtained. At the end of figural memory test, a report about the results was obtained and this report included the level.

Statistical Analysis: For data analysis, all statistical measures were performed through the Statistical Package for Social Studies (SPSS) version 25. Data was summarized using mean and standard deviation in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using non- parametric Kruskal- Wallis[14]. P- values less than 0.05 were considered as statistically significant.

Data analysis:

The current study involved two tested dependent variables (attention / concentration variable and figural memory variable) which were measured for all groups and percentage of deviation of cognitive abilities in hypertonic and hypotonic groups from normal group was also analyzed.

- **Results:**

  Demographic data: The characteristics of the participants showed that there were no statistically significant differences between groups regarding age and gender distribution (P>0.05)**Table (1).**

Table 1: Demographics data for all groups.

		Groups						P value
		Group A		Group B		Group C		
		No.	%	No.	%	No.	%	
Sex	Boys	4	23.5%	7	43.8%	9	60.0%	0.11 NS
	Girls	13	76.5%	9	56.2%	6	40.0%	
Age (year)		x□	SD	x□	SD	x□	SD	0.702 NS
		6.65	±1.11	6.31	±1.25	6.53	±1.19	

x□: Mean **SD:**Standard Deviation**NS:** Non significant

The mean and standard deviation values of attention / concentration reached level revealed significance difference ($p<0.05$) and there was no significant differences between groups ($P>0.05$) in maximum reaction time (ms). Considering the figural memory reached level , there was significant difference between participants in all groups ($p<0.05$).as shown in **Table (2).**

Table 2: **Mean values ofattention / concentrationlevel,maximum reaction time and figural memory level for thethree groups:**

		Group A	Group B	Group C	P value
Attention and concentration level	x□	1.80	1.69	3.59	0.005*
	SD	±1.08	±1.01	±2.12	
Maximum reaction time (ms)	x□	51493.80	53332.25	29937.12	0.240 NS
	SD	±65191.72	±55052.87	±22012.92	
Figural memory level	x□	3.13	2.75	4.94	0.001*
	SD	±1.55	±1.88	±1.56	

x□: Mean **SD:** Standard Deviation **P value**: Probability value ***Significant **NS:** Nonsignificant

As shown in **Table (3)**, attention and concentration level in hypertonic samples is less than normal samples by 52.92% and in hypotonic samples is less than normal samples by 49.86%. The maximum reaction time (ms) in hypertonic samples is more than normal samples by 78.15% and in hypotonic samples is more than normal samples by 72.01%. The figural memory level in hypertonic samples is less than normal samples by 44.33% and in hypotonic samples is less than normal samples by 36.64%.

Table3:Percentage ofdeviation of cognitive abilities in both hypertonicandhypotonic groupsfrom normal

Cognitive abilities	Hypertonic Group	Hypotonic Group
Attention and concentration level	-52.92%	-49.86%
Maximum reaction time (ms)	78.15%	72.01%
Figural memory level	-44.33%	-36.64%

- **Discussion:**

Cognition,usually referring to everything that is related to knowledge. In other words, the accumulation of information that have acquired through learning or experience[15].It is important to examine cognitive impairment in children with different muscle tone disturbance because their cognitive impairments independently affect the performance of functional activities and integration with community and school settings[16].

Selection of the age to be ranged from five to eight years as equivalent to school age children, so they can understand and follow verbal instructions. Also, at this age, children can actively share in assessment session. **Steinberg et al**[17] stated that, middle childhood is the period of concrete operations in which children's mental activities become more logical. Also, **Davis et al**[18]stated that, in this period the cognitive development allows children to become more strategic in their thinking and more proficient at planning.

Computerized Rehacom software was used in this study to assess cognitive function. This software supposed accurate results with saveing time and effort. This was reported by**Johnson et al**[19]who stated that due to accuracy, sensitivity and availability of computerized model, they become the preferred method of neuro-cognitive testing for assessing the cognitive abilities. Also,**Wild et al.,**[20]stated that in comparison with traditional cognitive assessment instruments, computerized tests represent a cost and time saving.

The study results revealed a significant deviation in the cognitive abilities including attention / concentration and figural memory levels from normal. Which may be attributed to the effect of muscle tone disturbance on the abilities of disabled children to collect information that any normal person have acquired through learning or experience. These results confirmed by **Casey et al.,**[21]who stated thatmature cognition is marked by the ability to filter out irrelevant information and process the relevant information.

The results of current study revealed that attention / concentration level in hypertonic samplewereless than normal sample by 52.92%.This may be due to the effect of mental fatigue that occurred to the child which affect child arousal. These results come in agreement with the work of**Anderson et al**[22]who stated that, the white matter lesions are common in children with hypertonia, give rise to inefficient information processing and impact the neural messages between brain regions due to damage of normal information processing circuits. Also, It was revealed that the maximum reaction time (ms) in hypertonic samplewas more than normal sample by 78.15% that may be attributed to the fact that the faster reaction time may be referredto increase speed of information processing. Hypertonic children have abnormal movement pattern with delayed response leading to slower reaction with longer time. These findings was supported by work of**Bottcher et al.,**[23] who examined attention in spastic children, their results showed that all timed tasks performance were slower than the

test norm which indicate an impairment in processing of information resulted from white matter lesions.

The results of this study revealed that attention / concentration in hypotonic childrenwas less than normal childrenby 49.86% as shown in table (3) due to decrease activity tolerance, strength and poor trunk extension. These results come in agreement with the work of**Gross-Tsuret al**[24] who stated thattheattentional skills appear weakened in the hypotonic children and made a large number of errors.

The reaction time in hypotonic children is more than normal children by 72.01% as shown in table (3) due to delay motor skills which limits the child to interact with the environment and take longer time. These results come in agreement with the work of **Deary et al**[25] who stated that the slower reaction time related to generalized hypotonia that affect child response tone stimulus.Also,**Hinnell and Virji- Babul**[26] stated that children with hypotonia have greater variability in the timing of the onset of muscle activation and proprioception deficiencies could be probable explanations for longer reaction times.

Regarding to the figural memory level in hypertonic children, it was decreased than in normal children by 44.33% as shown in table (3). These results come in agreement with the work of**Bottcher et al**[23]who argued that memory retrieval was slower in spastic children than norms. Figural memory in hypotonic childrenwas less than normal children by 36.64% as shown in table (3). This may be attributed to poor performance of hypotonic children due to low muscle tone which affect level of arousal, mood and physical or mental fatigue, leading to poor memory skills.These results come in agreement with the work of**Dykens**[27]stated that poor performance in hypotonic children is due to deficit in the executive function, individuals' capacity to organize and plan information so affecting the figural memory skills and attention level.

It was concluded that children with hypertonia and hypotonia were deviated by higher percentage from normal children in their cognitive abilities due to disturbance of muscle tone which affected the information processing and creative function.

The limitations during the study were: poor set up of the cognition lab as both isokinetic machine and Rehacom system are in the same place, So waiting until the testing environment become quite to avoid distraction of children during testing and some children were easily fatigued, angry and need rest.

It was recommended versus studies with large sample size with measuring the effect of other two domains (reaction behavior and logical thinking) on cognitive abilities on child with different muscle tone disorders.

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