Correlation between Dynamic Balance and Reaction Time in Children between Age 9 - 13 Years: An Observational Study

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Abstract: ***Background**: An efficient reaction time is closely associated with the ability to maintain equilibrium. Between the ages 6 - 10 years, children develop the skills to maintain balance under dynamic conditions which are essential for activities like sports, dance, etc. By the age of 11 years, children attain optimum reaction time. **Objective**: to find whether any correlation exists between dynamic balance and reaction time in children between age 9 - 13 years. **Method**: 105 participants between the ages 9 - 13 years were selected in the study based on inclusion and exclusion criteria. . Reaction time and dynamic balance were assessed using the ruler drop test and The Y - Balance test respectively. The data was collected and statistically analyzed. **Results**: The correlation of reaction time and dynamic balance scores were statistically analyzed, indicating a strong negative correlation with an r value of - .864. **Conclusion**: This study concludes that reaction time shows a strong negative correlation with dynamic balance in school children between the age 9 - 13 years (r = - 0.864).***

Keywords: reaction time, dynamic balance, children

1. Introduction

Simple reaction time is made up of two parts: a stimulus and a response and the time passing by between the two is defined as reaction time. Sensory neurons transform stimuli into an electrochemical signal, which travels the length of the sensory neuron (s), then through a central nervous system neuron or neurons, and finally through the length of the motor neuron (s). It is a measure of the Central Nervous System's ability to process information in an indirect manner. Reaction time can be used to assess the central nervous system's processing speed as well as the coordination between the sensory and motor systems in healthy people. It determines a person's sensory motor association and performance [1]. The ruler drop method can be used to calculate it. [2] The capacity to do a task while retaining a stable position is known as dynamic balance. The sensory system, made up of the vestibular, visual, and proprioceptive systems; the central nervous system; and the musculoskeletal system make up the posture control system [3]. Coordination of visual, auditory, and proprioceptive motor outputs are factors that determine dynamic balance. Feedforward control is required for balancing under changing task situations. Feed - forward control predicts postural disturbances and thus helps make necessary anticipatory postural adjustments (APAs) that allow the mover to retain stability. Equilibrium control is reflexive in nature, and it is dependent on the ability to quickly turn disturbances of proprioceptive or vestibular origin into appropriate motor responses, which has been connected to a properly functioning reaction time process. [4] The Y - balance test can be used to assess dynamic balance. [5] Children are not as skilled at controlling dynamic balance as adults until they reach the age of ten. The selection of balance techniques under varied circumstances is heavily influenced by neural maturation and experience. Experimental evidence shows that sensory perturbations generate postural response synergies and are seen as early as 15 - 31 months and have latencies equivalent to those of adults, indicating that a feedback - based system in the control of balance arises extremely early in life. On the other hand, a child's capacity to use feed forward control and make anticipatory postural modifications in response to future disturbances is highly dependent on their ability to use feed forward control. Controlling gravity and inertial forces, as well as moving the head independently of the trunk, are skills that emerge later in life, between the ages of 6 and 10. When comparing children aged 6 - 8 years to children aged 8 - 11 years, children aged 6 - 8 years perform poorly in the ruler drop test. This means that reaction time develops between the ages of 8 and 11. [6] After then, the amount of time spent anticipating events remains consistent throughout adulthood. According to a study conducted by V. Hatzitaki, reaction time peaks at the age of 11 years. Age, gender, type of stimuli, habits, being on alert, exhaustion, alcohol, nicotine, and exercise all affect reaction time. [6] Children's ability to maintain dynamic balance is required for activities such as sports and dancing. [6]

2. Literature Survey

Previous researches and studies done were referred by using the key words reaction time, dynamic balance, school children. PubMed and Google Scholar were the databases used for the purpose of research. Articles included were randomized and non - randomized trials, quasi experimental trials, case studies and systematic reviews.

3. Materials and Methodology

The study was an observational study conducted on school children between the ages 9 - 13 years where a sample size of 105 school children was collected using a convenient sampling method. The study utilized chair, table, ruler, masking tape, measuring tape for ruler drop test and Y - balance test.

Inclusion criteria:

1) Children willing to participate
2) Aged between 9 - 13 years.
3) Male and female genders
4) Able to follow simple instructions.

Exclusion criteria:

1) Uncooperative children
2) Open wound
3) Recent fractures
4) Inability to maintain static balance
5) Children with neurological, musculoskeletal impairments

Outcome measures: Two tests were used to assess reaction time and dynamic balance.[1]. The Ruler drop test: The subject is in a sitting position with their dominant side elbow flexed at 90 degree in mid - pronation resting at the edge of the table. Ruler will be suspended vertically by the examiner. Subject is instructed to catch the ruler as quickly as possible once released. The distance the ruler travels will be noted. The distance is converted into time using the formula: t= √g d/2 where, d=distance; g= gravitational constant (9.8m/s). Time measured in milliseconds. The reliability of this test is 0.81 and Validity is 0.54. [2] 2. The Y - Balance test is used to measure dynamic balance. The subject stands barefoot, behind the starting line. The participants attempt to reach the farthest point on tiptoes on one foot without losing balance. Before the measurement, each leg was subjected to six tests in the Anterior, Postero - lateral, and Postero - medial directions, followed by three measurements, with the longest access distance employed in the analysis. To get the balance, multiply the total of three access directions by 100 and divide into a multiplication of leg length (cm) by 3. The reliability of the test is 0.85 to 0.91 [5]

Procedure: Subjects were screened as per inclusion and exclusion criteria. Prior to the study, the purpose and procedure was explained to the subject and also their parents. Ruler drop test was used to assess the reaction time. The individual sat on the table with their dominant side elbow flexed at 90 degrees in mid - pronation and an open hand at the table's edge. The examiner suspended the ruler vertically. When the ruler was released, the subject was instructed to catch it as quickly as possible. The distance the ruler travels was recorded. The distance was converted into time using the formula: t= √g d/2 where, d=distance; g= gravitational constant (9.8m/s). Time measured in milliseconds. Dynamic balance was measured using the Y - Balance test. The feet of the subject placed behind the starting line. The subjects performed barefoot. The subjects tried to reach the furthest point on the tiptoes of one foot without unbalancing. Before the measurement, 6 tests were conducted for each leg in the Anterior, Postero - lateral and Postero - medial directions and then 3 measurements obtained for each, and the longest access distance were used in the analysis. The total of 3 access directions multiplied by 100 and divided into the multiplication of leg length (cm) by 3 to find the balance score. The above assessment procedure was referred from a study conducted by (Phillip J. et. Al, 2009). Data collected was statistically analyzed.

Figure 1 (A): Illustrates ruler drop test

Figure 1 (B): Illustrates Y balance test.

3. Statistical Analysis

Data was analyzed using SPSS version 28.0.0.0 (190). The Shapiro Wilk test was done to analyze whether the data was normally distributed. The test confirms the normal distribution of the data. Descriptive statistics was done for age, height, weight, BMI, reaction time and dynamic balance. Correlation of age, gender, height, weight, BMI with reaction time and Y - balance score was studied using Pearson's correlation test.

4. Results

105 participants between the ages 9 - 13 years were included in the study, out of which 52 were male and 53 were females with an average age of 10.98 (±1.53) years, average height of 141.42 (±8.28), average weight of 141.42 (±8.28), average BMI of 19.7 (±2.06). A basic demographic data of the participants was recorded, shown in table 1 given below.

Table 1: Demonstrates the demographic data of participants

Mean Age	10.98 (±1.53)
Mean Height	141.42 (±8.28)
Mean Weight	39.51 (±5.81)
Mean BMI	19.72 (±2.06)
Mean Reaction Time	184 (±26.36)
Mean Y - Balance Score	83.07 (±4.53)

Reaction time and dynamic balance of the participants were assessed using the ruler drop test and Y - balance test respectively. The mean reaction time was 184 ms (±26.36) and mean Y - balance score was 83.07 (±4.53) as shown in table 2 given below.

Table 2: Illustrates the Descriptive of Reaction Time and Y - balance score

		Statistic	*Std. Error*
Reaction Time	Mean	184	2.573
	Std. Deviation	26.36	
	Minimum	128	
	Maximum	239	
Y - Balance score	Mean	83.07	0.443
	Std. Deviation	4.54	
	Minimum	74	
	Maximum	93	

Table 3: Illustrates the Correlation of Reaction time and dynamic balance with age, weight, height, BMI

		Reaction Time	*Y - Balance score*
Reaction Time	Pearson Correlation	1	- .864**
	Sig. (2 - tailed)		<.001
	N	105	105
YB score	Pearson Correlation	- .864**	1
	Sig. (2 - tailed)	<.001	
	N	105	105
Age		-0.91	0.87
Height		-0.35	0.31
Weight		-0.34	0.27
BMI		0.34	0.03

The above table 3 depicts correlation between reaction time and Y - balance. Reaction time and dynamic balance scores were analysed. The scores of the two tests show a strong negative correlation.

The table depicts correlation for age, weight, height, BMI with reaction time and dynamic balance. Correlation for age, gender, height, weight, BMI with reaction time and Y - balance score was studied using Pearson's correlation test. Correlation for age with reaction time was - 0.91 indicating a very strong negative correlation. Correlation for age with dynamic balance was 0.87 which indicates a strong positive correlation. Correlation for height with reaction time was - 0.35 indicating a weak negative correlation. Correlation for height with dynamic balance was 0.31 indicating a weak positive correlation. Correlation for weight with reaction time was - 0.34 indicating a weak negative correlation. Correlation for weight with dynamic balance was 0.27 indicating negligible correlation. Correlation for BMI with reaction time and dynamic balance were - 0.09 and 0.03 respectively indicating negligible correlation.

5. Discussion

Reaction time and dynamic balance are particularly important in school children as they require these skills to be able to perform better in activities like dance, sports, etc. Upon studying previous literature, it was noted that there are very limited studies done to find the correlation between dynamic balance and reaction time in children particularly with no athletic background.

In this study, we found a strong negative correlation between reaction time and dynamic balance indicating that children that were quicker in catching the ruler being dropped performed better in the Y - balance test. This indicates that training school children to improve upper extremity coordination will contribute to improving their dynamic balance. The study supports previous literature on relationship between balance with anticipation time (Sinan Bozkurt, Oya Erkut, Orkun Akkoç. Relationships between Balance and Anticipation Time, Reaction Time in School Children at the Age of 10 - 12 Years). A study by Hatzataki et al. shows results parallel to this study. An association was found between balance, anticipation time and depth perception tests. Altigan studied association between upper limb coordination and balance stating the upper limb coordination positively affects balance.

Erdal et. al. in his study examined reaction time and balance relation in children between the ages 9 - 13 years shows similar results. The study states that with an increase in control of movements, reaction time decreases. This control of movement is influenced by age. Therefore establishing a negative correlation between age and reaction time in children between ages 9 - 13 years

Also, a strong negative correlation was found of age with reaction time and a strong positive correlation with dynamic balance indicating that older children had better ruler drop and y - balance test scores. Cuisinier et al. studied postural balance in children between the ages of 7 - 11 years. The study concludes a linear progressive relationship between postural balance and reaction time. Cuisinier et al. conclusion goes hand in hand with our study as older children were observed to score better in the Y - balance test.

Another study by Kiselev et al. done on children between the ages of 4 - 6 years states that reaction time reduces as age increases indicating a negative correlation. It supports our study as older children were noted to have shorter reaction time to stimulus. Lida et al. performed a study on 153 children between the ages of 6 - 12 years and established a strong negative correlation between age and reaction time. Mickle et al. did a study in 2011 on 84 children between the ages of 8 - 12. He concluded that with age, balance increases indicating a significant positive correlation. In a study conducted Ihıra et al. in 2011, he found that with an increase in balance loss, there was an increase in reaction time. The above findings show parallelism with this study.

A study done in India by Dr. Bhabhor Mahesh in 2011 compared reaction time of badminton players and healthy controls. The study concludes that badminton players had a better reaction time score than healthy control. This indicated that being involved in sports activities significantly reduces reaction time.

Height of children when correlated with ruler drop test and Y - balance test scores showed a weak negative and positive correlation respectively. Weight of children showed negligible correlation with dynamic balance. However, indicated a weak negative correlation with reaction time. This is supported by a comparative study by Dr. Asish Paul. He analysed the relation between reaction time and anthropometrical measures of college students and it concludes that though a negative correlation was found, the values were too low to draw a significant relationship between the reaction time and height and weight.

Our study will help to understand the relation between human motor skills and reaction time. The results from this study would help schools better understand the important relationship between reaction time and dynamic balance and the other variables. This will improve the understanding and in turn quality of training of conditioning the children to improve their performances in activities that require a quick response time and a good dynamic balance.

Racket sports such as tennis, table tennis and badminton require a combination of physiological requirements like speed, resistance, strength, motor coordination, quick reaction times. Sports scientists and coaches should interest in these areas that correspond the need of human potential and sport performance as sport and exercise contribution decreases the reaction times. PE programs in schools should emphasize more on activities like badminton that improve eye - hand coordination in children to improve the two motor skills. Special PE drills can be incorporated to specifically train the two. Thus, significantly improving the overall performance in sports activities.

6. Conclusion

105 children between the age of 9 - 13 years were included in this study. This study concludes that reaction time shows a strong negative correlation with dynamic balance in school children between the age 9 - 13 years (r = - 0.864). This suggests that children with lesser anticipation time had better Y - balance test scores. The two motor skills have an influence on each other. Therefore, students should be taught to improve their reaction time and balance by the physical education teachers during PE classes.

The study also reveals a strong negative correlation of age with reaction time (r= - 0.91) and a strong positive correlation with dynamic balance (r= 0.87) indicating that older children had quicker reaction tine and better Y - balance scores. Reaction time when correlated with height shows a weak negative correlation (r= - 0.35), suggesting that taller children had quicker response time. Height and dynamic balance show a weak positive correlation inferring that taller children performed better in the Y - balance test (r=0.31). Although there is a weak correlation of height with the two variables but the values are too low to establish a significant relations. Weight was correlated with reaction time and dynamic balance showing a weak negative correlation (r= - 0.34) and negligible correlation (r=0.27) respectively. This indicates that weight does not significantly affect response time and dynamic balance in children. Similarly, BMI was correlated with reaction time and dynamic balance, showing a weak positive correlation with reaction time (r=0.34) and a negligible correlation with dynamic balance (r=0.03). This infers that BMI does not significantly influence reaction time and dynamic balance in children. There will be negligible effect on reaction time and dynamic balance upon increase or decrease of BMI.

7. Future Scope

Further studies can include a larger sample size. Study should be conducted once schools are functional offline with regular PE sessions. More motor skills such as static balance can be correlated with reaction time and dynamic balance Intervention studies can be done to study the effect of balance training on reaction time.

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