HOMO - Journal of Comparative Human Biology 68 (2017) 63–68

Contents lists available at ScienceDirect

HOMO - Journal of Comparative Human Biology

journal homepage: www.elsevier.com/locate/jchb

Reaction time norms as measured by ruler drop method in school-going South Asian children: A cross-sectional study

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ARTICLE INFO

Article history:
Received 2 July 2016
Accepted 21 October 2016

Keywords:
Age
Attention
Child
Executive
Response time
Neuromuscular
Visuomotor

ABSTRACT

This study aimed to estimate normative range for reaction time using ruler drop method for school-going South Asian children between 6 and 12 years of age. A cross-sectional study was used to evaluate the reaction time for 204 children. Normal values for each age group were obtained. The results of multiple linear regressions showed a decrease in the reaction time values with age, and a significant change occurring between six and eight years of age. No difference in reaction time was obtained between boys and girls. Ruler drop method is an easy to use test and the results of this study provide a normative data for age groups 6–12 years ranging from 214.2 ms to 248.8 ms. These values can serve as a reference to screen children with delayed reaction time.

Introduction

Reaction time is the time interval between stimulus and response. It has been extensively used in the past decades to assess neuropsychological functions, motor cognitive processing and executive attention (Grane et al., 2014; Sayeur et al., 2015; Silva et al., 2015). Often used as an outcome measure in research, reaction time is reported to be slowed in children with learning disabilities, traumatic brain injuries, cerebral palsy (Gao et al., 2015; Kobor et al., 2015; Kostyun et al., 2015). Poor reaction time is suggested to be associated with child's behavior, overeating, obesity, poor readiness and poor competence at school (Blair and Razza, 2007; Borella et al., 2010; Brown and Landgraf, 2010; Diamond, 2013; Duncan et al., 2007; Miller et al., 2011; Weissberg et al., 1990; Will Crescioni et al., 2011). An early identification of delayed reaction time would help the teachers, parents and therapists to better address the child's functional deficits and quality of life. Despite being a significant indicator of function, behavior and performance, reaction time is rarely used in clinics and schools to identify children with slowed motor cognitive processing.

During the course of normal development and growth, reaction time significantly changes (improves) with almost a three-fold decrease over the age span of 4–17 years (Bellis, 1933; Goodenough, 1935). Improvement of reaction time in children 4–6 years old was reported to be age and task specific and significantly different from young adults (Elliott, 1970; Kiselev

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http://dx.doi.org/10.1016/j.jchb.2016.12.001
0018-442X/

et al., 2009; Miller and Vernon, 1996). Different reaction time tasks have been used to assess it and movement trajectories in children – simple reaction time (single stimulus – single response), choice reaction (multiple stimuli, different responses) (Gentier et al., 2013; Nisiyama and Ribeiro-do-Valle, 2014). The neurological demands imposed by reaction time tasks vary with each type of task, contributing to the variability in the reaction time values (Feher da Silva and Baldo, 2015; Gorus et al., 2006; Kumru et al., 2006). With so much diversity in the reaction time values, it is difficult to implement reaction time assessment as a part of regular assessment protocols in clinics. To bridge the gap between the research evidence supporting the significance of reaction time assessment and its use in clinical and academic settings, there is an urgent need to develop age wise norms on tasks that can be easily used.

Recently, reaction time has been assessed using a computer based specialized software in research and as a part of standard neuropsychology assessment tests (Bolfer et al., 2010). Owing to the high cost and training associated with these measures, their use is limited. Therefore, a more economical, simple and computer independent clinical measure, the Ruler Drop Method previously described and validated for use in children and adolescents has been recommended (Aranha et al., 2015; Eckner et al., 2011). It is a simple reaction time task that is considered to be most promising for use with young children (Weissberg et al., 1990). It involves a specific motor response to a visual stimulus and is an adapted version of the 'ruler drop test' that is used in science classes to explain the relationships between distance, acceleration and time for a body falling free under gravity. Unfortunately, no norms exist for ruler drop method to serve as comparison for identifying children with slowed reaction time at an early stage of their development. Therefore, this study aims to establish normative data for reaction time using the ruler drop method for children between 6 and 12 years of age.

Methods

This was a cross-sectional study which took place in the sports rooms/labs of recognized primary schools between October 2014 and March 2016. The ethical clearance was obtained from Maharishi Markandeshwar University's Ethics Committee (MMU/IEC/445) in accordance with the guidelines laid by Indian Council for Medical Research, ICMR (2006) and Helsinki Declaration (Revised 2013). This was followed by obtaining consent from the Heads/Principals of the participating schools. The assent from children and consent from their parents/legal guardians was then obtained.

Participants

Single stage cluster sampling of all the public and private schools in Mullana, Ambala District, India was used to recruit 204 school-going South Asian children between 6 and 12 years of age from 12 primary schools. Children with confirmed history of neurological, orthopedic and metabolic disorders, upper extremity injury or surgery and complaints of weakness or pain were excluded from the study. Participants and their parents were explained the study procedure before they signed the consent/assent form.

Procedure

All anthropometric measurements were performed in the sports rooms at each school. Body weight was measured with a calibrated weighing scale (Equinox BR-9015, Analog Weighing Scale) and recorded to the nearest 1 kg. Height was measured without shoes and socks, with a standard height measuring flat metallic piece over a mounting measuring tape (Freemans® MRL 2 m 16 mm, Metal Wired Tape) on a wall with feet about 250–300 mm apart and a result was recorded to the nearest 1 mm. Body mass index (BMI) was calculated by dividing the weight (kg) by the square of the height (m). To measure reaction time by the ruler drop method the participant was made to sit with his/her dominant side elbow flexed at 90° with a mid-pronated forearm resting on a flat horizontal table surface, and an open hand at the edge of the surface. The ruler was suspended vertically by the examiner, such that the lower end was aligned across 50 mm between the web space (i.e. thumb and index finger) of the child's hand. The child was then asked to catch the ruler as quickly as possible, once released from the examiner's hand (Aranha et al., 2015; Eckner et al., 2011). The reading against the dominant index finger lateral border with the ruler was marked for documenting the distance traveled. Children were given a demonstration regarding the test procedure and become familiar with the procedure by the two practice trials.

The distance the ruler traveled from starting 50 mm was recorded and converted into time by using following formula: $T = \sqrt{2d/g}$, where d is the distance traveled by a ruler, g is the gravitational constant (9.8 m/s^2) (Aranha et al., 2015; Eckner et al., 2011). Each participant performed three trials and the mean value of reaction time was used for the analysis. The children were not subjected to any exercise/physical activity before performing the test as acute physical activity has a significant effect on the reaction time. All the readings were collected during daytime between 12-noon and 13:00 h.

Data analysis

Descriptive statistics were expressed in terms of mean and standard deviation. Children were grouped according to age ranges and each age group was tested for normality using the Kolmogorov–Smirnov's tests. As the data were bind to follow normal distribution, we used the parametric tests for analysis. A multiple linear regression model was used to compare reaction time between different age groups and between sexes, with height, weight and BMI as covariates. The association