DOI: 10.7860/JCDR/2018/33920.11516

Original Article

Physiotherapy Section

Relationship between Anthropometrics Characteristics and Dynamic Balance in Children of Anand City, Gujarat

NIRAV P VAGHELA[1], JIGAR N MEHTA[2], DHRUVESHI RANA[3]

ABSTRACT

Introduction: Paediatric physical therapists use a variety of functional balance screening tools developed for adults including the Functional Reach Test (FRT), the Time Up and Go test (TUG), and the Berg Balance Scale (BBS).

Aim: To assess the relationships among age, gender, anthropometrics and dynamic balance in 5 to 12 years of children in Anand city, Gujarat, India.

Materials and Methods: Cross-sectional study was conducted in which 150 school going children of 5-12 (75-females, 75-males) years were recruited from the school of the Anand city, Gujarat, India. Height, weight, arm and foot length were measured. Dynamic balance was assessed using TUG, FRT, Paediatric Balance Scale (PBS).

Results: Positive relationship (r=0.58 and r=0.77) were found between increasing age and FRT and PBS scores. A negative relationship (r=-0.46) was observed between age of males and TUG test. Significant gender by age group difference was observed in FRT. Arm length and height has the strongest influence on FRT. Age, height, foot length and arm length has the strongest influence on PBS.

Conclusion: Age and arm length have the strongest relationship with the dynamic balance (FRT, PBS). It helps the paediatric therapists in selecting dynamic balance test according to the age.

Keywords: Age, Anthropometric, Gender

INTRODUCTION

The spine is linked with many mutual relation in body. With its static equilibrium, the spine shows affect and receives forces (dynamics), all of which are linked with the chain of motion (kinetics). Also, spine is having affect on neighbouring structures and organs [1]. The term posture is often used to describe both the biomechanical alignment and its orientation to the environment. Postural control includes controlling the position of body in space for stability and orientation. Postural stability, also known as balance is the capacity to control the centre of mass in relationship to the base of support. The postural control development in children occurs in a ladder like gradual progression, on the basis of development of particular systems involved in postural control [2]. Balance is an important agent that provides a background for children to develop and achieve motor functions. In developing infants, the ability of balance enables them to become successfully mobile [3]. Maintainence of balance during walking is a complex work, as it includes achieving a negotiation between the forward movement of the body, which is a highly disrupting force and the need to sustain the lateral stability of the body, even simple walking on a flat surface that is free of hurdles, gives a reasonable problem to balance to young walkers. Indeed, the difficulty of maintaining equilibrium during walking is further heightened by the point that the weight of the whole body must be maintained by one leg during the swing phase of gait. This is the most difficult balance problem which has to faced by kids for learning to walk [4,5]. The control of balance is organised from the head to the feet in descending pattern [6].

Postural control is not thought as one system or a set of equilibrium and righting reflexes. Rather, postural control is considered a complex motor skill derived from the interaction of multiple sensory motor processes [7]. The development of the necessary systems occurs at different ages: the proprioceptive system matures first, followed by the visual and vestibular systems [8]. Because of shorter height in children and difference in the location of centre of mass, they sway at a faster rate than adults. Thus, the maintenance of static balance is difficult as the body is moving at a faster rate during imbalance. After seven years of age, there is no correlation between structural growth of the human body (height, body mass, and age) and sway during normal quiet stance [9]. According to some studies, with respect to the development and maturation of body structures and systems linked to gender, girl's bone age had maturing before than the boys [10].

Peterson ML et al., demonstrated that girls at the age of 7-8 years have better use of vestibular information and consequently reduce the body sway as compared to boys of the same age [11]. Donahoe B et al., looked at the influence of age, gender and height on control of balance with the help of FRT in children aged 5 to 15 years. Functional Reach (FR) distance was found to increase with weight and height, even though age was the only important element linked to a child's FR capacity [12]. Paediatric physical therapists use a variety of functional balance screening tools developed for adults including the FRT, the TUG, and PBS is the part of BBS which has been used for paediatric age group [12-15].

There are limited literatures available on this study, so the aim of present study, was to investigate relationships among age, gender, and dynamic balance in children aged 5 to 12 years during performance on the TUG, FRT, PBS. Another objective was to examine the influence of various anthropometric variables, including height, weight, arm length, and foot length on balance abilities.

MATERIALS AND METHODS

It was cross-sectional study in which 150 school going children with age group 5 to 12 years were recruited as per the participant recruitment procedure who follow the instruction and feasibility. The study took place in the primary schools of the Anand city, Gujarat, India. In the present study, mental, physical, psychological and other health illness, identified developmental delays and other neurological disorders were excluded. Permission was already taken from authority of school for conducting study. The study proposal was approved from institutional ethical committe as well as informed consent form from school principal and children were obtained after explaining the purpose of the study.

Each participant performed the three dynamic balance measures (TUG, FRT, PBS) in random order. A minimum of five years of age is taken for participant selection as five years is considered a transition period in the development of postural control. Basic data like school name, standard in which child is study and aged as well as his or her problems or illness were taken from each school and details of child examination has been done and recored.

Participants were asked to remove their shoes before height, weight, and foot length were measured. Each child was weighed in kilograms by using a portable digital weight scale. Height was measured in a centimeter using a stadiometer. Foot length was marked on the floor with the chalk and measured in centimeters by using a measuring tape which is perpendicular distance from the back of the heel to the end of the big toe. Subject's arm length was measured in centimeters from the base of the middle finger to the acromion process of humerus.

The TUG test, PBS and FRT were performed in a simple random order. TUG test in which time (seconds) for participant to stand up from the chair, walked three meters, turn around, walked back, and sit in chair was measured. The TUG test is reliable and valid test of balance and functional mobility.

The FRT is also valid, reliable measurement of postural control, with reaching to the forward in standing. The reach distance is measured in centimeters or inches, with sum of distances as the final score. The patient is instructed not to touch the wall and position the arm that is closer to the wall at 90° of shoulder flexion with a closed fist. The starting position at the third metacarpal head on the measure tape. Instructions given to patient are "reach as far as you can forward without taking a step". The location of the third metacarpal is recorded. Three trials are done and the average of the last two is noted.

The PBS includes 14 balance items, each scored from 0 to 4, with a total score of 56. Each balance items has to check by performing on child and scored it individually. In children, the PBS is a reliable test of balance. Verbal commands were given to the children to perform the task properly.

STATISTICAL ANALYSIS

For statistical analysis, STATA 14 software was used. In the present study, dependent varibles were age, gender, weight, arm length, and foot length while independent variable TUG, FRT, PBS scores. Correlation coefficient was done between anthropometric measures and dynamic balance. To find association between three or mores variables used one way analysis of variance by ANOVA. Mean and standard deviations were calculated for the variables.

RESULTS

Non significant negative correlation was found between age and balance scores on the TUG test. While a positive correlation was found between age and balance using the FRT and PBS. Negative significant correlation between boys and dynamic balance was observed using the TUG test while boys having a positive correlation in relation to dynamic balance by using the FRT and PBS. A positive correlation between girls with dynamic balance tests were observed but non significant positive correlation was found between girls and dynamic balance using the TUG. A positive non significant correlation between BMI and dynamic balance was observed using the TUG and FRT while a positive correlation between BMI and dynamic balance was observed using the PBS. A negative correlation between arm length and balance scores on TUG was found. A positive correlation between arm length and FRT and PBS was observed. Non significant negative correlation between foot length and dynamic balance measured by the TUG was observed. A positive correlation between foot length and dynamic balance measured by the FRT and PBS was observed [Table/Fig-1].

Variables	Time up and go test	Paediatric functional reach test	Paediatric balanced test scored
Age (p-value)	-0.1372 (0.094)	0.5816 (< 0.001)	0.7744 (< 0.001)
Age (male) (p-value)	-0.4667 (<0.001)	0.6927 (<0.001)	0.8136 (<0.001)
Age (female) (p-value)	0.1159 (0.318)	0.4989 (<0.001)	0.7315 (<0.001)
BMI (p-value)	0.1013 (0.217)	0.0894 (0.276)	0.3153 (<0.001)
Arm length (p-value)	-0.2792 (0.005)	0.6504 (<0.001)	0.6875 (<0.001)
Foot length (p-value)	-0.1217 (0.137)	0.5196 (<0.001)	0.6942 (<0.001)

[Table/Fig-1]: Correlation between anthropometric factors and balance measures.

Correlation coefficient analysis indicated that arm length and height was the strongest correlation of balance abilities on the FRT and PBS. Foot length was identified as the strongest correlation of balance abilities on PBS. Age was determined to be the strongest correlation of balance abilities on the PBS [Table/Fig-2].

Mean and standard deviations for each balance measure by age are shown in [Table/Fig-3]. The mean TUG test values increased with increasing age, except for seven years and remain plateaued for 9 to 11 years. The FRT values increased with increasing age. The mean PBS scores increased with increasing age for five to seven years and then remain plateaued for 8 to 12 years at the maximum possible score of 56.

Mean and standard deviations for each balance measure by age and gender (boys and girls) were shown in [Table/Fig-4]. 56 Variable values of TUG score were obtained for the both genders as seen in [Table/Fig-4] which shows not significant change with increasing age for both gender. FRT score is more in boys with increasing age as compare to the girls. The PBS scores increased with increasing age for five to seven years and remain plateaued for 8 to 12 years with maximum possible score. The mean PBS score increased with increasing age for five to seven years and then plateaued for 8 to 12 years with maximum score of 56.

Variables	Age	Height	Weight	BMI	Arm length	Foot length	TUG	FRT	PBS
Age	1	0.76	0.43	0.36	0.87	0.82	-0.13	0.58	0.77
Height	0.76	1	0.50	0.14	0.85	0.73	-0.28	0.69	0.60
Weight	0.43	0.50	1	0.38	0.48	0.40	-0.04	0.36	0.28
BMI	0.36	0.14	0.38	1	0.37	0.45	0.10	0.08	0.31
Arm length	0.87	0.85	0.48	0.37	1	0.82	-0.27	0.65	0.68
Foot length	0.82	0.73	0.40	0.45	0.82	1	-0.12	0.51	0.69
TUG	-0.13	-0.28	-0.04	0.10	-0.27	-0.12	1	-0.37	-0.09
FRT	0.58	0.69	0.36	0.08	0.65	0.51	-0.37	1	0.38
PBS	0.77	0.60	0.28	0.31	0.68	0.69	-0.09	0.38	1

[Table/Fig-2]: Intercorrelations among anthropometric factors and balance measures.
BMI: Body mass index; TUG: Time up and go; FRT: Functional reach test; PBS: Paediatric balance scale

Overall	Age (year)	Time up and go test Mean (SD)	Paediatric functional reach test Mean (SD)	Paediatric balanced test Mean (SD)
	5	7.10 (0.87)	17.68 (4.85)	51.84 (1.21)
	6	7.55 (1.50)	17.05 (5.37)	53.77 (1.11)
	7	5.94 (0.52)	19.94 (6.37)	54.26 (0.99)
	8	7.47 (1.02)	18.05 (5.33)	56 (0)
	9	6.38 (0.50)	28.05 (5.24)	56 (0)
	10	6.21 (0.91)	29.52 (6.58)	56 (0)
	11	6.31 (1.45)	27 (5.96)	56 (0)
	12	7.15 (1.21)	31.21 (11.54)	56 (0)
p-value		<0.001	<0.001	<0.001

[Table/Fig-3]: Age mean difference in dynamic balance test.

Age (year)	Gender	TUG Mean (SD)	FRT Mean (SD)	PBS Mean (SD)
5	Boys	7.09 (0.83)	17.9 (4.48)	51.90 (1.22)
	Girls	7.12 (0.99)	17.3 (5.62)	51.75 (1.28)
6	Boys	7.88 (1.26)	17 (4.97)	53.55 (0.88)
	Girls	7.22 (1.71)	17.1 (6.05)	54 (1.32)
7	Boys	5.8 (0.42)	20.7 (7.39)	53.9 (0.87)
	Girls	6.11 (0.60)	19.1 (5.32)	54.6 (1)
8	Boys	7.33 (0.70)	19.3 (7.14)	56 (0)
	Girls	7.6 (1.26)	16.9 (2.92)	56 (0)
9	Boys	6.66 (0.5)	30.4 (4.90)	56 (0)
	Girls	6.11 (0.33)	25.6 (4.63)	56 (0)
10	Boys	5.88 (1.05)	28.7 (7.66)	56 (0)
	Girls	6.5 (0.70)	30.2 (5.78)	56 (0)
11	Boys	5.4 (0.51)	29 (5.98)	56 (0)
	Girls	7.33 (1.5)	24.7 (5.40)	56 (0)
12	Boys	6.28 (0.75)	39.1 (6.74)	56 (0)
	Girls	7.66 (11.5)	26.5 (11.4)	56 (0)
p-value	Boys	<0.001	<0.001	<0.001
	Girls	0.0070	<0.001	<0.001

[Table/Fig-4]: Age with both gender mean difference in dynamic balance test.
TUG: Time up and go; FRT: Functional reach test; PBS: Paediatric balance scale

DISCUSSION

This study was to examine the relationship among age, gender, anthropometrics characteristics (height, weight, BMI, arm length, and foot length) and dynamic balance (TUG test, FRT and PBS) in children age group between 5 to 12 years.

The balance scores improved with increasing age from 5 to 12 years reported by Habib Z et al., and he also reported that decreasing values on the TUG test with increasing age [16]. The mean TUG test values in this present study were more shown [Table/Fig-3,4] than those values reported by Habib Z et al., and the trend in decreasing values was not similar. Habib Z et al., found a mean TUG test score of 5.1 seconds for children from Pakistan, aged 5 to 13 years, and Williams EN et al., reported a mean TUG test score of 5.9 seconds for children from Australia, aged three to nine years [14,16]. The differences between the mean TUG test scores in present study, shown in [Table/Fig-3,4], which didn't fall between the mean from Habib Z et al., and the mean reported by Williams EN et al. There are literature available of the study done in different western countries [16]. However, no literature is available on Indian children population for antrometric charaterstics with dynamic balance. The difference in TUG mean can be due to nutrition and ethnicity. In the present study, boys performed better than girls on the TUG test. There was no significant correlation found in age, BMI, arm length, foot length, and negative significant correlation was found in boys shown in [Table/Fig-1].

The FRT score increased with the age in 5 to 12-year-old children shown in [Table/Fig-3,4]. In FRT two trials were given and the average of last two was noted. The present study recommend two practice trial to orient the child to the task and one recorded test trial. All subjects performed the FRT easily and without difficulty. In the present study, the mean of FRT increased with the increasing age in both genders. FRT score is more in boys as compare to the girls [Table/Fig-4]. FRT scores increased with age, similar to the results reported by Habib Z and Westcott S [17]. Donahoe B et al., reported that FRT scores increased as a function of age up to 11 to 12 years and then the FRT scores reached a plateau [12]. In the present study, no raise on toes was found for FRT while flexing forward to increase the reach distance. Donahoe B et al., reported that children commonly raise on to their toes while flexing forward at the hips in an attempt to increase the reach distance. Use of the FRT may identify children with potential balance deficits at an early age [12]. FRT is only one measure of dynamic balance and should be used in conjunction with other tests available to examine balance in children [13]. Duncan PW et al., reported that the reach capabilities by gender reveals that females have a shorter reach than males. Also, he had reported an highly association between age, gender height, arm length, and foot length and FRT [18].

In the present study, PBS score increased with age, and plateaued by eight years [Table/Fig-3,4] and the reason for plateau in PBS is that PBS is an ordinal scale and children with typical development can achieve maximum score by eight years. Franjoine MR et al., reported scores of PBS plateau at seven years of aged [19]. In PBS, there were 14 task and from these three task (standing with one foot in front, standing on one foot, placing alternate foot on stepper) was difficult to perform for the children age group between five to seven years. Franjoine MR et al., reported that height and weight were moderately correlated with PBS scores, and both were correlated with age. In the present study, in PBS, no gender difference was found [Table/Fig-4], both gender performed equally well according to the age. Franjoine MR et al., had reported that girls performed better than boys in PBS total test scores and it was most pronounced in children at four years and younger [19].

In the present study, foot length and age were the strongest correlation of balance abilities on PBS [Table/Fig-2]. Niznik TM et al., reported the strong reliability of the BBS, FRT, and TUG for children with cerebral palsy [20]. In addition, good inter-rater reliability in the BBS and FRT was demonstrated. In regard to concurrent validity, the BBS total score strongly correlated with the FRT and TUG. The FRT reflects skill in forward weight shifting and anticipatory control of balance, whereas the TUG integrates transitions and walking, thus providing information on dynamic balance ability, all of which are skills included in the PBS, thus leading to the high correlation [21].

In the present study, age, height, arm length, foot length were found to be the strongest correlation of balance abilities on PBS as well as on FRT [Table/Fig-2]. Thus, anthropometrics factors play an important role on dynamic balance. Dynamic balance ability is directly correlated with the age. However, in TUG there is no influence of age as per the result in [Table/Fig-3].

LIMITATION

Small sample size and limited to participant age group, hence, it can not be generalised which was limitation of the study.

CONCLUSION

As a conclusion, the findings of the present study showed that FRT and PBS scores improve with increasing age through the age of 12 years. Gender difference was found in FRT, boys score was more as compared to the girls. No significant correlation was found between anthropometric factors and TUG score. This findings help paediatric physical therapists to select a dynamic balance test according to the age. Age has strongest influence on PBS and FRT. Example-it might be more appropriate for a therapist to select the FRT for a child older than eight years, PBS can be used in children younger than eight years due to the plateau and PBS provide 14 number of balance items, which include all balance skills and ability. In future study with large sample size as well as study on other paediatric conditions can be done like hydrocephalus, muscular dystrophy, Gullian Barrier syndrome for compaire.

Declaration of interest: The authors report no declarations of interest. No funding is used for the present study.

REFERENCES

[1] Illustrated Orthopedic Physical Assessment, 3rd Edition, Ronald C. Evans. chapter 8. 2009.
[2] Anne Shumway-cook and Marjorie H. Woollacott. Motor Control, 4th Edition, Philadelphia. 2012. Pages 162,195,275,277.
[3] Santa FV. Motor Development in Paediatric physical therapy (Tecklin JS Ed.) JB Lippincot Co, New York. 2nd Edition. 1992 .
[4] Assaiante C. Development of locomotor balance control in healthy children. Neuroscience & Biobehavioral Reviews. 1998;22(4):527-32.
[5] Thelen E. Learning to walk: Ecological demands and phylogenetic constraints: Advances in Infancy Research. 1984.
[6] Assaiante C, Mallau S, Viel S, Jover M, Schmitz C. Development of postural control in healthy children: a functional approach. Neural Plast. 2005;12(2-3):109-18.
[7] Horak FB, Macpherson JM. Postural orientation and equilibrium. In: Rowell LB, Shepard JT, eds. Handbook of Physiology: Section 12, Exercise Regulation and Integration of Multiple Systems. New York: Oxford University Press, 1996;46(9):255-92.
[8] Geuze RH. Static balance and developmental coordination disorder. Human movement science: 2003;22(4):527-48.
[9] Cech DJ, Martin ST. Functional movement development across the life span. Elsevier Health Sciences. 2002. Mar 29.
[10] Beunen GP, Malina RM, Lefevre J, Claessens AL, Renson R, Eynde BK, Vanreusel B, Simons J. Skeletal maturation, somatic growth and physical fitness in girls 6-16 years of age. Int. J. Sports Med. 1997;28(06):413-19.
[11] Peterson ML, Christou E, Rosengren KS. Children achieve adult-like sensory integration during stance at 12-year-old. Gait and Posture. 2006;23(4):455-63.
[12] Donahoe B, Turner D, Worrell T. The use of functional reach as a measurement of balance in boys and girls without disabilities ages 5 to 15 years. Paediatric Physical Therapy. 1994;6(4):189-93.
[13] Norris RA, Wilder E, Norton J. The functional reach test in 3-to 5-year-old children without disabilities. Paediatric physical therapy. 2008;20(1):47-52.
[14] Williams EN, Carroll SG, Reddihough DS, Phillips BA, Galea MP. Investigation of the timed 'up and go' test in children. Dev Med Child Neurol. 2005;47(8):518-24.
[15] Kembhavi G, Darrah J, Magill-Evans J, Loomis J. Using the berg balance scale to distinguish balance abilities in children with cerebral palsy. Paediatric physical therapy. 2002;14(2):92-99.
[16] Habib Z, Westcott S, Valvano J. Assessment of balance abilities in pakistani children: a cultural perspective. Paediatric physical therapy. 1999;11(2):73-82.
[17] Habib Z, Westcott S. Assessment of anthropometric factors on balance tests in children. Paediatric physical therapy. 1998;10(3):101-09.
[18] Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol. 1990;45:M192-M197.
[19] Franjoine MR, Darr N, Held SL, Kott K, Young BL. The performance of children developing typically on the paediatric balance scale. Paediatr Phys Ther. 2010;22(4):350-59.
[20] Niznik TM, Turner D, Worrell TW. Functional reach as a measurement of balance for children with lower extremity spasticity. Phys Occup Ther Paediatr. 1995;15(3):1-15.
[21] Zaino CA, Marchese VG, Westcott SL. Timed up and down stairs test: preliminary reliability and validity of a new measure of functional mobility. Paediatric Physical, Therapy. 2004;16(2):90-98.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Physiotherapy, K M Patel Institute of Physiotherapy, Karamsad, Anand, Gujarat, India.
2. Associate Professor, Department of Physiotherapy, K M Patel Institute of Physiotherapy, Karamsad, Anand, Gujarat, India.
3. Postgraduate, Department of Physiotherapy, K M Patel Institute of Physiotherapy, Karamsad, Anand, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Jigar N. Mehta,
D2-13, Staff Quater, Shree Krishna Hospital, Karamsad, Anand-388325, Gujarat, India.
E-mail: jigar_n_mehta@yahoo.co.in

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Sep 26, 2017**
Date of Peer Review: **Nov 29, 2017**
Date of Acceptance: **Mar 19, 2018**
Date of Publishing: **May 01, 2018**