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*Original Research Article*

# Relationship of Arm Length, Foot Length and Dynamic Balance in 9-12 Years Old Children

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## ABSTRACT

**OBJECTIVE:** Dynamic balance (DB) is defined as abilities that are operating during performance of a functional task such as reaching, walking, or running, irrespective of changing support surface (i.e. BOS). Functional Reach Test (FRT), which was developed by Duncan et al. in 1990. FRT is defined as the maximal distance one can reach forward beyond arm's length while maintaining a fixed Base of Support (BOS) in standing. The outcome measures of dynamic balance (DB) are important elements of examination, which measures correlate with specific age but how anthropometric variables (e.g.: arm length, foot length, height, weight) which might influence balance is still unclear. The influence of arm length, foot length on dynamic balance in children is not well understood. Hence there is a need to investigate the relationship between arm length, foot length on dynamic balance in children. The objective of this study is to investigate the relationship of arm length, foot length on dynamic balance in 9-12 years old children.
**METHODOLOGY:** This descriptive study (correlational study) was conducted among 41 children with typical development of age 9-12 years old (50% male and 50% females). Arm length (males 58.6 $\pm$ 4.0; females 58.7 $\pm$ 3.6), foot length (males 20.8 $\pm$ 1.4; females 20.6 $\pm$ 1.6). Dynamic balance was assessed using FRT, the participants were asked to reach three times and the scores were recorded.
**STATISTICAL ANALYSIS:** The collected data was summarized using the descriptive statistics such mean +S.D. (standard deviation) to find the relationship between the arm length, foot length with dynamic balance in 9-12-years-old children. Pearson correlation coefficient is used, p value <0.05 was considered as significant. The data was analyzed using Microsoft Excel and SPSS 21.
**RESULTS:** The mean distance reached by the children aged 9-12 years old were (males 22.2 $\pm$ 5.1; females 22.9 $\pm$ 6.6). The obtained p value for Pearson correlation coefficient is >0.05 and hence there is between arm length, foot length and dynamic balance in children of 9-12 years old.
**CONCLUSION:** Dynamic balance has correlation with arm length and foot length. Hence it suggests that the arm length and foot length does influence the score of dynamic balance on FRT in children.

***Keywords:*** Arm length, foot length, dynamic balance, children, 9-12-year-olds

## INTRODUCTION

Postural control is the ability to control the position of the body's COM (Centre of Mass) over its BOS (Base of Support) to prevent the body from falling and to achieve specific functional tasks [1].

Its development occurs in a stage like progression based on the system involved in the postural control [2].

It includes integration of various sensory information through visual, vestibular, and somatosensory feedback and execution of postural responses [1].

In typical development, the direction of postural stability growth occurs cephalocaudally. Hence an infant at first achieves head control, trunk control and then postural stability. By the age of 6-10 years postural stability and balance attains maturity. Postural stability maintained or controlled over BOS is balance [3].

Visual, vestibular, somatosensory, and musculoskeletal systems, through these systems balance is maintained. With age, varies the development of these systems. First system to develop is somatosensory and last is the vestibular. As each system reaches attains a certain threshold which now has ability to support associated behavior in turn develops postural control [2].

In activities like walking, running, and playing balance plays a vital role. Either at home, school, and community. Both balance components are influencing these activities [3]. Dynamic balance is operationally defined as the ability to maintain postural control during movement, such as reaching or walking [2]. Balance mainly depends on visual-vestibular systems during early childhood and the dependence then changes to somatosensory-vestibular system [3].

It requires more than 6 years to develop adult like balance. Balance improves as children age, which allows them to participate in daily activities independently. Adequacy of postural stability influences the reaching activity quality. Sensory impairment (visual, vestibular, and somatosensory deficit) and children with developmental disabilities such as CP, results in postural and balance issues. These results in various functional impairments like frequent falls leading to reduction in mobility which further leads to disability then morbidity. The dependency on caregiver increases with the postural stability issues and the impairment leads to community participation restriction as the child ages [3].

Within BOS if the vertical line of COM passes then, stability can be maintained. Lower the COM over larger BOS and or within same BOS more central the COM stability improves. An unstable posture is observed because of high COM over relatively small BOS. Therefore, dynamic postural stability control system is needed as for the naturally occurring spontaneous sway [1].

As known, there are various factors like gender, weight, age, height, BOS influences balance, hence any issues involving these factors can lead to frequent falls leading to morbidity [4]. Due to imbalance, it results in traumatic injuries and influence the developmental pattern (proximal and distal). Increased frequency of falls in children leads to functional disability and state of distress. This in turn has its influence on several developments like social, psychological, and biological. Hence the requirement of standardized norms is essential for the estimation of the fall risks. And necessary precautions can be planned for the children with less balance as compared with the norms as prescribed. For the examination of the static and dynamic balance there are many tests for certain age group and children with and without disabilities. The balance examination through these tests helps us to understand about the current balance status of the child so that if the examination results show reduced balance compared to the prescribed norm, early detection of its cause and the intervention can be initiated. The tests involved in the examination of balance do not only assess balance some also assess the gross motor skills [4].

The static and dynamic balance can be examined in 2 ways either in a laboratory or through standardized scales or tests. The instruments in the laboratory used to examine balance are stabilography, motion analysis, posturography and accelerometer these are highly cost effective, and functions are complex. Scales or tests used to assess static balance one of them is Romberg test. FRT is a test used to assess dynamic balance in forward direction in children which was given by Ducan et al [4].

In dynamic balance control there is involvement of the environment, task, and biomechanical constraint as well, hence these factors must also be looked upon while assessing. During reaching activity there is a certain pattern for muscle activation, which also includes shoulder blades protraction and trunk rotation these end up altering the distance reached scores. These are not only the factors that influence reach distance but there are other factors like characteristics of the participants and procedure used for the testing. In the context of the psychometric properties of FRT it has been proposed as discriminative

Within BOS the ability to keep COG with limited amount of sway is equilibrium. Hence essential for activities and postural control. Controlling equilibrium is an ability that is crucial for children. Daily living activities have been influenced by postural control in standing and sitting. As balance and gait can be influenced by interior or exterior factors, it plays a critical role in daily activities [6].

10-29% of prevalence is of postural balance disturbances [7].

A significant component of physical therapy examination is balance examination. Balance can be assessed in either clinical or laboratory tests. But the downside of laboratory test is it requires special equipment and cost effective, such as force platform and are of complex functioning. These may hinder the clinical application held routinely. Thus, the use of balance assessment tools is highly recommended [8].

Those are FRT (Functional Reach Test) and MRT (Multidirectional Reach Test) as it is commonly used for dynamic balance. The advantages of using tests are its cost effective, easy administer and time saving without usage of special equipment. In FRT the participant is supposed to reach beyond the arm's length while feet should be kept fixed position, participant should perform the task without losing balance, taking a step, or touching wall for support or taking assistance of examiner. FRT has a test-retest reliability of 0.75, inter rater value of 0.83 and intra rater value of 0.98 [8].

Movement pattern and muscle strategies are involved in postural strategies. There are three strategies like hip, knee, and ankle strategies [9].

The ability to move voluntarily, react to perturbation and to maintain a position is balanced. It can be either static or dynamic. In antigravity, weight-bearing posture ability to maintain steady position is static balance. In altering position or change in position ability to move while maintaining balance is dynamic balance [10].

Adults are likely to rely on hip strategy, while children are more likely to rely on the ankle strategy [11].

From vestibular, proprioceptive, and visual systems the information from these must be (re)weighed and integrated by the CNS which induces muscular responses which are well coordinated which in-turn allows an individual to stand upright [12].

Ankle joint torque controls the whole body by moving it as a single segment inverted pendulum. Ankle strategy is used under conditions like slow and small amplitude perturbation (i.e. quite bipedal standing). The body moved as double segment inverted pendulum, along with the presence of counterphase motion at ankle and hip is known to be the hip strategy it can be used in conditions like fast or large amplitude perturbation. Although, postural control is said to be multivariate in nature [12].

With age static balance improves, but the reliance on vision continues. During external perturbation there is requirement of whole-body reaction which should be rapid and must include counter rotation of segments about the COM, lower extremity joint movements, stepping, reaching for a stabilizing object, while in dynamic reaction [11].

In relation to environment with feet stationary on the floor during forward, backward, side bending and reaching activities, balance is essential [4].

FRT is defined as maximal distance an individual can reach forward beyond arm's length in a standing position without loss of balance, taking a step, or touching the wall [13]. In functional context of reaching, measures dynamic balance on FRT. While controlling the moving COM at a self-induced velocity forward displacement occurs. Test of balance control is FRT, hence biomechanical constraints and environment, tasks must be taken into consideration [5].

Although measures of DB are important elements of examination, which measures correlate how anthropometric variables might influence balance is unclear [2].

Thus, there is a need to investigate the relationship of arm length, foot length and dynamic balance in children aged 9-12 years.

## MATERIALS & METHODS

This Descriptive Study (Correlational study) was carried out in a period of 12 months from March 2019 to March 2020. Children aged 9-12 years were included from schools of Mangaluru in Dakshina Kannada, were screened for inclusion and exclusion criteria, after seeking permission from the Deans of the respected schools, the subjects falling within the inclusion criteria were recruited for the study. A sample size of forty-one was estimated. Convenient sampling technique was used to include the participants in the study.

Ethical clearance was obtained. The parents of the subjects participating in the study were given information sheet containing the study details and, also the Child Assent consent form was obtained from the subjects prior to the study.

### INCLUSION CRITERIA:

- 9-12 years of age group.
- Both gender with typical development.

### EXCLUSION CRITERIA

- Neurologic or orthopedic diagnoses.
- History of developmental delay or balance impairments.
- History orthopedic surgeries within the past 6 months.
- All diagnostic conditions and surgical histories were identified through parent report.

### MATERIALS:

- Pencil
- Paper
- Measuring tape
- Yardstick

## PROCEDURE:

At first an informed consent will be obtained from the parents of the participants. A detailed procedure will be explained about the test to all participants. All the recruitment of the participants in this study will be held according to the inclusion and exclusion criteria. After the recruitment an initial examination will include following: demographic data, height, weight, arm length and foot length.

### OUTCOME MEASURE:

- To measure the arm length: Measuring tape
- To measure the foot length: Measuring tape
- To assess dynamic balance: FRT

**Measuring the arm length with Measuring tape:**

- It was measured in supine lying, from the tip of the acromion process through the tip of the middle finger (right arm) in centimeter it was recorded. Arm should be in a relaxed position with shoulder in neutral, elbow in extended position, wrist in neutral position and finger are in extension.

**Measuring the foot length with Measuring tape:**

- It was measured from the end of the heel to the tip of the big (greater) toe in centimeters.

**Functional Reach Test (FRT)**

- The participants were asked to remove their footwear and to stand against the wall, where wall mounted ruler was present.
- Participants right acromion process palpated, and the ruler was adjusted to the level of it. The participants stood parallel to the ruler with their right shoulder flexed up to $90^0$.
- Initial marking was made with reference to the tip of the right middle finger against the ruler this marking was the initial reach point without the attempt of reaching forward. While performing reaching activity the opposite arm should be kept relaxed on the side of the body.
- They were then asked to reach forward as far as possible without losing balance or taking a step forward or taking wall support or assistance of the examiner. Once they reach a point beyond their arm's length, they were asked to maintain that position for 3 seconds and terminal reach point was recorded.
- They were asked to reach forward 3 times between each a 5 second rest time was provided. The average of the 3 scores was then calculated and included as results [3].

**Fig 1. FRT initial position.**

## STATISTICAL ANALYSIS

- The collected data was summarized using the descriptive statistics such mean +S.D. (standard deviation) to find the relationship of arm and foot length with dynamic balance in 9-12 years old children.
- Pearson correlation coefficient is used, p value <0.05 was considered as significant.
- The data was analyzed using Microsoft Excel and SPSS 21.
- The obtained p value for Pearson correlation coefficient is <0.05 hence there is relationship between the arm length, foot length and dynamic balance in children.

## RESULT

Demographic characteristics of the sample population

**Table 1: Gender wise distribution of subjects**

| | FREQUENCY | PERCENT |
|---|---|---|
| FEMALE | 21 | 51.2 |
| MALE | 20 | 48.8 |
| TOTAL | 41 | 100.0 |

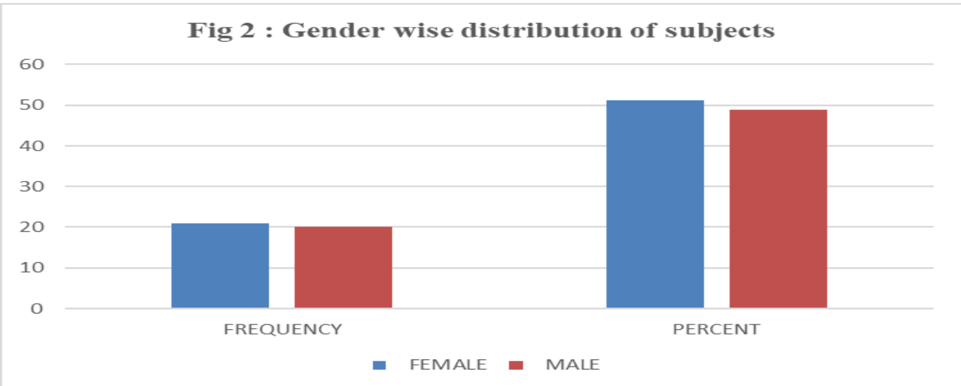

**Table 2: Age wise distribution of subjects**

| | FREQUENCY | PERCENT |
|---|---|---|
| 9 | 11 | 26.8 |
| 10 | 10 | 24.4 |
| 11 | 10 | 24.4 |
| 12 | 10 | 24.4 |
| TOTAL | 41 | 100.0 |

**Table 3: Distribution of arm length, foot length and FRT Mean ± S.D. according to age among males**

| AGE (MALE) | | HEIGHT | WEIGHT | ARM LENGTH | FOOT LENGTH | TRIAL 1 | TRIAL 2 | TRIAL 3 | FRT MEAN |
|---|---|---|---|---|---|---|---|---|---|
| 9 | Mean | 131.2 | 23.8 | 56.8 | 20.4 | 18.0 | 19.42 | 22.5 | 19.9 |
| | S.D. | 2.16 | 0.44 | 0.76 | 0.31 | 3.60 | 5.03 | 1.84 | 2.85 |
| 10 | Mean | 133.6 | 23.0 | 57.6 | 20.3 | 22.7 | 23.8 | 23.3 | 23.2 |
| | S.D. | 1.51 | 2.0 | 1.87 | 0.40 | 5.58 | 3.89 | 3.67 | 4.33 |
| 11 | Mean | 128.2 | 21.8 | 56.9 | 20.4 | 26.6 | 27.3 | 26.7 | 26.8 |
| | S.D. | 7.39 | 3.76 | 6.08 | 2.25 | 5.74 | 3.00 | 2.86 | 3.44 |
| 12 | Mean | 141.2 | 29.6 | 63.2 | 22.1 | 17.4 | 19.1 | 20.7 | 19.0 |
| | S.D. | 3.83 | 2.70 | 1.66 | 1.36 | 5.52 | 6.34 | 7.18 | 6.26 |

**Table 4: Distribution of arm length, foot length and FRT Mean ± S.D. according to age among females.**

| AGE (FEMALE) | | HEIGHT | WEIGHT | ARM LENGTH | FOOT LENGTH | TRIAL 1 | TRIAL 2 | TRIAL 3 | FRT MEAN |
|---|---|---|---|---|---|---|---|---|---|
| 9 | Mean | 128.1 | 22.6 | 56.5 | 19.3 | 23.3 | 21.5 | 24.3 | 23.0 |
| | S.D. | 6.91 | 4.27 | 1.08 | 1.25 | 3.50 | 3.50 | 4.42 | 4.53 |
| 10 | Mean | 133.2 | 29.0 | 57.4 | 21.3 | 19.24 | 21.0 | 22.0 | 20.7 |
| | S.D. | 6.76 | 8.97 | 2.05 | 1.48 | 8.00 | 7.76 | 5.17 | 6.83 |
| 11 | Mean | 131.9 | 32.2 | 59.3 | 20.4 | 21.8 | 19.7 | 20.1 | 20.3 |
| | S.D. | 21.3 | 9.44 | 4.14 | 1.99 | 7.75 | 4.88 | 3.99 | 5.44 |
| 12 | Mean | 142.2 | 33.8 | 62.3 | 21.6 | 26.9 | 27.6 | 29.0 | 27.8 |
| | S.D. | 5.21 | 2.16 | 3.99 | 1.04 | 9.06 | 8.59 | 8.76 | 8.76 |

**Table 5: Correlations of arm length, foot length with FRT trials and FRT mean**

| | TRIAL 1 | | TRIAL 2 | | TRIAL 3 | | FRT MEAN | |
|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p |
| ARM LENGTH | 0.198 | 0.214 | 0.207 | 0.195 | 0.175 | 0.275 | 0.203 | 0.204 |
| FOOT LENGTH | 0.094 | 0.557 | 0.156 | 0.330 | 0.082 | 0.609 | 0.116 | 0.471 |

****. Correlation is significant at the 0.01level (2-tailed).**

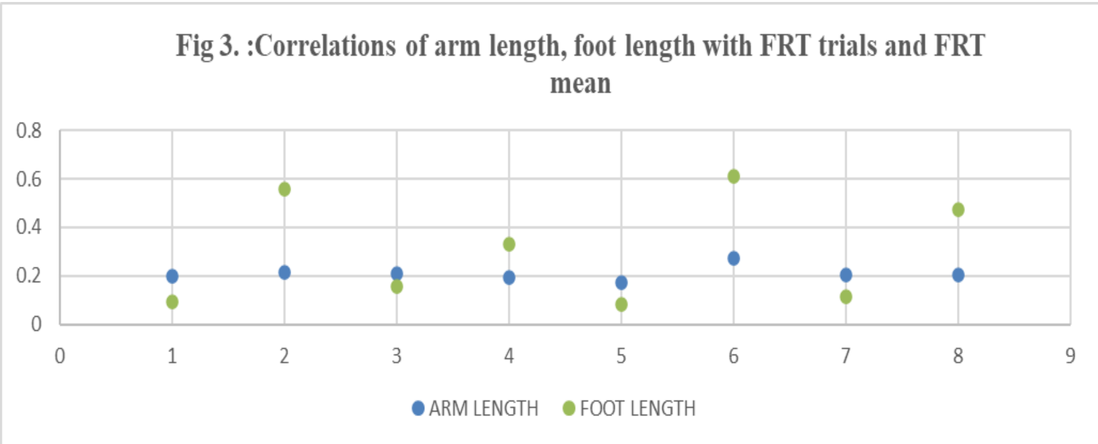


**Table 6: INDEPENDENT SAMPLES TEST**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | |
|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2 tailed) |
| ARM LENGTH | Equal variances assumed | 0.143 | 0.707 | -0.113 | 39 | 0.911 |
| | Equal variances not assumed | | | -0.112 | 37.871 | 0.911 |
| FOOT LENGTH | Equal variances assumed | 0.790 | 0.380 | 0.465 | 39 | 0.644 |
| | Equal variances not assumed | | | 0.467 | 38.706 | 0.643 |
| TRIAL 1 | Equal variances | 1.580 | 0.216 | -0.690 | 39 | 0.494 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | assumed<br>Equal variances not assumed | | | -0.694 | 37.747 | 0.492 |
| TRIAL 2 | Equal variances assumed<br>Equal variances not assumed | 0.105 | 0.747 | -0.009<br>-0.009 | 39<br>38.446 | 0.993<br>0.993 |
| TRIAL 3 | Equal variances assumed<br>Equal variances not assumed | 1.484 | 0.230 | -0.315<br>-0.318 | 39<br>36.520 | 0.754<br>0.754 |
| FRT MEAN | Equal variances assumed<br>Equal variances not assumed | 1.15 | 0.289 | -0.375<br>-0.377 | 39<br>37.354 | 0.710<br>0.708 |

**Table 7: Interpretation of t- test**

| | GENDER | MEAN | Std. Deviation | "t" | p value |
|---|---|---|---|---|---|
| Arm length | M<br>F | 58.65<br>58.78 | 4.08<br>3.61 | -0.113 | 0.911 |
| Foot length | M<br>F | 20.84<br>20.61 | 1.44<br>1.65 | 0.465 | 0.644 |
| Trial 1 | M<br>F | 21.19<br>22.70 | 6.12<br>7.74 | -0.690 | 0.494 |
| Trial 2 | M<br>F | 22.44<br>22.45 | 5.58<br>6.62 | -0.009 | 0.993 |
| Trial 3 | M<br>F | 23.34<br>23.88 | 4.58<br>6.31 | -0.315 | 0.754 |
| FRT Mean | M<br>F | 22.28<br>22.98 | 5.13<br>6.68 | -0.375 | 0.710 |

**Table 8: INDEPENDENT SAMPLES TEST**

| | | t-test for Equality of Means | | | |
|---|---|---|---|---|---|
| | | | | 95% Confidence Interval of the Difference | |
| | | Mean Difference | Std. Error Difference | Lower | Upper |
| ARM LENGTH | Equal variances assumed<br>Equal variances not assumed | -0.13571<br>-0.13571 | 1.20377<br>1.20748 | -2.57056<br>-2.58040 | 2.29914<br>2.30897 |
| FOOT LENGTH | Equal variances assumed<br>Equal variances not assumed | 0.22571<br>0.22571 | 0.48515<br>0.48349 | -0.75560<br>-0.75248 | 1.20702<br>1.20391 |
| TRIAL 1 | Equal variances assumed<br>Equal variances not assumed | -1.50976<br>-1.50976 | 2.18874<br>2.17613 | - 5.93691<br>-5.91608 | 2.91739<br>2.89656 |
| TRIAL 2 | Equal variances assumed<br>Equal variances not assumed | -0.01714<br>-0.01714 | 1.91896<br>1.91084 | -3.89860<br>-3.88396 | 3.86431<br>3.84968 |
| TRIAL 3 | Equal variances assumed<br>Equal variances not assumed | -0.54571<br>-0.54571 | 1.73065<br>1.71735 | -4.04628<br>-4.02694 | 2.95485<br>2.93551 |
| FRT MEAN | Equal variances assumed<br>Equal variances not assumed | -0.70071<br>-0.70071 | 1.86873<br>1.85669 | -4.48057<br>-4.46152 | 3.07914<br>3.06009 |

**Table 9: Interpretation of t-test**

| | GENDER | MEAN | S.D. | Lower | Upper |
|---|---|---|---|---|---|
| Arm length | M<br>F | 58.65<br>58.78 | 4.08<br>3.61 | -2.57 | 2.29 |
| Foot length | M<br>F | 20.84<br>20.61 | 1.44<br>1.65 | -0.75 | 1.20 |
| Trial 1 | M<br>F | 21.19<br>22.70 | 6.12<br>7.74 | -5.93 | 2.91 |
| Trial 2 | M<br>F | 22.44<br>22.45 | 5.58<br>6.62 | -3.89 | 3.86 |
| Trial 3 | M<br>F | 23.34<br>23.88 | 4.58<br>6.31 | -4.04 | 2.95 |
| FRT Mean | M<br>F | 22.28<br>22.98 | 5.13<br>6.68 | -4.48 | 3.07 |

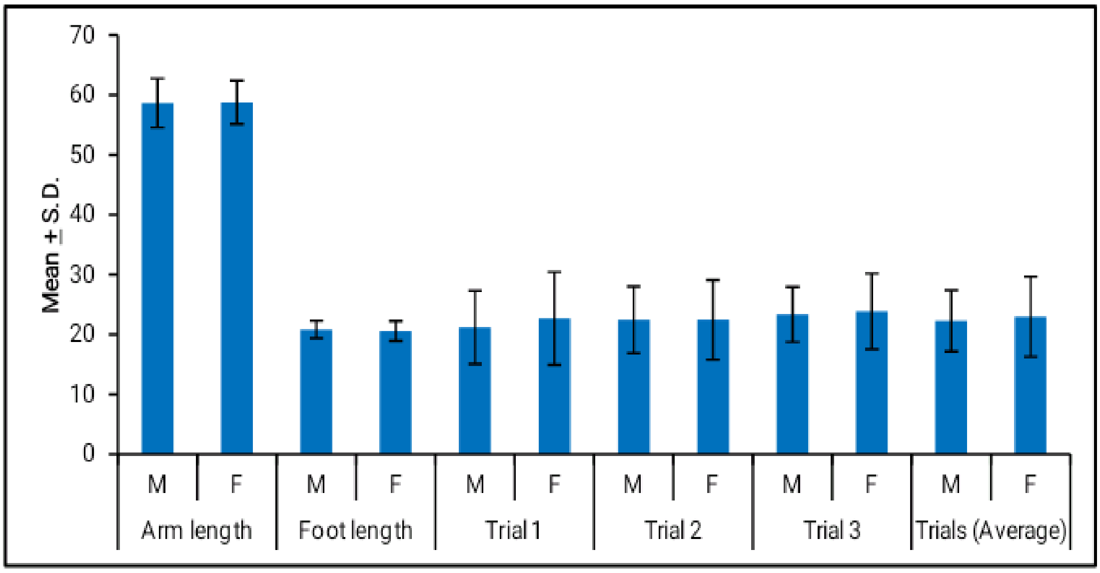


**Fig 4 : Interpretation of t test**

## DISCUSSION

The purpose of this study was to investigate how anthropometric characteristics (arm, foot length) relates with dynamic balance in children of age range 9-12 year. The hypothesis of the study was anthropometric characteristics (arm, foot length) relates with dynamic balance. This hypothesis was supported halfway, as arm length directly associated with dynamic balance and to some extent with foot length.

As know that dynamic balance plays a critical role in the development of the child. It influences the development of gross motor skills such as running walking, stepping etc. The lesser the dynamic balance the more severely the gross motor skills may get affected, leading to disability. The fall frequency increases with the reduced dynamic balance which in-turn will lead to impairment, which in later stages becomes disability, this causes the dependence level of child to increase. Hence due to all these consequences the examination of balance becomes very essential for the prevention of the severity of the consequences. Early detection of the balance impairment and detecting the underlying causes can lead to better goal specific intervention. Which will lead to speedy recovery.

While examining the balance of a, child the examiner must keep in mind that the balance can get affected due to several factors which should also be taken into consideration. Factors include internal, external environment, anthropometric characteristics like age, height, weight, gender, arm length and foot length. The factors included in this study were arm length and foot length, which were found to be influencing dynamic balance. There are several studies resulting in positive correlation of anthropometric factors with dynamic balance.

The results of this study also showed a positive relation between the anthropometric characteristics (arm, foot length) with dynamic balance. The studies supporting the results of this study include Habib and Westcott examined FRT scores in Pakistani children, Arm length was not examined in their study, but in 8- to 10-year-old children, base of support (foot length) was a significant predictor of mean FRT scores. Duncan et al reported an association between arm length and functional reach. Butz et al Although arm length was found to be the strongest predictor of the PRT score, height and foot length are also factors potentially affecting reach. Volkman KG. et al states in their study that BOS does play a role in the reach score while assessing through FRT. Mathew W. Hill et al in their study mentions that the arms does influence the reaching activity in children. Ertugrul Yusksel et al in their study states that not only length of upper limb but also age and weight do affect the dynamic balance in children. Although Butz et al in their study states that balance is directly correlated with balance scores. Nirav PV et al conducted a study in which they stated that when balance was assessed on PBS it was found that anthropometric characteristics like arm length, foot length, age and height influence the balance scores.

Some studies that oppose the results of this study, Norris et al examined 3- to 5-year-old children and determined weight to be the only anthropometric factor to predict FRT scores for 3- and 4-year-old children, but no factors predicted FRT scores for the 5-year-old group. Volkman et al in their study mentions that when assessed for dynamic balance in children with typical development the results showed that the reach scores were affected by age and height. Limitation of this is the sample size and the procedure used to measure the distance reached beyond the arm's length in FRT. Several studies do suggest that other methods like 1 arm toe to finger, 2 arm toe to finger do influence the score recorded as the reaching limit of the participant when assessed on FRT and which may lead to misinterpretation when the score deflect from the expected standard norms which are age specific. It may influence the clinician's decision, while assessing a child with typical development. Not only the method used for the measurement of reaching activity but also the methods of reach like 1 arm finger to finger, 2 arm finger to finger.

Conclusion of this study states that anthropometric characteristics (arm, foot length) relates to the dynamic balance within the age considered in this study. Even though this study concludes that the anthropometric factor specifically arm, and foot length do affect directly the reaching scores of the children with typical development when assess for dynamic balance on FRT, we cannot completely rely on this information as this study was conducted in a very small sample size, which cannot be considered as the representation of the whole population. There may be variances, if the study was to be conducted in a very large sample size, the reasons for not relying completely on the conclusion of this study are 1) sample size 2) method used for the measurement of reach score while assessing on FRT 3) different ways of reach has not been used in this study 4) different ways of assessing BOS was not used in this study.

Hence due to all these reasons the suggestion is that there should further studies on the same factors influencing the balance in children with typical development. As we know that assessing the balance is a part of the physical examination in routine examination which allows the clinician to make decisions regarding the normal development of the systems of the child and detect abnormal one's as well. It is well known that abnormal development or underdevelopment of the any system can affect the child's well-being and can worsen on a longer term if it is not diagnosed at earliest. Thus, all the possibility should be taken into consideration when assessing all the systems of the child, as children have their systems developing as they age, and each system attains maturity at a specific age range. Hence any misdiagnosis may lead to inconvenience to the child as well as their caretaker.

All in all, there should be further investigation involving children with typical development for the high reliance on the results of this study. Future investigations should include large sample size, various ways of measurement and various ways of reaching should be included, different ways of assessing BOS, and while assessing reach whether to consider dominant or non-dominant arm while assessing for the dynamic balance by using FRT as the test measure, which easy, reliable, and non-time-consuming method to assess the dynamic balance in children without disability.

## CONCLUSION

The conclusion of this study provides us with the information on arm and foot length which should also be an area of interest while examining for the dynamic balance in children. The arm and foot length may have a varying degree of influence on the dynamic balance of the children with also the inclusion of the biomechanical and environmental factors. This study hence proves that the arm length, foot length has its influence on dynamic balance in children of age range 9-12 years.

***Declaration by Authors***

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## REFERENCES

1. Smith A, Ulmer F, Wong D. Gender differences in postural stability among children. Journal of human kinetics. 2012 Jun 1;33(1):25-32.
2. Butz SM, Sweeney JK, Roberts PL, Rauh MJ. Relationships among age, gender, anthropometric characteristics, and dynamic balance in children 5 to 12 years old. Pediatr Phys Ther. 2015;27(2):126-33.
3. Deshmukh AA, Ganesan S, Tedla JS. Normal values of functional reach and lateral reach tests in Indian school children. Pediatr Phys Ther. 2011;23(1):23-30.
4. Duncan P, Weiner D, Chandler J, Studenski S. Functional reach: anew clinical measure of balance. J Gerontol. 1990;45:M192-M197.
5. Volkman KG, Stergiou N, Stuberg W, Blanke D, Stoner J. Factors affecting functional reach scores in youth with typical development. Pediatric physical therapy: the official publication of the Section on Pediatrics of the American Physical Therapy Association. 2009;21(1):38.
6. Jung HK, Chung E, Lee BH. A comparison of the balance and gait function between children with Down syndrome and typically developing children. Journal of physical therapy science. 2017;29(1):123-7.
7. Ludwig O. Interrelationship between postural balance and body posture in children and adolescents. Journal of physical therapy science. 2017;29(7):1154-8.
8. Yuksel E, Ozcan Kahraman B, Nalbant A, Kocak UZ, Unver B. Functional reach and lateral reach tests in Turkish children. Physical & occupational therapy in pediatrics. 2017 Aug 8;37(4):389-98.
9. Metgud DC, Parikh Y, Kharith Y. Comparison of dynamic balance between deaf and normal children using the functional reach test: An observational study. Indian Journal of Physical Therapy and Research. 2019 Jul 1;1(2):100.
10. Patel H, Malawade M, Butte-Patil S, Khairnar P, Gawade S. Comparison of balance in children with and without hearing impairment. Int J Healthcare Biomed Res. 2017 Jan;5(5):19-27.
11. Conner BC, Petersen DA, Pigman J, Tracy JB, Johnson CL, Manal K, Miller F, Modlesky CM, Crenshaw JR. The cross-sectional relationships between age, standing static balance, and standing dynamic balance reactions in typically developing children. Gait & posture. 2019 Sep 1;73:20-5.
12. Hill MW, Wdowski MM, Pennell A, Stodden DF, Duncan MJ. Dynamic postural control in children: do the arms lend the legs a helping hand?. Frontiers in physiology. 2019 Jan 17;9:1932.
13. Norris RA, Wilder E, Norton J. The functional reach test in 3-to 5-year-old children without disabilities. PediatrPhys Ther. 2008 20(1):47-52.

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