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**Sreejisha PK**
Assistant Professor, Laxmi Memorial College of Physiotherapy, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India

**Jasni CP**
Post Graduate Student, Laxmi Memorial College of Physiotherapy, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India

**Corresponding Author:**
**Jasni CP**
Post Graduate Student, Laxmi Memorial College of Physiotherapy, Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India

# Relationships between core strength, hip external rotator muscle strength, with star excursion balance test in children: A pilot study

**Sreejisha PK and Jasni CP**

**Abstract**
The current study's goal is to investigate the relationships between hip ER strength, and core strength with lower extremity balance. The study included 20 children of age 8 -14 years who were living in and around Mangalore. Using a star excursion balance test (SEBT), the balance was evaluated. Core strength was evaluated using the plank and lateral plank, while hip external rotator strength was evaluated using a handheld dynamometer. Karl Pearson's Correlation Coefficient was used to assess the relationship between the star excursion balance test, hip external rotator muscle strength, and core strength in children. According to the results, SEBT was correlated with hip external rotator strength which shows that bilateral hip external rotation strength has statistically significant moderate positive correlation with dynamic balance (Right side r=0.56, p=0.009; Left side r=0.49, p=0.02). While correlating the SEBT and core strength, plank had a positive moderate correlation which was statistically significant whereas right and left lateral plank test were non-statistically positively correlated (plank r=0.5, p=0.02; Right lateral plank r=0.29, p=0.20; Left lateral plank r=0.17, p=0.45). Thus it is concluded from the study that hip external rotator strength and core strength has a direct relation with dynamic balance in children.

**Keywords:** Core strength (CS), Hip external rotator (HER), Star excursion balance test (SEBT)

## 1. Introduction
The dynamic of a person's posture to avoid falling is referred to as their "balance." For the most of daily activities and many sports, proper balance is essential for both injury prevention and athletic performance. Inertial forces operating on the body and the inertial properties of body segments are related to balance, a complicated motor skill that defines the dynamics of body posture to prevent falls. The ability to keep or bring the body's COG (centre of gravity) back within the BOS-determined LOS (limit of stability) is known as biomechanical balance (base of support) [1].

The distinction between static and dynamic balance is a prevalent one in the literature. While standing or sitting, static balance tries to keep the body's centre of pressure (COP) as stationary as possible within the Base of Support [1]. Dynamic balance is defined as the capacity of a person to keep their centre of gravity stable while moving, and it is a crucial element in many sports. Dynamic stability is defined as the maintenance or restoration of balance in reaction to internal or external disturbances, while static stability refers to balance in unperturbed situations, such as while quiet standing. Dynamic could be instabilities brought on by changes to the support surface or the upper body, as well as voluntary segmental or whole-body motions during silent posture or locomotion. In order to maintain or move the centre of mass over the base of support, the postural control system is thus necessary [2, 3].

Daily actions like walking, running, and climbing stairs all need dynamic balance. Additionally, it has a significant role in both athlete performance and injury to the lower extremities. Lower extremity injuries in females are known to be influenced by decreased proprioception and balance. By preventing the knee from internal rotation, adduction and reaching a dynamic valgus position during movement, improved balance may lower the incidence of knee injuries [3, 4].

In recent years, the Star Excursion Balance Test (SEBT) has become widely used in both healthy and injured populations to detect dynamic balance deficiencies and improvements as

well as to assess the likelihood of lower extremity injury. While maintaining a single leg stance on one leg and extending the contralateral leg as far as possible during the test, strength, flexibility, and coordination are required [5].

Core stability is defined as the cornerstone of trunk dynamic control to produce, transfer, and control force and motion to the terminal segments of the lower body kinetic chain [6]. Thus, core strength (CS) is regarded as essential for proximal stability and distal motion [7]. While allowing for a stable base of mobility, the core functions as a rigid cylinder with a higher moment of inertia against perturbations [8]. On this basis, the study's hypothesis is that the performance of core stabilisation and balance ability may be related.

When walking and engaging in daily activities, external rotation (ER) is crucial for preserving proper pelvic and limb alignment [9, 10]. According to earlier studies, the hip musculature contributes significantly to the stability of the knee complex and also lessen ACL and patellofemoral injuries. [11] Thus, it can be said that hip strength is crucial for maintaining posture and balance as well as for anatomically and biomechanically interconnecting the upper and lower extremities [12]. Nevertheless, research has shown that the hip external rotators and balance do not significantly correlate. (2012) Farzaneh Hesari *et al*. [13]. Therefore, it is necessary to learn more about their affiliation.

Despite the studies on these three, it is still not apparent whether hip ER and CS strength have any real impact on lower body balance [4]. The current study's goal is to investigate the relationships between hip ER strength, and core strength with lower extremity balance as measured by the SEBT.

## 2. Materal and Methodology

### 2.1 Study Design and Sample

Children from Mangalore and the surrounding areas were studied using a cross-sectional study design to determine the relationship between balance, hip external rotator strength, and core strength. Data was gathered between September 2021 and May 2022. The study included 20 boys and girls between the ages of 8 and 14. Children with neurological or musculoskeletal conditions that would impair their movement and balance, lower extremity injuries, low back discomfort, or other conditions were not allowed to participate.

### 2.2 Procedure

In accordance with ethical standards, the A.J Institute of Medical Science's institutional ethical committee gave its approval. All participants and their legal representatives signed the consent and accent forms respectively after receiving a brief explanation of the study protocol. Using a star excursion balance test, the balance was evaluated (SEBT). Core strength was evaluated using the plank and lateral plank, while hip external rotator strength was evaluated using a handheld dynamometer. The statistical method was used to determine the association between balance, core strength, and hip external rotator strength.

### 2.3 Measurement: Assessment of Balance by Using Star Excursion Balance Test

The SEBT is a useful screening tool for determining the lower extremities' dynamic stability. The SEBT examined the three reach directions (Anterior (A), Posteromedial (PM), and Posterolateral). One examiner performed a pre-procedure demonstration of each SEBT measure. Standing on one of their lower extremities, participants position their great toe in the center of the grid (stance foot). They subsequently continue single-leg stance while reaching with the reach leg positioned anteriorly, posteromedially, and finally poster laterally. Participants reached the farthest distance on each leg while maintaining their balance, and the greatest reach distance was recorded. Three trials in each direction were performed, and the mean was used as the final. The SEBTCOM represented the mean of all directions [4].

### 2.4 Assessment of core strength using plank test

Prone plank: In a prone position, the participant was instructed to hold and maintain a 90-degree angle between the elbow and the trunk. Only elbows and toes were allowed to make contact with the floor. Total time maintained by the participant in the position was recorded in seconds.

Side plank test: While side-lying, the participants were asked to maintain a straight body line perpendicular to the elbow for as long as possible, allowing just the elbow and shoes to make contact with the ground. Total time maintained by the participant in the position was recorded in seconds [8].

### 2.5 Assessment of hip external rotator strength by using hand held dynamometer

HER isometric strength was measured bilaterally using a portable, hand-held dynamometer. While seated on a chair with their knees and hips flexed at a 90-degree angle, HER isometric strength was assessed. A strap was fastened across the thigh, and a towel roll was positioned in between the knees to avoid hip adduction. A dynamometer was positioned five cm above the medial malleolus, and the participant was instructed to rotate their leg inwards strongly. The three test trials' peak values (pounds) were noted [4].

### 2.6 Statistical Analysis

The participant's demographic data was compiled using descriptive statistics. Karl Pearson's Correlation Coefficient was used to assess the relationship between the star excursion balancing test, hip external rotator muscle strength, and core strength in children. The statistical programme SPSS version 21.0 was used for the analysis, probability (p) value $< 0.05$ was considered as statistically significant.

## 3. Result

This study comprises of 20 participants of mean age 10.3±1.26 which includes 10 boys (mean age 10.5±1.26) and 10 girls (mean age10.1±1.28) [table 1]. Table 2 and table 3 show the mean and standard deviation of SEBT directions, hip external rotation strength and core strength.

**Table 1:** demographic details of 20 children including 10 girls and 10 boys

| | Total (Mean ± SD) | Girls (Mean ± SD) | Boys (Mean ± SD) |
|---|---|---|---|
| Age | 10.3±1.26 | 10.1±1.28 | 10.5±1.26 |
| weight | 37.24±9.70 | 33.13±6.22 | 41.35±11.07 |
| Height | 143.33±9.92 | 142.37±10.82 | 144.3±9.42 |

**Table 2:** The mean and standard deviation of SEBT in 20 children

| | Total (Mean ± SD) | Girls=10 (Mean ± SD) | Boys=10 (Mean ± SD) |
|---|---|---|---|
| Right anterior SEBT (cm) | 107.95±11.99 | 103.4±10.93 | 112.5±11.75 |
| Right posterolateral SEBT(cm) | 98±22.24 | 89.5±23.56 | 106.5±18.14 |
| Right posteromedial SEBT(cm) | 86.6±18.53 | 81.2±18.96 | 92±17.35 |
| Left anterior SEBT(cm) | 102.45±17.56 | 93.2±15.17 | 111.7±15.19 |
| Left posterolateral SEBT(cm) | 86.65±16.21 | 80.2±15.44 | 93.1±14.98 |
| Left posteromedial SEBT(cm) | 72.8±12.34 | 69.7±13.88 | 75.9±10.37 |
| SEBTCOM(cm) | 92.40±14.33 | 86.2±14.03 | 98.61±12.28 |

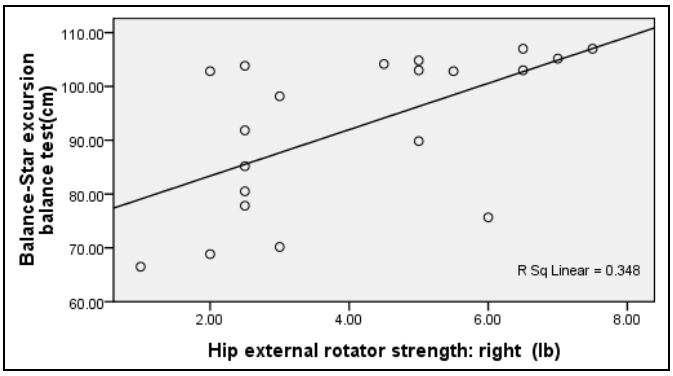
**Table 3:** The mean and standard deviation of hip external rotation and core strength

| | Total (Mean ± SD) | Girls=10 (Mean ± SD) | Boys=10 (Mean ± SD) |
|---|---|---|---|
| Right external rotator (lb) | 4.02±1.89 | 4.5±2.08 | 3.55±1.67 |
| LEFT external rotator (lb) | 4.2±2.27 | 4.25±2.18 | 4.15±2.46 |
| Plank (sec) | 22.51±15.50 | 25.17±16.22 | 19.85±15.12 |
| Right lateral plank (sec) | 13.57±6.40 | 16.24±6.73 | 10.90±5.02 |
| Left lateral plank (sec) | 15.92±7.85 | 16.43±9.01 | 15.40±6.95 |

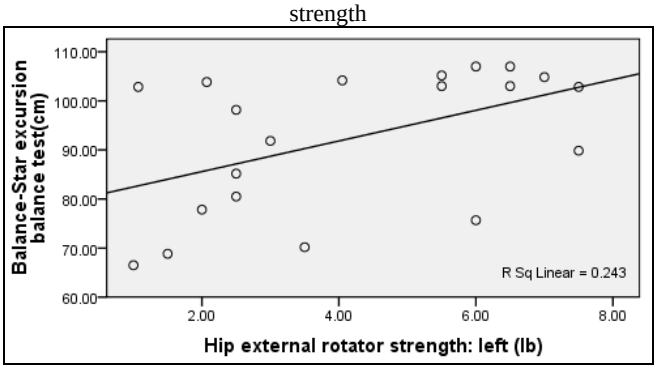
Using Karl Pearson Correlation Coefficient, SEBT was correlated with hip external rotator strength which shows that bilateral hip external rotation strength has statistically significant moderate positive correlation with dynamic balance [Table 4, Graph 1 and 2]. While correlating the SEBT and core strength plank had a positive moderate correlation which was statistically significant whereas right and left lateral plank test was non-statistically positively correlated [Table 4].

**Table 4:** Correlation of balance (SEBTCOM) with hip external rotation and core strength using Karl Pearson Correlation Coefficient. Correlation is significant at the 0.05 level (2-tailed).

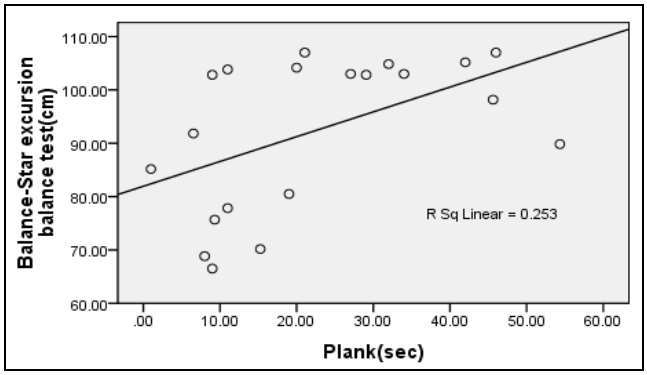
| Right external rotation strength | R=0.56 | P=0.009 |
|---|---|---|
| Left external rotation strength | r=0.49 | p=0.02 |
| Plank | r=0.5 | p=0.02 |
| Right lateral plank | r=0.29 | p=0.20 |
| Left lateral plank | r=0.17 | p=0.45 |



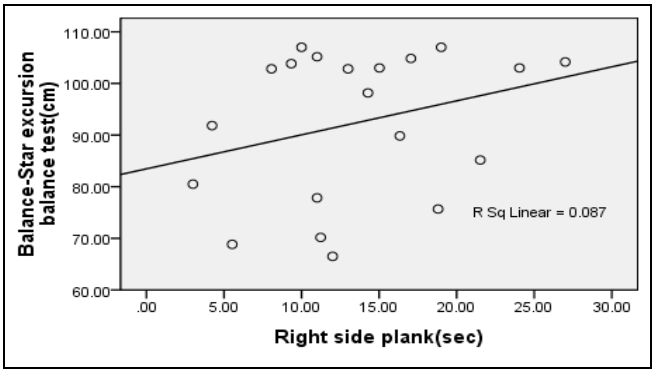

**Graph 1:** Correlation between balance and right hip extern rotation strength



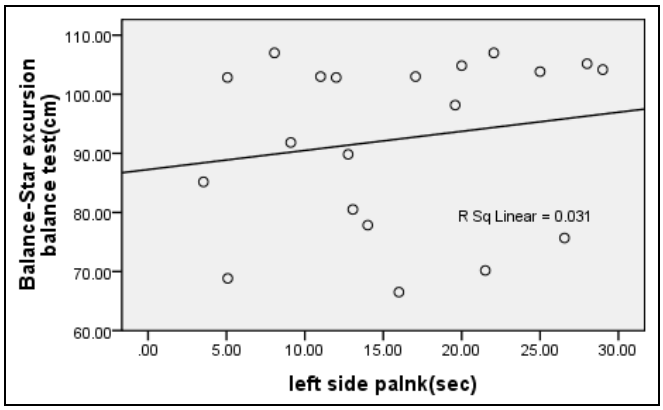

**Graph 2:** Correlation between balance and left hip external rotation strength




**Graph 3:** Correlation between balance and plant test




**Graph 4:** Correlation between balance and right lateral plant




**Graph 5:** Correlation between balance and left lateral plant

## 4. Discussion

The goal of this study was to determine if LE dynamic balance in children aged 8 to 14 years is influenced by Core

strength (CS) and Hip External rotator muscle strength (HER). The core stability of 20 participants was assessed using prone, right, and left lateral planks, dynamic balance was assessed using the SEBT, and HER isometric strength was recorded bilaterally using a hand-held dynamometer.

In LE kinematics and mobility, CS plays a significant role [4]. In the current study correlating the SEBT and core strength, the plank test had a statistically significant positive moderate correlation, although the right and left lateral plank test was none significantly positively correlated [table 4]. The results are in direct opposition to those of Gordan *et al*., who discovered no correlation between balance and core strength. Whereas our study in in agreement with the study done by Mikayla Lovin *et al*. who showed a weak, positive relationship between balance and core strength. We can therefore draw the conclusion that children's balance improves as their core strength does [4, 14].

Because the abdominal muscles contract to stabilise the spine, a firmer base of support is created for lower extremity movement, which helps to explain the positive association between core strength and balance. Additionally, when the transverse abdominis contracts, the thoracolumbar fascia tenses due to an increase in intraabdominal pressure. These contractions take place prior to the start of limb movement, providing the limbs with a stable base for motion and muscle activation. In relation to limb movement, the rectus abdominis and oblique abdominals are stimulated in precise patterns that help promote posture [8, 15].

The result regarding the correlation between Side Bridge and balance is not in terms with the study done by Tarik OZMEN *et al*. [3] where he found no significant relationship between side bridging and SEBT in soccer player. While the current study, which was conducted on a normal population, found a positive correlation but it was statistically insignificant. Therefore, additional research involving a broader population is required for the results to be generalised and for more clarity.

Adequate postural control is important for SEBT performance, but so are isometric hip external rotation (ER), extension, flexion, and abduction (ABD) strength. Lower extremity injuries are more likely to occur when isometric hip ER strength is compromised. The average hip ER strength scores in the 20 subjects in the current study were HER-R=4.02±1.89 lb and HER-L=4.2±2.27 lb. A correlation analysis showed a statistically significant moderately positive correlation between bilateral hip external rotation strength and dynamic balance. The same conclusion was reached in an interventional study conducted by Ness *et al.* on female soccer players, where it was found that increases in hip ER strength were substantially correlated with advancements in anterior reach performance. HER and balance were not found to be significantly correlated by Farzaneh Hesari *et al.* There is conflicting information in the literature on the relationship between hip external strength and dynamic balance, so more research is necessary to understand this relationship [13, 16, 17, 18].

Although very few research has been done demonstrating the relationship between core strength and external rotation strength with dynamic balance, one of the limitations of the present study is its smaller sample size.

## 5. Conclusion

This study concluded that bilateral hip external rotation strength and plank have a direct association with dynamic balance whereas to conclude the association of side planks with the dynamic balance, study with larger population is needed.

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