

**Original article:**

## Correlation between single leg postural control and toe flexor muscle strength in young adults

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### Abstract

**Purpose:** The purpose of the current study is to find the relationship between single leg postural control and toe flexors muscle strength in young adults. The toe flexors strength helps in determining the anterior limit and functional base of support whereas the single leg postural control determines the person's ability to maintain balance by using only one limb.

**Methodology:** Total 60 young adults aged between 20-30 years voluntarily participated and performed test for single leg postural control and toe flexor muscle strength. The single leg postural control was measured through multiple single leg hop stabilization test and toe flexor muscle strength was measured through modified sphygmomanometer test.

**Result:** Correlation analyses were conducted between the single leg postural control and toe flexor muscle strength. Karl Pearson's correlation was used to find out the result. Negative correlation ( $r = -0.34$ ) is seen between these two variables.

**Conclusion :** The Result of the study suggest that if the toe flexor muscles strength would get better than the chances of error ( landing and balance ) would be less thus single leg postural control and balance would also get better.

**Keywords:** Single leg postural control, toe flexor muscle strength, multiple single leg hop stabilization test, modified sphygmomanometer test.

### Introduction

The human base of support (BOS) is defined by an area bounded posteriorly by the tips of the heels and anteriorly by the line joining the tips of the toes. The center of mass (COM) is the point where the whole mass of the body is centered. The position of COM is not fixed and therefore changes with changing postures. In young children the COM in standing position is located within the body about the level of 12<sup>th</sup> vertebrae while in standing adults the COM moves lower to a location about the level of the second sacral vertebrae [1].

Furthermore the main aspect of the postural control is to maintain the body's center of mass over its base of support/ functional base of support within the limit of stability. The stability occurs when the center of mass can be moved freely without changing base of support. The stability in the body can be depend on a) the task requirements such as double leg stance, running, jumping and single leg stance. b) Support surface conditions such as friction c) individual's biomechanics such as body morphology and configuration, joint range of motion and strength of the joint and muscle. Moreover as the task requirement, body biomechanics and support surface characteristics changes

then it also alters the postural responses [2], while maintaining single leg posture the body will remain in continuous motion and never achieved absolute equilibrium even when the task is to remain still as possible. Therefore it is necessary to have movement and counter movements to maintain stability and equilibrium of the body [3].

The single leg stance plays an important role in daily activities such as putting on a pair of pants. The postural instability occurs as a result of the required organization of COM over a short narrow BOS. The saggital plane helps in controlling the double leg stance whereas the frontal plane is hypothetically more important during single leg postural control [4]. Furthermore there are certain sports and physical activities where an individual must rely on the single leg base of support therefore, the use of single leg test to measure the postural control/ stability is logical as well as warranted from clinical as well as sports research perspective. Maintaining the balance on a single leg base of support requires the postural control system to reorganize the total body center of mass over a narrow base of support [5].

The toe flexors strength is a combination of planter intrinsic muscles (flexor haullucis brevis, flexor digitorum brevis and lumbrical pedis) and extrinsic muscles (flexor hallucis longus and flexor digitorum longus). The toe flexor helps in supporting foot arch, walking, standing, running and jumping performance therefore reduction in toe flexor muscle strength can lead to foot abnormalities such as plantar fasciitis, pes cavus, claw toe and hammer toe deformities. Furthermore, early reduction in toe flexor strength is a risk factor of falls especially in elderly groups. Thus estimation of toe flexor strength plays an important role in physical fitness, activities of daily living and a type of preventive care for elderly groups to prevent falls [6].

The toe flexor muscle strength is of the important essential to maintain postural control while standing and walking. During locomotion the activation of toe flexor muscles is required for the push off phase as the heel leaves the ground and the dorsiflexion of metatarsophalangeal joint increases. It is also seen that the increase in toe flexor strength also contribute in physical performances whereas the low level of toe flexor strength is highly associated with impairment of physical performances especially in athletes. Therefore appropriate evaluation of toe flexor strength is required to quantify the physical activities in daily living and sports [7].

### **Aim & Objective**

The aim of the study was to find out the correlation between single leg postural control and toe flexor muscle strength in young adults. To determine if any correlation existed between single leg postural control and toe flexor muscle strength in young adults.

### **Material and method**

The material used during the study were Sphygmomanometer (NEWNIK LIFECARE) to check muscle strength, a white Tape or marker draw the starting point from where the subjects will hop and a standard measuring tape to measure the distance of hop patters on the floor.

### **Participants**

Sixty young participants (30 males; 30 females; age 20- 30 years; height 150-189cm; weight 40-85kg) were used in this study. All of the participants had no history of balance or lower extremity neurological disorder and no participants had sustained a musculoskeletal or head injury within the past 12 months. The dominant leg being defined as the preferred leg used to kick the ball, sit and walk test and stair climbing test. Informed consent was

obtained from all the participants in accordance with the Manav rachna international institute of research and studies (physiotherapy department).

Firstly, the dominant legs of the participants were checked for which they had to perform several tests which are required to obtain their single leg postural control and toe flexor muscle strength.

**Dominant leg tests:**

- Ball kick: the participant was asked to kick the ball, the leg he/she used to hit the ball was considered as dominant extremity.
- Sit and walk test: the participant was asked to sit and then walk. The first step he/she took from lower extremity was considered as dominant.
- Stair climbing test: the participant was asked to climb the stairs the first step he/she took from lower extremity was considered as dominant.

These three tests determined the leg dominance in the subjects.

After dominant leg tests were completed the subjects were required to perform single leg hop test that was required for single leg postural control

**The multiple Single leg hop stabilization test:**

A numbered floor pattern was marked with 11 pieces of white tape shown in **figure 1**. The inter-tape distance was set according to the height of each participant the largest distances that the participants were required to hop in the pattern were for the diagonals between tape marks 2 and 3 and tape marks 7 and 8 shown in **figure 2**. We chose to use 45% of a participant's height for the diagonal dimensions, the largest inter-tape distance of the pattern. For example, for the participants height of 170cm the diagonal dimension would be 76.5cm, with the distances between adjacent pieces computed using the Pythagorean theorem (54cm) another modification was made from the original test involved the participants using only one limb i.e. dominant limb rather than alternating limbs between the tape marks to perform the entire test.

And the last step was to measure the toe flexor muscle strength through modified sphygmomanometer test

**Modified sphygmomanometer test:**

The toe flexor muscle strength of the dominant leg was measured using this method. The conventional sphygmomanometer was adapted using the bag method. The bag was inflated to 100mmhg to remove any wrinkle on its bladder. Sufficient air was released to achieve a baseline pressure of 20mmhg in such a way that it provided measurement intervals between 20 and 300mmhg. The valves were closed tightly to prevent any leakage. The cuff was placed in a position to resist the movement generated by the muscle group to be tested. The force exerted by the subjects was noted from the dial.



Figure1: Multiple single leg hop stabilization test.

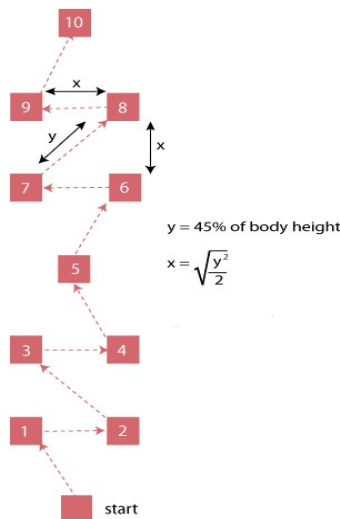


Figure 2: The measurement of inter-tape distances. [8]

### Procedure

The participants underwent the testing procedure one time only. During the procedure the participants went for dominant leg test where they performed three tests to obtain their dominant leg, after obtaining their dominant leg participant performed second test that was multiple single leg hop stabilization test. Before starting the test, the subjects were given an overview of the test, the scoring system and standardized instructions. The instructions emphasized the error-scoring system and test procedures. Each of the subjects was given the opportunity to try several practice hop-stabilization sequences prior to data collection. Then the subjects were instructed to start on the start mark with their dominant foot covering the tape mark, facing forward, with the hands on the iliac crests. They were required to hop to the first tape mark, and upon landing, maintain single leg balance with their hands on their iliac crests for five seconds. At the conclusion of five seconds, the subjects were then instructed to hop to the next successive tape mark, repeating the procedure through all ten points of the floor pattern shown in **figure 3**. The performance during the test was determined using separate criteria for the two phases of the test (landing and

balance). The Landing phase included landing on the tape mark and establishing body control. The balance phase encompassed the subsequent 5 seconds after body control is established during which the subject maintained single leg balance before the next jump was executed therefore less errors signifies stability and better single leg postural control. Criteria for error in landing and balance are included in **Table 1**. The third and the last test was modified sphygmomanometer test which was used to obtain the toe flexors strength. The subject was seated on the bench and the feet were touching the ground. The cuff was placed in a position to resist the movement generated by the muscle group to be tested i.e. below the toe made sure that the planter flexors were not involved during this procedure. The subjects were instructed to press the cuff with their toes as hard as they can. The force exerted by the subjects was noted from the dial as shown in **figure 4**.



**Figure 3: Testing position for the multiple single leg hop stabilization test.**

**Table 1: Error scoring system**

<b>Landing errors.</b>	Not covering tape mark.
	Stumbling on landing.
	Foot not facing forward with 10 degree of inversion and eversion.
	Hands off hips.
<b>Balance errors.</b>	Touching down with non dominant limb.
	Non dominant limb touching dominant limb.
	Non dominant limb moving into excessive flexion, extension and abduction.
	Hands off hips.



**Figure 4: Testing position for the modified sphygmomanometer test.**

**Result**

The initial result of the study shows that there is negative correlation is seen between the single leg postural control and toe flexors muscle strength in young adults.

The Demographic data of the subjects were taken according to the 60 subjects which were selected for the study. The subjects participated in the study falling within the age group of 20 to 30 years.

**Table 2** the demographic details of the subjects.

S.No.	Demographic details	Mean ± SD
1.	Age (years)	21.5 ± 1.15
2.	Height (cm)	165.6 ± 10.38
3.	Weight (kg)	61.22 ± 11.98
4.	BMI (kg/ m <sup>2</sup> )	24.92 ± 20.51

Table 3 shows, negative relation between single leg postural control and toe flexor muscle strength ( $r = -0.34$ ) which was measured through multiple single leg hop stabilization test and modified sphygmomanometer test respectively and graph 5 shows, scatter plot representing the relationship between single leg postural control and toe flexors strength in young adults and it was found that there is negative correlation between both the variables ( $r = -0.34$ ).

**Table 3: shows negative correlation between single leg postural control and toe flexor muscle strength in young adults.**

		Toe flexor muscle strength. (modified sphygmomanometer test)
Single leg postural control (multiple single leg hop stabilization test)	r	-0.34

## Discussion

The aim of the study was to see the relation between the single leg postural control and toe flexor muscle strength in young adults. The main finding of the study was that there is negative correlation (-0.34) between single leg postural control and toe flexor muscle strength in young adults. The negative correlation states that if the toe flexor muscle strength would get better and strong then the chances of errors (balance and landing) would be less thus the balance and single leg postural control would also get better.

It is believed that while performing the test when a standing participant took a forward lean to initiate the movement, there is generation of forward angular and linear momentum of the body. Therefore to arrest this momentum before it takes the center of gravity beyond functional base of support, they typically uses the planter flexor muscles to depress the metatarsophalangeal joint against the ground so that the center of ground reaction force moves towards the metatarsophalangeal joint. When the center of gravity reaches metatarsophalangeal joint with forward momentum then it can only arrest by moving center of ground reaction force anterior to metatarsophalangeal joint by using toe flexor muscle strength.

Therefore, greater the muscle strength of toe flexors, more the subject can increase the ground reaction force under the distal phalanx of each toe. Hence, enhance stability. Furthermore as per the independently study [9] the main finding was that TFS was significantly correlated to the lower limb physical performance such as 50m sprint running, a side step, a standing broad jump and a 20 m shuttle run. Their results suggest that the measurement of TFS is practically meaningful to assess the muscles strength related dynamic lower-limb physical performance in adolescent. Subjects with high maximum force ability of toe flexor strength showed a better dynamic muscular performance in lower limb. Sprinting and jumping require high speed movement and high force production of lower limb therefore correlate with maximum force generating capacity of lower limb whereas vertical jump performances require multi segmental force transmission in order to generate large force on the ground. The EMG studies showed that during the stance phase of walking and running, the muscles are activated in following order i.e. thigh, calf and foot muscles this suggest that muscle strength of the foot mechanically reflects to the joint moment and power of lower limbs by kinetic chain, working as a terminal point of kinetic chain during locomotion. These biomechanical studies and their results indicate that the larger TFS is strongly associated with enhancement of the muscular performance of lower limb in adolescents.

According to another previous study [6] the main finding of the was that the toe flexor muscle strength decreases with increasing age along with hand grip and knee extensor strength. It also found that the toe flexor strength was positively associated with physical activity levels assessed by daily standing and walking time. Toe flexor strength was found to positively associate with walking performance such as walking speed, percentage of swing time in a gait cycle, and stride length during walking at maximal speed. The possible explanation for this correlation is that toe flexor muscles are intensely recruited during standing or walking actions leading to improvement of force production in muscles. Another previous study [10] showed that the decrease in strength of toe flexors was correlated with slower walking speed and shorter period of single limb support phase and shorter stride length during fast pace of walking. The slower walking speed is a sensitive marking of mobility limitation in older adults

and shorter period of single limb support phase represent poor balance control during gait. Therefore results suggest that toe flexor muscle plays an important role in walking at fast pace in older adults.

The significance of the study according to the result is that the toe flexor muscle strength helps in maintaining single leg postural control therefore helps in enhancing stability as well as balance and also contribute in physical performance. Furthermore there are few limitations of the study. The sample size included in the study was small, for more accurate results large sample size could have been taken another

limitation of the study was that not every participant could properly place the 5<sup>th</sup> toe over the bag of modified sphygmomanometer because the length of toes and metatarsals were different between participants and the last limitation of the study was the maximum voluntary push of the toes against the resistance (provided by bag) seems very unusual task for the participants. Therefore participants need some test trial before the final measurement.

### Conclusion

Based on the data obtained from the study there is negative correlation (-0.34) between single leg postural control and toe flexor muscle strength in young adults.

The negative correlation showed that if the toe flexor muscle strength would get better and stronger then the chances of errors (landing and balance) would be less thus the balance and single leg postural control would also get better.

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