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Effect of Q-angle on Static and Dynamic Balance in Older Population

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ABSTRACT

Background and Objectives: Lower extremity injuries are commonly due to impaired balance. The best to assess lower extremity alignment is the Quadriceps angle (QA), it says the important variable and because it represents quadriceps muscles vector direction in frontal plane. The purpose of this study is to find a correlation between quadriceps angle on static and dynamic balance measures.

Methodology: Ethical clearance was obtained from institutional ethical committee. Subjects fulfilling the inclusion and exclusion criteria were included. Informed consent form was taken from each of the subject prior to the treatment. A sample of 95 subjects recruited between 60 years and above. These participants were recruited using purposive sampling. This Correlation analytical study consists of Timed Up and Go Test And Berg Balance Scale for assessing functional mobility and Balance(Static and Dynamic) respectively and data was analysed using the statistical package SPSS 22.0 (SPSS Inc.., Chicago, IL) at $p<0.05$.

Result: The result of research suggests that there is a Statistically significant with moderate positive correlation (p=0.002*) observed between Q-angle with TUG (which measure dynamic balance). There is significantly weak positive (p=0.095) correlation observed between Q-angle with BBSS values (which measures both static and dynamic balance).

Conclusion: In this study, the effect of Q angle has moderately positive correlation with dynamic balance. A Q angle is weakly correlated with the static balance. That means quadriceps angle plays an important role in predicting injuries of lower extremity. This makes an important diagnostic tool during assessment of an individual, especially in Geriatric population.

Keywords: Q-angle; Static Balance; Dynamic Balance; L/E injuries; Elderly.

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INTRODUCTION

The most widely held view of ageing is that it is just a part of the life cycle. That is a progressive physiological cycle leading to senescence (the condition or process of deterioration with age), or a decline of biological functions and of the body's ability to adapt to metabolic stress. Ageing is also seen as a wide-ranging event being

a physical process, a psychological one and a social one. The division exists with three ages of "old", a starting point for considering the span of old age- 1) Between 60-75 years = young old 2) Between 75-85 years= old 3) Those 85+ are considered the frail older population.[1]

The total population of Bangalore is about 9.6 million according to census of year 2011. Among them 10% (Around 9.5 lakhs) are above the age of 60 years.[2] There has been a 100% rise in dementia cases in 25 years, said Dr. Satis Chandra.[1] A number of physical changes and balance problem are more common as we age.[1]

Old age is viewed as an unavoidable, undesirable and problem ridden phase of life. Problems of aging usually appear after the age of 65 years. These problems may be divided under 5 heads:- (1) Physiological (2) Psychological (3) Social (4) Emotional (5) Financial.[1]

As we age, we lose balance function through loss of sensory elements, the ability to integrate information and issue motor commands, and because we lose musculoskeletal function. Disease common in ageing populations lead to further deterioration in balance function in some patients. Treatment of balance dysfunction in aging processes and on an evaluation of the individual's balance loss and remaining balance elements.[3]

Q-angle (Quadriceps angle) is defined, as the angle between the quadriceps muscles (primarily the rectus femoris) and the patellar tendon and represents the angle of quadriceps muscle force.

The quadriceps angle (Q angle) was first defined by Brattström[4], and has become a widely used assessment method by orthopedicians, physiotherapists, and other healthcare professionals in the evaluation of certain pathologies or tendencies to pathology that may be observed in the lower extremities.[4]

The Q-angle is measured by extending a line through the centre of the patella to the anterior superior iliac spine (ASIS) and another line from the tibial tubercle through the centre of patella. The intersection of these two lines is the Q-angle.[3]

The normal value for this angle is 12 to 20 degrees. Men tend to have Q-angle closer to 13 and women usually have Q-angle at the high end of this range.[4]

The Q-angle is a measurement used in the evaluation of the function of the knee and kinetics of the patellofemoral joint.[3] In the literature, this measurement has recently been used with the objective of determining the alignment of the lower extremities in conditions including genu varum-valgum (especially patellofemoral instability).[4-5] In addition, studies have also examined the association of the Q-angle with static anddynamic balance.[6] The Q-angle gives an idea about the direction of the net lateral force occurring in the patella as a result of contraction of the quadriceps muscle.[7]

The direction and magnitude of force produced by the quadriceps muscle has great influence on patellofemoral joint biomechanics. The line of force exerted by the quadriceps is lateral to the joint line mainly due to the large cross-sectional area and force potential of the vastus lateralis. Since there exists an association between patellofemoral pathology and excessive lateral tracking of the patella, assessing the overall lateral line of pull of the quadriceps relative to the patella is a meaningful clinical measure. Such a measure is referred to as the Quadriceps angle or Q-angle.[3-8]

Balance refers to an individual's ability to maintain their line of gravity within their Base of support (BOS).

Balance is important considerations in the health of elderly subjects. It is estimated that 13% of adults self-report imbalance from ages 65 to 69 years and this proportion increases to 46% in those aged 85 and older in India. Additionally, impairments of balance (static and dynamic) have been implicated in increased risks of falls. In adults aged 60 years and above, the estimated annual prevalence of falls is 28%. Falls are associated with significant morbidity and mortality in the elderly.[6-7]

Balance is often used along with stability and postural control. It is an important aspect in day-to-day life as it helps to maintain a stable posture, for performing daily activities while neutralizing external or internal conflict.[8]

There are two types of balance- Static and Dynamic. Static balance is our ability to hold our body in a specific position and posture while dynamic is our ability to maintain balance while moving our body.[9]

In static balance the body remains stationary, and centre of mass is over the BOS (normal BOS-18 to 20 inches).[6] This type of balance is important when doing activities such as squatting or standing on one leg. Dynamic balance is required when your body is in motion and most mimics real life situations, such as walking, running. Having good dynamic balance is essential in your body's ability to react to sudden changes in your balance.[9]

Balance is sustained by several factors which includes the vestibular system, visual-

spatial perception, tactile input, proprioception, musculoskeletal and neuromuscular system. Any insufficiency in these factors may results into postural imbalance and increase the risk of injury.[10]

These factors ultimately cause fall. Risk factors for falls include muscle weakness, a history of falls, use of four or more prescription medications, use of assistive device, arthritis, depression, age older than 80 years, and impairments in gait, balance, cognition, vision, and activities of daily living.[10]

Balance is necessary for an individual to maintain posture, respond to voluntary movements, and react to external perturbations. This "limit of stability" depends on an individual's biomechanics, the requirements of the task, and the type of surface the individual is standing on.[8]

Animal studies suggest that posture is controlled via supraspinal mechanisms. Specifically, the vestibular system and cerebellum are thought to play primary roles in postural control with the cerebellum important for modifying limb and trunk movements and balancing opposing muscle forces for a required task.[10] Postural control depends on sensory inputs: somatosensory information from muscle and joint proprioceptors, cutaneous sensory information which identifies surface characteristics, vestibular information for head and trunk orientation in space, gravity information from graviceptors in the trunk, and visual input. Situational cues and prior experiences modify these inputs and contribute to balance control.[6]

Lower extremity injuries are most commonly due to impaired balance.[1] Research suggests a change in static and dynamic balance in individuals with a history of injuries such as ankle sprains, ankle instability, ACL deficiency and patellar femoral syndrome screening for balance impairments seems necessary based on its potential to predicts and prevent MSk conditions of the lower extremity.[1]

The lower extremity structures and its alignment can influence the postural control strategies and greatly affects the stability. A change in the structural alignment can predispose an individual to injuries of the lower limb.[11] Literature shows contradicting conclusions on this topic. Alexander KM discussed that individuals with high QA had higher risk of fall due to balance impairments.[12] While DenizogluKulli concluded that low QA was responsible for impaired dynamic balance while higher QA did not contribute to balance impairments.[13]

The assessment of static and dynamic balance was achieved by using Timed up and Go (TUG) test and Berg Balance Scale (BBS).

Among total population of Bangalore, 10% population are above the age of 60 years according to sensus of year 2011.[2] In India, the annual prevalence of fall is 28% in recent years (2020-22).[5]

A study that explore, The effect of Q angle on balance in Young adults (between the age group of 22-35), Which shows Q angle is moderated correlated with static and dynamic balance.[1] While there are studies that suggest poor balance and poor lower extremity alignment make an individual susceptible to injury, so as to predict lower extremity injuries that may occur in the future.[10] This makes it an important diagnostic tool during assessment of an individual, and it also helps during rehabilitation.

There is no study which check the impact of Q angle on balance in older population. So the purpose of this study is to see the effect of Q angle on static and dynamic balance in older population.

Research Question:

There will be significant effect of Q-angle on static and dynamic balance in older population.

Null hypothesis

There will be no significant effect of Q-angle on static and dynamic balance in older population.

Alternative hypothesis

There will be significant effect of Q- angle on static and dynamic balance in older population.

OBJECTIVES OF THE STUDY

To find out the effect of Q-angle on dynamic balance in older population.

To find out the effect of Q-angle on static and dynamic balance in older population.

Institutional Ethical committee clearance was obtained. Subjects were selected based on inclusion and exclusion criteria and all participants were provided consent prior to enrollment. Demographic details such as name, age, sex, were noted. Outcome measures (TUG and BBS) was used to assess Balance. Participants were selected randomly.

The subjects, firstly measured Q-angle and then static and dynamic balance using "Timed Up and Go" test and Berg Balance Scale. And find out the correlation between the Q angle and Balance.

The study was conducted on the participants' dominant leg; dominance was assessed by a ball kicking test.[14] All the participants performed test without wearing shoes. The participant was accompanied throughout the test to ensure safety. The tests were stopped anytime during the procedure keeping in mind the termination criteria such if patient gets tachycardia or blood pressure increases.

Q angle was measured in standing, (Fig. 1) three landmarks were identified anterior superior iliac spine (ASIS), centre of patella and tibial tuberosity. The foot should be placed in a neutral position relative to supination and pronation with the hip in neutral position relative to medial and lateral rotation. For marking patellar midpoint, the borders of patella were palpated and outline was drawn. The point joining the maximum vertical and transverse diameters of patella was marked as midpoint of patella. The point of maximum prominence at anterior upper end of tibia was noted as the tibialtuberosity. The fulcrum of goniometer was placed on centre of patella; the moving arm was directed to the ASIS and the stationary arm to the tibial tuberosity. The angle created by the intersection of the 2 lines is the Q angle.[1]

2] Timed Up and Go (TUG) test measures, in seconds. TUG is a simple test used to assess a person's mobility and requires both static and dynamic balance. It uses the time that an individual to stand up from a standard arm chair (approximate seat height of 46 cm, arm height 65 cm), walk a distance of 3 meters (approximately 10 feet), turn, walk back to the chair, and sit down.

3] Berg Balance Scale (BBS), it is a 14-item scale designed to measure balance of the older adult in a clinical setting. A five-point ordinal scale, ranging from 0-4. "0" indicates the lowest levelof function and "4" the highest level of function.

Total Score = 28 and is the interpretation of BBS is:

41-56 = low fall risk

21-40 = medium fall risk

0–20 = high fall risk

< 36 fall risk close to 100%

RESULTS AND DATA ANALYSIS

Statistical Analysis

The Data will be analyzed using spss version 20.00 with the level of significance Set at P<0.05%

Table 1 & Fig. 1: Depicts frequency and percentage of frequency distribution of Q-angle in study Population

-	Frequency (n)	Percentage (%)
≤ 10	12	12.7%
>10- 13	35	36.8%
>13-16	36	37.8%
>16	12	12.7%
Total	95	100%

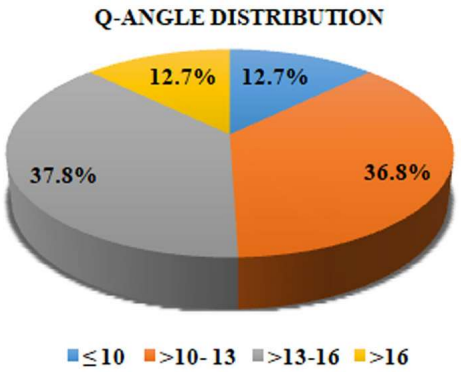


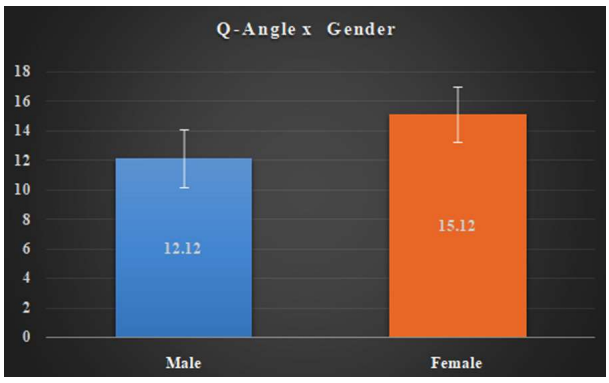
Table 1 shows frequency and percentage distribution of Q angle. according to data Collection 12.7% people have ≤10-degree Q-angle, 36.8% have >10-13-degree Q-angle, 37.8% have >13-16-degree Q-angle, 12.7% have >16 degree of Q-angle.

Table 2 & Fig. 2: Depicts association between Q-angle with Gender Population

	Mean	SD
Male (n=49)	12.12	1.95
Female (n=46)	15.12	1.86
	Unpaired t test value = -7.646, p< 0.001** (highly statistical association) Females have significant higher q angle	

p>0.05 – no statistical significant correlation *p< 0.05 – significant correlation

The above association indicates that, females



have higher Q-angle than males the mean value for male is-12.12 and for females-15.12.

Table 3 & Fig. 3: Shows frequency and percentage of frequency distribution of Berg Balance Scale Score In Study Population

-	Frequency (n)	Percentage (%)
0-20 (High Fall Risk)	0	0%
21-40 (Medium Fall Risk)	3	3.15%
41-56 (Low Fall Risk)	92	96.85%
Total	95	100%

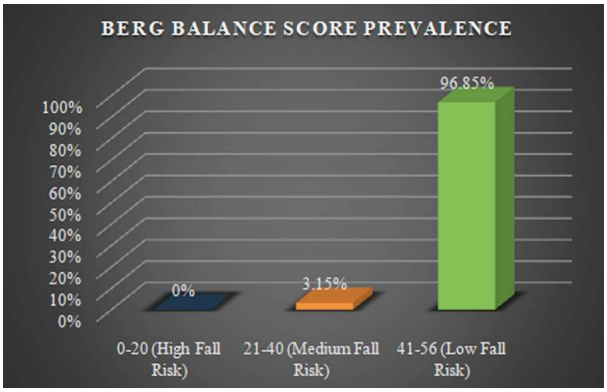


Table 3 shows the distribution of BBS Score in study population. The analysis of this test shows 3.15% were scored between 41-56 (low fall risks) and only 96.85% were scores between 21-40 (medium risks of fall).

Table 4 & Fig. 4: Shows frequency and percentage of frequency distribution of TUG Score in Stuyd Population

-	Frequency (n)	Percentage (%)
< 12 seconds (No Risk for Falling)	52	54.7%
≥ 12 seconds (Risk for Falling)	43	45.3%
Total	95	100%

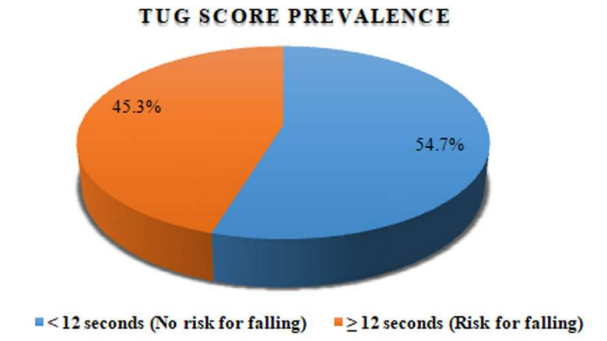


Table 4 shows the distribution of TUG Score in study population. The test shows 54.7% participants who takes <12 seconds to complete the entire procedure (which means no risk for falling) and there are 45.3% participants who takes ≥12 seconds to perform the entire test (which means these participants have risks for falling).

Table 5 & Fig. 5: Shows Correlation between Q-Angle with Berg Balance Scale Score (Bbss) and Timed Up & Go Test (TUG) Score

-	Frequency (n)	Percentage (%)
Q-Angle x TUG Time	r = 0.319 (moderate positive correlation)	p =0.002* (statistical significant correlation)
Q-Angle x BBSS	r = 0.172 (weak positive correlation)	p = 0.095 (no statistical significant correlation)

p>0.05 – no statistical significant correlation *p< 0.05 – significant correlation

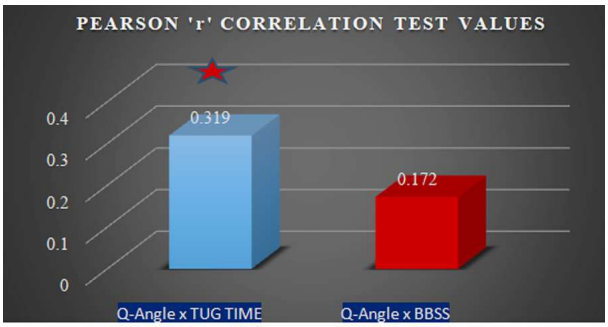


Fig. 5. The study evidenced that there is statistical significant moderate positive correlation (p<0.05) observed between Q-angle with TUG Time indicating as Q angle increases, TUG time also increases suggesting more risk for falling with increased Q angle and the correlation was found to be of statistically significant (p=0.002*). This shows Q angle Moderately Correlated with dynamic balance.

No statistical significant weak positive (p>0.05) correlation was observed between Q-Angle with BBSS (p=0.095).

DISCUSSION

This discussion attempts to find out the correlation between Q-angle on static balance and dynamic balance in older population. So as to predict lower extremity injuries that may occur in the future.

95 participants were selected by the method of purposive sampling, from the age group of 60 years and above in this study fulfilling the inclusion criteria.

The Q-angle is a measurement used in the evaluation of the function of the knee and kinetics of the patellofemoral joint.[9]

In the literature, this measurement has recently been used with the objective of determining the alignment of the lower extremities in conditions including genu varum-valgum (especially patellofemoral instability).[10]

In addition, studies have also examined the association of the Q-angle with static and dynamic balance.[11]

To measure balance TUG test and BBS was taken. The percentage and frequency distribution of the dominant leg in this study showed that, out of 95 participants, 88.4% people are right dominant and 11.6% are left dominant leg. Which shows that most of individuals are right dominant.

J. Thompson, conducted a study on limb dominance. Shows, out of 100 participants, 86% were right leg dominant and 14% are left dominant. The concept of limb dominance is stemmed from the premise that the two hemispheres of the brain function differently and there is a preferential use of either the right or left limb, eye, ear, and other bodily functions. The hemisphere of speech is the stronger hemisphere, and the majority of humans have a dominant left cerebral hemisphere.[15]

Chloe Schorderet, indicate that balance performance is not influenced by the leg's dominance. This means that performances of both legs can be used as reference.[16]

In this study, subjects were measured with Q-angle and to test the balance we have taken two outcome measures- (1) Time Up and Go test(which measure dynamic balance) (2) Berg Balance Scale (which include both component-static and dynamic)

The Q-angle is one of the most clinically used parameter in evaluating the quadriceps forces and factors acting on the patellofemoral joint which is considered to be as an indicator assessment, diagnosis and to predict prevention of fall and any injuries that may occur in future in older population. It also used in diagnosis of several patellofemoral painful disorders and diseases.[17]

According to data most of people shows Q angle between 10-13 degree and 13-16 degree which has taken in standing position.

LH Woodland have observed in their study that, When Q angle measured in standing position, standing postural variations, such as increased foot pronation and genu valgum along with excessive foot pronation and supination which have some influence on Q angle and may affect patellar mechanism.[18] It also showed muscle strength and balance also effect the lower extremity alignment.[19]

Knee alignment indicators such as Q angle are highly correlated with the quadriceps femoris muscularity. Any alteration in alignment that increases the Q angle is thought increase the lateral force on patella. This can be harmful because the increase in this lateral force may lead to increase the compression of the lateral patella on the lateral lip of the femoral sulcus. In the presence of a great enough lateral force, the patella may actually sublux or dislocate over the femoral sulcus. when the quadriceps muscle is activated on an extended knee. It has also been found that an abnormal Q angle may also influence neuromuscular response and quadriceps reflex response time,[20] consequently, it may be a risk factor for ACL injury.[21]

The study conducted by, Melissa G Hirton, etc. also found that women have larger Q angles than men, but they fail to provide an anatomical explanation or new predictor of Q angle. The possible explanation of females having high Q angle values can be attributed to the fact that their pelvis anatomy is wider than males' pelvis which is extrapolated by having a long distance between the pelvis and the patella in comparison to the distance of patella to the tibial tuberosity, thereby inducing an alteration in the position of ASIS that has a huge impact on the Q angle values.[22]

Study shows the distribution of BBS Score among population. The analysis of this test shows 3.15% were scored between 41-56 (low fall risks) and only 96.85% were scores between 21-40 (medium risks of fall). (Table 3)

The correlation of the Q-angle with BBS is-significant weak positive ($p>0.05$) correlation was observed between Q-Angle with BBSS ($p=0.0095$) (Table 5)

L D Thorbahn, Used BBS to predict falls in elderly persons. They found that there is no relation between increasing age and decreasing performance on the BBS.[23]

The distribution of TUG score shows, 54.7% participants who takes <12 seconds to complete the entire procedure (which means no risk for falling) and there are 45.3% participants who takes ≥12 seconds to perform the entire test (which means these participants have risks for falling) (Table 4)

The correlation of the Q-angle with TUG test is statistically significant with moderate positive correlation ($p<0.05$) between two variables.

Individuals with high Q angle, TUG time also increases suggesting more risk for falling with increased Q angle and the correlation was found to be statistical significant (p=0.002) (Table 5).

Proper co-contraction of lower limb muscles is necessary to maintain the balance and improve functional stability.[24] Multiple anatomical factors influence the magnitude of QA such as tibiofemoral angle, hip internal rotation which impacts QA that is related to dynamic knee function.[25]

Dr. Khyati Patole, Dr. Tushar Patekar et al., found that there was significantly higher activity of VMO and VL in anterior direction, higher activity of tibialis anterior (AT) in posteromedial direction and higher activity of biceps femoris (BF) and AT in posterolateral directions as compared to other muscles of the lower limb.[24] Which means these particular muscles play an important role in maintaining dynamic balance and their weakness will result in poor dynamic balance. Weakness of the quadriceps muscle will cause a change in the force of muscle pull; the Q angle will change and any change in this angle other than normal will make an individual to have impaired balance.[26]

The direction and magnitude of force produced by the quadriceps muscle has great influence on patellofemoral joint biomechanics. The line of force exerted by the quadriceps is lateral to the joint line mainly due to the large cross-sectional area and force potential of the vastuslateralis. Since there exists an association between patellofemoral pathology and excessive lateral tracking of the patella, assessing the overall lateral line of pull of the quadriceps relative to the patella is a meaningful clinical measures. Such a measure is referred to as the Quadriceps angle or Q-angle.[13]

Many sensory systems contribute to balance, such as foot/ankle sensory input, visual input, and vestibular input.[5]

However, many of these systems decline with age. For example, older adults have significantly decreased foot position awareness in comparison with young adults, likely due to decrease plantar mechanoreceptive sensation. This decline is exacerbated by footwear, which impairs awareness of foot position through decreased tactile feedback.[27] Similarly, the elderly have decreased mechanoreceptive sensation in the toes and heels.[28] Vestibular function also declines with age, with significant decline seen after age 65.[29]

Several studies have examined the role of different systems in maintaining balance in the elderly. Judge *et al*. found that balance was impaired when visual or foot/ankle proprioceptive input was decreased in elderly adults.[30]

Balance was almost four times more impaired by reduced proprioception (swaying platform) than by reduced visual input. However, the relative risk of losing balance was increased 5.7 to 7.4 times when visual input was diminished in addition to proprioception. In addition to sensory input, decreased muscle strength also impairs balance in the elderly: for each Nm/kg increase in lower extremity muscle strength, the adjusted odds of losing balance decreased by 20%.[30]

Study Limitations

a. Only older population are included.

b. In this study only Q-angle is measured, there are other factors which affect the balance, these are not assessed.

c. Other factors which include MMT, BMI, Height and Weight are not assessed.

d. Study have not taken postural variation (i.e. foot pronation, knee deformities-genu valgum and varum).

Future Scope

In this study we found out that quadriceps angle and speed (functional mobility) play important role in predicting injuries of lower extremity in older individuals. This makes it an important diagnostic tool during assessment of an individual, and it also helps during rehabilitation.

In future muscle strength and balance has to be trained.

CONCLUSION

The findings of the study suggest that there is moderate positive correlation observed between Q angle with TUG (which measure dynamic balance) in older population. That shows if Q angle increases TUG time also increases. There is weak positive correlation was observed between Q angle with BBS (which measure both static and dynamic balance) in older population.

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