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Relationship between Isokinetic Strength of Quadriceps muscles and Dynamic balance among Asian young individuals with and without Genu Recurvatum: A Cross-Sectional Study

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ABSTRACT

Background: Genu recurvatum (GR) is characterized by hyperextension of the knee or back knee. It leads to retardation in the strength and balance of the quadriceps. Optimal muscular strength and balance are required for performing daily activities. Articles concentrate on the strength of the quadriceps and balance in GR. Still, negligible studies have been working towards isolating the correlation between the strength of quadriceps muscles and balance in GR versus individuals without GR. The present study aimed to find a correlation between strength and balance of quadriceps between healthy individuals versus individuals with GR.

Methods: A cross-sectional study comprising 64 patients, 30 regular and 30 with GR were enrolled. An isokinetic dynamometer was used to assess quadriceps strength, and the Y Balance lower quarter test (YB-LQT) was used to assess balance in healthy individuals and individuals with GR.

Results: Peak knee extension torque (PKET) generated from the right limb is found to be moderately correlated to the performance of the composite score of YB-LQT in individuals with GR (r=0.48; r=0.44). In contrast, PKET is weekly correlated with the performance of the composite score of YB-LQT for healthy individuals (r=0.028; r=0.163). When comparing both groups, no significant difference was found between them.

Conclusion: While each test measures a unique construct, there is an association between its components. In individuals with GR, YB-LQT, and isokinetic strength tests find asymmetries and propose using them as outcome measures before and after therapeutic interventions.

Keywords: Balance, Muscle, Muscular strength, Quadriceps muscle, Torque.

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INTRODUCTION

Many lower limb muscles are involved in the act of weight bearing. A component of strength plays a significant role in facilitating this weight bearing. The quadriceps is a bulk muscle formed by combining the Rectus Femoris, Vastus Medius, Vastus Intermedialis, and Vastus Lateralis, thus dominating its presence and action for smooth activities of daily living (ADLs). Its strength varies in different age groups. Kinematic limitation is defined from a biomechanical perspective by a ground response force vector that passes well in front of the knee. A knee extensor moment is produced due to this phenomenon to prevent collapse during the stance phase [1]. The normal range for knee hyperextension is 5 degrees in normal healthy adults. Genu Recurvatum (GR) has been defined as hyperextension of the knee beyond 5 degrees. GR, which is commonly accompanied by knee discomfort, reduces the patient's autonomy during ADLs [2].

GR, called 'back knee,' is an angular knee malformation in the sagittal plane [3]. GR results from quadriceps muscle spasticity or weakening, triceps surae spasticity and/or contracture, and poor proprioception [4]. Every third person in the Asian population is diagnosed with GR, where the lower limb has a hyperextended knee, which is shorter than the contralateral leg, imposing a significant impact on one's posture and gait [5-7]. Pain, weakness, instability of persistent leg, leg-length discrepancy, and limitation in range of motion are the highly evident signs of GR. It comprises medial instability [8]. GR is a condition determining ranges exceeding the standard limit [9].

Postural alignment, joint integrity, joint ranges, and muscle performance contribute to balance control and muscular strength [10]. Strength is the ability of a muscle to perform body functions, and balance is the capacity to align body segments against gravity in order to shift the center of mass of the body within the available base of support without falling [11]. Muscle performance is based on three parameters: endurance, power, and strength, while the interconnection between the contextual, musculoskeletal, and nervous systems forms balance control [10,12].

In the present study, the Y Balance lower quarter test (YB-LQT) was used to assess dynamic balance, and an isokinetic dynamometer was used to assess the strength parameters of the same individuals. Peak knee extension torque (PKET) is measured by an Isokinetic Dynamometer (IKD) to assess quadriceps strength and measure the maximum reach in centimeters to examine dynamic balance. The study aims to find a relationship between the strength and balance of the main affected muscle group quadriceps in GR and healthy population. A healthy population is taken simultaneously to find a normative reference value to compare it with the GR population.

METHOD

Participants

The is a cross-sectional research design conducted between March 2022 to March 2023. With an appropriate screening criterion, 68 subjects (38 female, 26 male) were recruited using convenience sampling. The minimum sample estimate was 64, with the estimated correlation coefficient being 0.343, and = 0.05, = 0.20 [13]. An information sheet comprising details in the context of participation, eligibility procedure, and timelines was shared with participants. After reading the information sheet, participants were requested to confirm participation by signing the Informed Consent Form. Outcomes were assessed in a sports laboratory of a tertiary care hospital.

The study included individuals between 18 and 25 years old, walking independently, and able to read and sign an informed consent form in English. However, individuals with neurological deficits, pregnancy, malignancies, previous knee or ankle surgeries, restricted knee range of motion, and acute traumatic injuries were excluded [14]. Four participants were excluded, not fulfilling the selection criteria.

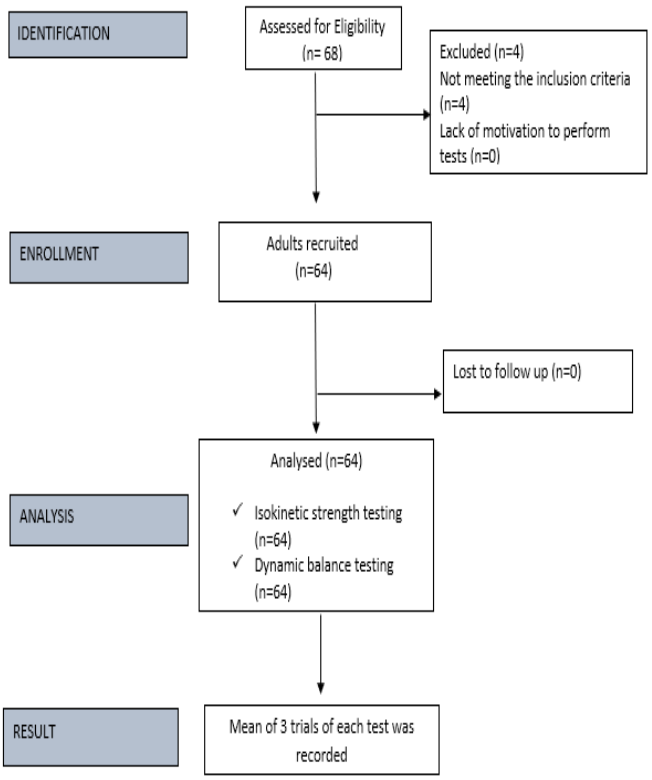


Figure 1: STROBE Flowchart

Measures

Isokinetic strength testing

An IKD machine has been used to assess the isokinetic strength of an individual/group of lower limb muscles. IKD was used to isolate quadriceps muscle strength, where the subject was asked to sit on an IKD chair and strapped with a corset around the upper trunk and thigh region. Alternatively, either ankle is fixed to the chair, and the other ankle strapped allows for performing the motion. To begin with, the swing from the knee was 90 degrees, and the participant was asked to perform 3-5 repetitions. Participants are asked to move the unlocked leg to maximum extension with full force against the fixed

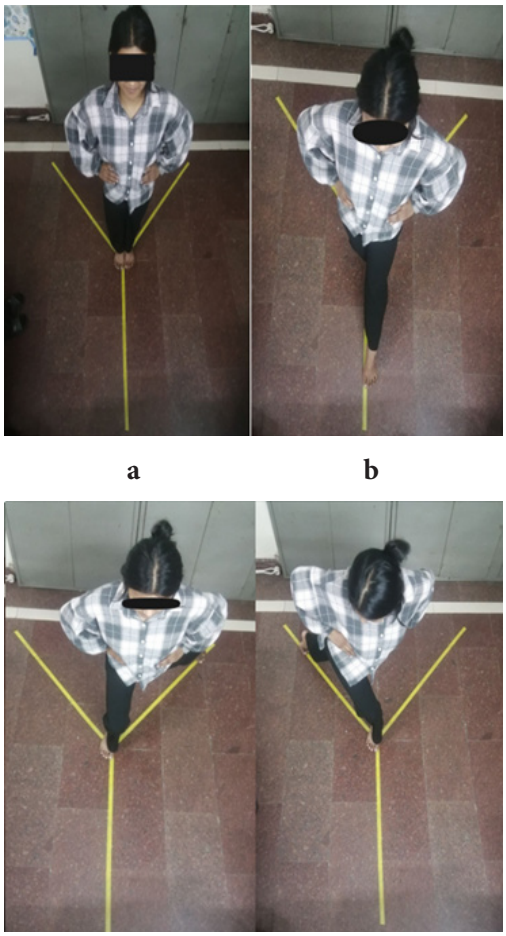
angular velocity of 180°/s as five repetitive contractions. Hence, the maximum contraction of the repetition is considered peak torque. Work, power, quadriceps/hamstring ratio, and flexion/extension peak torque are also assessed in one go. PKET is measured for both lower limbs alternatively, and readings are generated through software attached to the IKD machine. The procedure is performed as three attempts on each side with a minute rest period between each attempt [15,16]. Following testing of the IKD machine, a rest is given for 10-15 minutes.

a b

Figure 2: (a) Starting position on IKD machine (b) Performing right extension of knee to test isokinetic strength

Dynamic balance testing

To begin with, a YB-LQT is used to assess dynamic balance for the lower extremities. The subject is asked to be barefoot while performing the test. The therapist demonstrated prior test movement for the correct generation of readings. The subject was asked not to attain the initial position until completion of the test in all three directions with each leg. In continuation, the participant stood with both hands on the waist in a relaxed position at the center of the Y. Later asked to extend the unsupported leg in one of the three destined directions - posteromedial, posterolateral, and anterior - with each side alternatively while tapping the tape with the bottom of their foot. A chalk was applied to the mark on the tape when the participant reached a maximum point. There is a 20-second rest between each trial. The maximal reach with the nearest 0.5 cm is measured using a tape in all directions. Measurements were documented. Distance in the three successive trials has been used to determine the YB-LQT score. The mean of all distances was used to analyze the data generated. The reach distance is adjusted according to each participant's limb length, and consideration is given to their height. Thus, the reach distance was divided by leg length and multiplied by 100. Limb length was measured by putting the participant supine on the same leg. The distance was measured with a measuring tape extending from the anterior superior iliac spine to the inferior medial malleolus of the same leg. The participants' limb length and total maximal reach distances from all three directions were divided by 3 and multiplied by 100 to calculate the composite score for each side separately [17,18].



a b

c d

Figure 3: (a) Starting position (b) Performing the proper anterior reach test of the lower quarter YB-LQT (c) Performing the proper posteromedial reach test of the lower quarter YB-LQT (d) Performing the right posterolateral reach test of the lower quarter YB-LQT.

Range of motion measurement of knee hyperextension

The range of knee hyperextension was measured with a universal short-arm goniometer and an IKD machine. Subjects only with a bilateral increase in knee angle where more than 5 degrees of knee hyperextension were considered as GR, whereas less than 5 degrees were considered healthy [9].

Data analysis

The authors examined the subjects and entered the collected data in an Excel sheet. Data collected was analyzed by Statistical Package for Social Sciences (SPSS), version 16. Kolmogorv-Smirov test was used to verify the normality of data. The significance or alpha value was set less than 0.05, i.e., $p < 0.05$. As the data was not normally distributed, non-parametric statistical tests were used to analyze data. Spearman correlation coefficient was used to rule out the association between PKET and YB-LQT scores on each side separately in both populations. Correlation values are interpreted by already established criterion of correlational values as 0.00 to 0.25 denotes little or no correlation, 0.25

to 0.50 denotes fair relationship, 0.50 to 0.75 denotes moderate to good relationship, and above 0.75 denotes good to excellent relationship between variables.

RESULTS

Participant's characteristics

Sixty-four subjects were recruited for the study. Subjects were between 18 to 25 years of age. Demographic characteristics were described through descriptive data, whereas the correlation of the YB-LQT score with isokinetic strength was shown in the healthy and GR groups. Demographics taken at baseline are represented in Table 1. Values for baseline demographics were calculated as Median (IQR) and 95% CI with probability of error. Results were described as Spearman correlation coefficient values in Table 2 formed between right and left PKET and YB-LQT in each direction for both groups. Values demonstrate more significant results in the GR group, while significant values are found in both sides of the anterior reach in the healthy group. The association was demonstrated by the r-value of the composite score and PKET of both limbs in both groups, concluding the final result showing a significant fair correlation in the GR group with no or little correlation in the healthy group.

Table 1: represents demographics taken at baseline

Demographic Details	Median (IQR)	(95% CI)	p-value
Age	24.00(25,19)	(22.78 to 23.65)	0.000*
Height	165.00(182,146)	(162.91 to 167.50)	0.053
Weight	65(100,38)	(60.44 to 67.83)	0.20
BMI	23(34,16)	(22.10 to 24.10)	0.019*

Notes: IQR- Interquartile range, CI- Confidence interval, p- Probability of error, and * = P<0.05 shows not normal distribution of data

Table 2 represents Spearman correlation(r) values of individuals with and without GR.

Direction	Group	PKET(Right)		PKET(Left)	
		r	p-value	r	p-value
Anterior	GR	0.366	0.47	0.267	0.153
	Healthy	0.344	0.046*	0.349	0.043*
Posteromedial	GR	0.443	0.14	0.581	0.001*
	Healthy	0.248	0.158	0.281	0.107
Posterolateral	GR	0.655	0.00*	0.570	0.001*
	Healthy	0.30	0.085	0.33	0.054
Composite score	GR	0.485	0.007*	0.445	0.014*
	Healthy	0.028	0.877	0.163	0.357

Notes: PKET= Peak knee extension torque, GR= Genu recurvatum, r= Correlation coefficient, p= Probability of error and * = p<0.05 shows significant correlation

DISCUSSION

The present study comprised 64 subjects aged 18 to 25 years to determine the relationship between quadriceps strength and dynamic balance of the lower limb in individuals with GR and without GR. A normative value for comparison among individuals with GR was developed using data from the healthy population. To our knowledge, investigations have demonstrated a correlation between strength and balance in different populations. However, this is the first study to show a relation between these parameters in people with GR. In the present study, the relationship between these parameters was positive in both groups, but the results were more significant in people with GR. One interesting finding was that females are more affected than men by GR. Also, females with overweight BMI show more quadriceps weakness as compared to other BMIs.

The Kolmogorv-Smirov test was used to determine the normality of the collected data. The Spearman correlation coefficient correlates the isokinetic strength of quadriceps and dynamic balance. The result revealed a significant medium to essential relationship between isokinetic strength and dynamic balance of knee extensors in the genu recurvatum population. In contrast, there was a low to medium correlation in balance and strength of quadriceps in a healthy population. No study correlated these parameters earlier in this GR population, explicitly focusing on the single muscle group.

A previous study by Lee et al. (2014) performed on 40 adult healthy women between 45 - 80 years found a positive but moderate correlation between dynamic balance and lower limb muscle strength [14]. Similarly, in another study, 24 healthy young women were taken as subjects to anticipate the correlation between proprioception, balance, and isokinetic muscle testing. Proprioception, force sensing, quadriceps strength, the quadriceps/hamstring ratio, and balance correlate differently at various knee angles. Likewise, they found a positive relationship between isokinetic strength and dynamic balance concerning their outcomes [19].

However, the findings of a study by Muehlauer et al. (2013) conducted on 21 children aged 7 to 10 years demonstrate that strength, mobility, and balance are independent in both single-task and dual-task conditions, indicating independent training and assessment. GR produced more noteworthy findings in this investigation [20].

In the present study, the interpretation reflects a fair association between isokinetic strength and dynamic balance in individuals with GR. In contrast, no correlation was found between strength and balance in healthy individuals. We state that any alteration in isokinetic strength can lead to associated alteration in dynamic balance in individuals with GR. It signifies that balance and isokinetic strength are dependent factors in the genu recurvatum population but are not dependent on healthy individuals. Also, both outcomes can be used together in clinical rehabilitation protocol. Two main limitations of

the present study are that it does not consider BMI and the small sample size.

CONCLUSION

The study concluded a positive correlation in both the healthy and GR subcategories. According to the present investigation, both the genu recurvatum population and healthy persons experience dynamic balance issues if the quadriceps muscle strength is compromised. Clinically, both balance and strength can be used together to treat this condition or many other types of weakness.

Ethical approval

Before data collection, Maharishi Markandeshwar University, Mullana's institutional ethical committee, obtained ethical approval (IEC/MMU/2022/2305).

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