ORIGINAL RESEARCH PAPER

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ASSOCIATION OF BALANCE WITH LENGTH OF RECTUS FEMORIS, STRENGTH OF GLUTEUS MAXIMUS & CORE MUSCLES IN YOUNG HEALTHY FEMALES

KEY WORDS: Star Excursion Balance test, Ely's test, Lafayette muscle tester

Dr. Chhaya V. Verma — Professor & Head of Department, Physiotherapy Departmrnt, B.Y.L. Nair G\Ch. Hospital, Mumbai central

Ms. Divya A. Rangwani* — Junior Physiotherapist, Physiotherapy Departmrnt, B.Y.L. Nair G\Ch. Hospital, Mumbai central. *Corresponding Author

ABSTRACT

There had been studies of balance on athletic and elderly population, emphasizing risk of injury and falls. But there are very few studies on younger population for balance. The purpose was to study the association of Gluteus Maximus (G.Max) and core strength with balance performance in dynamic test i.e. Star Excursion Balance test (SEBT) & to determine effect of Rectus Femoris extensibility on G.Max strength. 76 normal females (21.8±1.89years, 157.11±5.69cms, 52.19±7.93kgs) performed SEBT in all 8 directions on both the extremities. Rectus Femoris length was assessed by Ely's test. Participants were instructed to perform maximum voluntary isometric contraction of G.Max muscle which was measured using Lafayette Muscle Tester and strength testing of core muscle was examined using Pressure biofeedback unit(PBU). Pearson's product moment correlation was applied to find association between SEBT, G.Max strength & Rectus Femoris length. Spearman rho test examined relationship between SEBT & Core strength. SEBT scores positively correlated with Rectus Femoris length bilaterally (p=0.000, rR=0.616, rL=0.699) and positive correlation of Rectus Femoris length with G.Max strength (p= 0.001 to 0.005, r= 0.320 to 0.382). Strength of core and G.Max did not correlate with SEBT (p>0.05).

Introduction

Balance is the ability of body to be in state of equilibrium and reduce the displacement of center of gravity to minimum, such that center of mass lies within base of support, within the limits of stability. Dynamic balance is the ability of body to maintain balance being in motion [1] It is an important tool to assess neuromuscular function, to prevent injury and for rehabilitation. Poor balance has been proposed as a risk factor for injury. Various tests are used to assess dynamic postural control. SEBT is a highly illustrative dynamic balance test for physically active people. It is a reliable & valid test to anticipate lower extremity injury risk, to recognize balance deficits & responsiveness to training. For comparison of SEBT scores among individuals, it needs to be normalized to limb length. [2]

Balance between strength and stability in the kinetic chain is vital for prevention of injuries. Core musculature acts as stabilizer at spine. Core stability comprised of global & local stabilizers. Local stabilizers maintain stability at intervertebral segments & lumbo-pelvic region, e.g. Transversus abdominis (TrA) & multifidus. They act as key stabilizers during reaction-based tasks of the trunk pelvis segment. (2) It allows production, transfer and control of force in the kinetic chain. (2) Without stabilization by local stabilizers, spine would collapse in upright position. It plays a prime role, in stabilizing lower extremity and knee movements. (3) Thus, it helps to maintain balance, either static or dynamic. [1,2]

Abdominal drawing-in maneuver (ADIM) helps in activation of core muscle. Pressure Biofeedback Unit (PBU) is used to evaluate abdominal muscles contraction. The pressure variations of the TrA contraction in response to ADIM performed reflects strength of muscle. If any muscle of the trunk functions below the optimum level, the stabilization & function at the trunk would be compromised. [5]

Gluteus maximus provides three-dimensional stability at hip and sacroiliac joint. It plays important role in controlling the lumbo-pelvic rhythm, by transferring the load from lumbar spine to lower extremity via sacroiliac joint, forming a protective bracing around it. Pelvic stabilization is mostly achieved from gluteus muscle contraction.

Rectus femoris being global mobilizer; is prone to develop tightness. According to Janda, when the equilibrium between length and strength of agonist and antagonist muscle is altered, it leads to imbalance. [6] Overactivity of hip flexors result in reduced hip extension and gluteus maximus activation due to reciprocal inhibition leading to imbalance in terms of strength, power and length. [6,7]

Proximal muscles of trunk and hip, i.e. core and gluteus maximus, form a firm base for prime movers to act, during lower-limb movements. By improving force output they improve the coordination of movement, maintain balance, performance & function. The purpose is to study the association of gluteus maximus and core strength with balance. Due to muscle imbalance there is reduced stabilization at lumbar spine, so effects of muscle strength on balance needs to be addressed. Considering the negative implications of restricted hip flexor length on hip extensor strength, (4) secondary purpose is to determine effect of rectus femoris extensibility on gluteus maximus strength.

Methods

Participants

It is a cross-sectional, observational study. 76 asymptomatic female students from the physiotherapy department attached to the tertiary hospital took part in the study. The mean ±standard deviation of age 21.8±1.89year, height 157.11±5.69cm, leg length 85.39±4.39cm & weight 52.19±7.93kg. Participants were excluded if they were involved in regular recreational sports or gym activities. subjects with any musculoskeletal, neurological, endocrinal, psychological, vestibular, sensory impairment or were under effect of sedatives at the time of testing were excluded.

Procedure

Approval from Institutional Review Board was sought. Participants signed an informed consent, prior to participation. Participants performed SEBT, Rectus Femoris length was measured using Ely's test, hip extensor strength was measured using Lafayette muscle tester and core strength using PBU.

Star Excursion Balance Test (SEBT)

SEBT is a screening tool for assessment of lower limb dynamic stability. Subjects stand in the center formed by grid lines in 8

directions, each at 45 degrees to each other. Participant standing on one leg with hands on iliac crest, was asked to squat on one leg (stance leg) and reach out maximally with the other leg, lightly touch down on the line and return leg back to the center. They were to touch each line in clockwise directions. The reach distance was marked on the tape. The directions were assigned in relation with the stance leg. Trials for learning effect were given. The trial was discarded, if participant shifted weight onto reach leg or wasn't able to maintain single leg stance or moved/lifted stance leg. Three readings were taken with adequate rest pause. The reach distances were measured in cm and each distance was normalized to limb length, which was measured from anterior superior iliac spine to medial malleolus. [2]

Assessment of rectus femoris length using Ely's test:

Digital Horizontal Level in Smartphone (DHLS) app was used to examine pelvis movements which occur while performing Ely's test. (9) Subject was asked to lie down prone with arms by the side & feet outside the plinth. A smartphone with DHLS app was fastened over the sacrum of subject using Velcro straps. Gyrosensor in the app determined leaning angle of surface at the onset of anterior pelvic tilt while performing knee exion. No movement of the bubble was seen with pelvis in neutral position. Examiner passively moved subject's knee into exion. When the y-axis of DHLS showed deviation by 1°, knee exion angle was noted using goniometer, (10) with its fulcrum over lateral condyle of femur, proximal arm along lateral midline of femur and distal arm along lateral midline of bula. (14) To reduce measurement error, adhesive markers were placed on greater trochanter and lateral malleolus. Mean of three readings was calculated.

Assessment of Gluteus maximus strength:

Subjects were positioned in prone position. Isometric contraction of gluteus maximus was performed with knee in 90 degrees exion, dynamometer was placed 5cm proximal to knee joint line. Subjects were asked to push and hold the contraction until assessor said relax. Lafayette Muscle Testing System Model-01165 (Lafayette Instrument Company, USA) (11) records force in kilograms. Mean of the three readings was taken.

Assessment of core strength:

Before testing, patients were trained to perform ADIM. In the supine position with knees bent at 90° PBU (Chattanooga group, Chattanooga, TN) was placed between the lumbar lordosis and the surface, with baseline pressure of 40mmHg. Subjects were asked to draw the umbilicus slowly inwards, maintaining the contraction hold for 10 seconds. Subjects were asked to perform ADIM targeting the pressure rise of up to 10mmHg. If subject was able to hold the contraction for 10 seconds (i.e. level 1), subject was moved onto new position for further grading. [1,6]

Level 2: Opposite Lower extremity on mat; bent leg falls out

	A. Lift bent leg to 90° hip flexion	B. Slide heel to extend knee	C. Lift straight leg to 45°
Level 3 (A, B, C)	Opposite Lower extremity is on table		
Level 4 (A, B, C)	Hold opposite Lower extremity at 90° of hip flexion with Upper extremity		
Level 5 (A, B, C)	Hold opposite Lower extremity at 90° of hip flexion (no Upper extremity assistance)		
Level 6 (A, B, C)	Bilateral Lower extremity movement		

Results

Data was analysed using SPSS 16. Normality of data was tested. Pearson product moment correlation was used to find the relationship of Gluteal Maximus strength, Rectus Femoris length with SEBT. Spearman rho correlation was used to find association between Core strength (ordinal data) and SEBT. For all tests Alpha=0.05, Power=0.80, Delta=0.32, r0=0.10, ra=0.42 was used.

Table 1: Descriptives of SEBT, Rectus femoris length, gluteal maximus strength, core strength.

Test	Variable	Mean	Standard deviation
Star Excursion Balance test (SEBT)(cm)			
	SEBTR	75.14	8.05
	SEBTL	73.75	7.86
Gluteus maximus strength(kg)			
	G.MaxR	5.15	1.70
	G.MaxL	5.21	1.57
Rectus Femoris Length(degrees)			
	Rectus femoris lengthR	45.58	8.80
	Rectus Femoris lengthL	44.95	9.04
Core strength(grades)			
		1.85	0.48

Table 2: Correlation of SEBT with strength of gluteal maximus, Rectus Femoris length, Core muscles.

Correlation of SEBT-R with			Correlation of SEBT-L with		
G.Max R	p value	r value	G.Max L	p value	r value
	0.898	0.015		0.842	-0.023
Rectus Femoris length Right	0.000	0.616	Rectus Femoris Length Left	0.000	0.699
Core	0.790	-0.031	Core	0.624	-0.057

Table 3: Correlation of strength of gluteal maximus & Rectus femoris length.

	G.Max R & Rectus Femoris length R	G.Max L & Rectus Femoris length L
p value	0.005	0.001
r value	0.320	0.382

DISCUSSION

Our study aimed to examine relationships between gluteus maximus strength, core strength, rectus femoris length & balance. We also studied whether rectus femoris length had any influence on gluteus maximus strength. The primary findings showed no relationships between core strength, hip extensor strength and SEBT scores. However, we observed there was a positive correlation between rectus femoris length & gluteus maximus strength, along with balance.

Balance & Core strength

In our study we used ADIM, for core activation. It is a typical manoeuvre practiced to activate TrA. Core comprises of TrA & Multifidus. The ADIM shows less global muscle involvement in comparison with other manoeuvres. Contribution from other abdominal muscles (external & internal oblique, rectus abdominis) could be present to maintain baseline pressure which influenced the strength scores. [5] Hence, true contribution of TrA as a part of core, while testing strength isn't known. It is possible ADIM is not as specific in measuring core strength as has been suggested in earlier research. Gordon et al. also did not find any correlation between core strength (assessed by bent leg lowering test) and balance (assessed by SEBT). Ambegaonkar et al. found positive correlation between left lateral core endurance and right posteromedial SEBT, whereas in other directions, correlation was inconsistent. [3] Shirley et al. found that the participants who activated their core voluntarily while single leg squat had

improved frontal plane knee and hip kinematics. [12] Differing tasks performed while testing could be the reason for discrepancy among the results of the prior and current study. Overall, to clearly delineate the relationship further research is needed.

Balance & Gluteus maximus strength

The hip extensor strength was measured isometrically, not dynamically. Hip extensors work in both concentric & eccentric way while performing functional movement. Therefore, it is unclear whether hip extensor strength which was measured, re ects the functional need of hip extensor. [11] Tapanya et al. found no correlation between SEBT score and hip exor, hip extensor and ankle dorsi exor strength, in obese young adults. [13] Ambegaonkar et al. found positive correlation of SEBT anterior reach and bilateral hip extensor strength, in active female athletes. [3] Norris et al found that hip muscle activation was lowest in the posteromedial direction as compared to the anterior and medial directions. [14] Overall, only one muscle group may not in uence the scores in SEBT. Each direction puts different demand & requires different muscle activity either in isolation or combination, to maintain balance. In earlier research, there were inconsistent relationship between reach distances and hip muscle strength [15]. Different methods such as electromyography, isokinetic testing should be used to measure hip musculature strength.

Balance & Rectus femoris length

Muscle tightness, ensues muscle weakness due to altered activation of muscle and breaks kinetic chain.[6] Mills et al. found that, with restricted hip exor length, there is more reliance on hamstrings as compared to G.Max. [7] Yasuhiro et al. found correlation between reach distances in SEBT & lower extremity tightness(iliopsoas, hamstrings, gastrocnemius, internal rotators), in junior high-school baseball players. [16] It is important for clinicians to encourage females to participate in exibility programs to improve balance.

G.Max and length of rectus femoris

G.Max by creating internal hip extension moment eccentrically control hip exion movement. [17] Hip exor tightness can lead to reciprocal inhibition of G.Max and alter its resting length. It leads to greater activation of hamstrings, while performing functional movements. [6,7] Mills et al found that amplitude of gluteus activation was signi cantly less in group with restricted hip exor length compared to normal muscle length in female soccer players. Though, muscle activation doesn't indicate muscle strength directly, both the attributes of muscle are associated. [14]

Conclusion

We conclude that, in females strength of core and G.Max do not correlate with SEBT. Subjects displayed positive correlation of length of rectus femoris with SEBT , and positive correlation of length of rectus femoris with gluteus maximus strength. Our ndings provide rationale for improving the extensibility of rectus femoris in order to improve activation & strength of gluteus maximus.

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