Correlation of Core Stability with Dynamic Balance and Quadriceps Strength in Adolescent Roller Skaters: An Observational Study

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ABSTRACT

BACKGROUND AND NEED OF THE RESEARCH: Skating is the sports activity where high intensity, coordinated movements are required along with the additional task to maintain the posture. Building the strong core is important for many different reasons including the sports and functional task. Having an adequate state of body balance allows the skater to control the execution of each sporting gesture. The need of the study is to assess the possible factors affecting sports performance and preventing injuries.

AIM: The aim of the study was to correlate the core stability with dynamic balance and quadriceps strength in adolescent roller skaters.

METHOD: Ethical clearance was obtained from institutional ethical committee. 76 adolescent roller skaters were randomly selected according to the inclusion and exclusion criteria from school and skating academy. Written informed consent and assent was taken. Core stability was assessed using mc gill endurance test and quadriceps strength using hand held dynamometer.

RESULT: Result were analysed using pearson correlation test. There was significant positive correlation of quadriceps strength with core stability in adolescent roller skaters (p=0.05) and there was significant positive correlation of trunk flexor muscle strength with dynamic balance in adolescent roller skaters (p=0.01).

CONCLUSION: There was positive correlation of core stability with dynamic balance and quadriceps strength among adolescent roller skaters.

KEYWORDS: Core stability, Dynamic balance, Quadriceps strength

INTRODUCTION

Skating has become one of the most popular sports in recent times and is gradually gaining more professional importance rather than being viewed solely as a recreational activity [1]. Roller skating is considered a lifelong fitness activity that benefits both children and adults [2]. As per the existing literature, balance, speed, and agility are essential components for optimal performance across various sports [2]. Several studies suggest that roller skating effectively engages the muscular system and smaller joints, contributing to the balanced development of different regions of the body [3].

Roller skating places significant demands on the muscular strength and endurance of the upper and lower limbs, along with the waist and abdominal region, and also requires considerable flexibility of the hip [3]. It is a movement skill that results from the coordination of multiple postural reflexes regulated by the neuromuscular system [1]. Enhancing skating performance involves understanding the key biomechanical factors that contribute to it [2].

The core is often described as the "powerhouse" of the body, serving as the foundation and driving force behind all limb movements [4]. Effective muscular control in the lumbopelvic and hip regions is essential for maintaining functional stability [4]. The core acts as the central component of the body's kinetic chain, contributing significantly to overall movement efficiency [4]. Local (postural or tonic) muscles are those that attach directly to the lumbar vertebrae and are responsible for providing segmental spinal stability, playing a key role in controlling lumbar spine movement [4]. These include the lumbar multifidus, psoas major, quadratus lumborum, lumbar portions of iliocostalis and longissimus, transversus abdominis, diaphragm, and the posterior fibres of the internal oblique [4]. Core stability supports efficient limb movement, helps prevent back injuries, ensures proper use of muscle forces, and enhances overall athletic performance [4].

The demanding nature of roller-skating particularly its spins, jumps, and balance-based elements necessitates sufficient lower limb strength, flexibility, and precise neuromuscular control of the deep trunk muscles [5]. Postural stability has been shown to play a crucial role in athletic performance, with higher-performing athletes typically demonstrating superior balance [5]. Insufficient balance and poor core stability have been associated with an increased risk of lower extremity injuries [5].

In roller and ice skating sports, quadriceps muscle strength plays a pivotal role in generating explosive leg power, essential for jumps, take-offs, and sharp accelerations [6]. Electromyographic analysis of elite roller figure skaters during jumps revealed that quadriceps (including rectus femoris and vastus lateralis) exhibit significantly higher activation in the take-off and flight phases compared to landing, underlining their importance for propulsive force and aerial control [6]. Additionally, anthropometric data from amateur roller skaters demonstrated a strong positive correlation ($r = 0.7$-0.8) between thigh muscle girth which largely reflects quadriceps size and agility performance, indicating that quadriceps development contributes substantially to lower-limb speed, quickness, and directional changes [17].

The quadriceps, located at the front of the thigh, consist of four muscles that are crucial for knee extension [6]. These muscles are engaged each time skaters push off, accelerate, or transition between movements [6]. Strong quadriceps are vital for maintaining speed and preventing fatigue during long skating sessions [6].

Roller skating requires a high degree of postural control, muscular coordination, and lower limb strength. Among adolescent athletes, proper development of core stability, dynamic balance, and quadriceps strength is essential for injury prevention and optimal performance. However, there is limited research available that explores the interrelationship between these components in young roller skaters. Understanding how these variables correlate can help design targeted training programs, improve performance, and reduce the risk of falls or musculoskeletal injuries. Therefore, this study is needed to fill the research gap and provide evidence-based insights for coaches, physiotherapists, and sport scientists. In line with this need, the present study aims to explore the relationship between core stability, dynamic balance, and quadriceps strength in roller skaters, thereby contributing to a better understanding of their combined role in athletic performance.

METHODOLOGY

An observational study was conducted for a duration of six months from various Shree Swaminarayan International School (SSIS) and various skating academies of Ahmedabad after obtaining ethical approval from the Institutional Ethical Committee. A written assent and consent form were taken from participants and their parents. A total sample size of 76 subjects which was calculated by using power analysis. Inclusion Criteria: 1) Individuals willing to participate. 2) Age: Between 10 to 17 years. 3) Both male and female were included. 4) Having no lower limb or lower back injury in the previous six months. 5) No chronic pain or surgery in the lower extremity and lower back. Exclusion Criteria: 1) Any somatosensory disorder that affects balance. 2) Any lower limb fracture in the past 6 months. 3) Any lower back pain or any musculoskeletal disorder. 4) Recent surgical history 5) Having limb length discrepancy.

OUTCOME MEASURES

1)CORE STABILITY

Trunk flexors and Side flexors endurance was assessed using MC Gill Endurance Test and Trunk extensors endurance was assessed using Prone Plank Test.

Prone Plank Test

For the prone plank test, participants maintained a prone position in which the body weight was supported by the toes and forearms [16].

Figure 1. Prone Plank Test

Trunk Flexor Endurance Test:

Testing of the torso flexors can be done by timing how long the patient can hold a position of seated torso flexion at 60°. Failure occurs when the athlete's torso falls below 60° [7].

Figure 2. Trunk Flexor Endurance Test

Side Bridge Endurance Tests:

In this assessment, participants lay in a lateral decubitus position with both legs extended and the upper foot placed anterior to the lower foot to aid stability. Support was provided through the elbow of the lower arm and both feet. Participants were instructed to raise their hips from the floor, relying solely on the support of the feet and lower elbow, while the upper arm was positioned across the chest with the hand resting on the opposite shoulder. The test was discontinued once the participant's hip made the contact with the bed. The total duration for which the position was maintained was measured using a stopwatch [7].

Figure 3. Side Bridge Endurance Test

2)DYNAMIC BALANCE

Dynamic balance was assessed using Y Balance Test.

The Y-Balance Test utilizes anterior, posteromedial, and posterolateral reach directions to assess dynamic balance. It involves a platform with three PVC pipes arranged at specific angles (135° between posterior directions and 90° from anterior), each marked with centimetre scales. Participants push a reach indicator along the pipe to measure reach distance accurately. In the absence of the official device, adhesive measuring tapes placed on the floor can be used as an alternative, though this requires greater precision from the evaluator due to the lack of an indicator for accurate contact.

Before performing the Y-Balance Test, the individual should either watch a demonstration video or receive live instruction from the evaluator. To ensure proper understanding, six practice trials are required for each leg in all three reach directions. The test is conducted either barefoot or with athletic shoes, with the stance foot placed centrally on the platform at the starting point. While maintaining a single-leg stance, the participant must reach with the opposite limb in the anterior, posteromedial, and posterolateral directions. This setup ensures both stability and accuracy during the dynamic balance assessment.

The maximum reach distance is recorded by noting the point on the tape measure where the farthest part of the reaching foot touches the indicator. A trial is considered invalid if the participant loses single-leg balance, fails to make controlled contact with the indicator, uses it for support, or cannot return the reaching foot to the starting position with control.

To normalize the reach distance, it is divided by the limb length (measured from the anterior superior iliac spine to the medial malleolus) and then multiplied by 100 to express it as a percentage. The composite score is calculated by summing the distances from all three directions, dividing by three times the limb length, and multiplying the result by 100 [8].

Figure 4. Postero-Medial Direction For Left Leg

Figure 5. Postero-Lateral Direction For Left Leg

Figure 6. Anterior Direction For Left Leg

3)QUADRICEPS STRENGTH

Quadriceps strength was assessed using Hand Held Dynamometer.

All measurements were conducted with the participant seated on a high plinth, ensuring the thigh remained horizontal and the knee positioned at the edge of the table, forming a 90° angle at both the hip and knee joints. For stability, participants were instructed to hold the edge of the plinth. The examiner, seated opposite the participant with one foot braced against the wall for added resistance support, positioned the hand-held dynamometer (HHD) perpendicular to the limb surface. The device was oriented such that the examiner could not view the scale during testing, with a separate assessor responsible for recording the values. Before the actual assessment, participants performed a submaximal trial to become familiar with the procedure, followed by a two-minute rest. During quadriceps testing, the knee was maintained at 90° using a goniometer, and the HHD was placed on the anterior aspect of the lower leg just above the talo-tibial joint line. Participants were instructed to perform a maximal isometric contraction for five seconds, and the average force output was documented in kilograms [9]. The handheld dynamometer showed high reliability (ICC=0.85–0.99) and moderate to high validity (r=0.57–0.86) for measuring lower-limb muscle strength in older adults [18].

Figure 7. Quadriceps Strength measurement

STATISTICAL ANALYSIS

Data of 76 subjects were analysed using statistical package for social science version 25 (SPSS V.25) and Microsoft excel-2010. Normality analysis was performed using the Shapiro-Wilk test, and the results suggested a normal distribution. Pearson's correlation was used to examine the relationship between different components in each assessment. The correlation coefficients were determined to be weak ($r \leq 0.30$), moderate ($0.30 \leq r \leq 0.50$) and strong ($0.5 \leq r \leq 1.0$). A two-tailed t-test was used, and the level of significance was set at ($p \leq 0.05$).

RESULT

Table 1 shows the Correlation of dynamic balance and quadriceps strength with all the components of core stability (trunk flexors, trunk extensors, and right and left elbow plank). Core trunk flexors showed positive and moderate correlation ($r \leq 0.50$) with the individual direction and composite score of dynamic balance for the right and left leg. Core trunk flexors were also found to be weakly and positively correlated with the right quadricep strength ($r \leq 0.30$). Each component of the trunk extensors showed a moderate positive correlation ($r \leq 0.50$) with dynamic balance on both sides; however, only a weak positive correlation ($r = 0.256$) was observed between trunk extensor strength and the posterolateral component of the right leg. Trunk extensors showed a moderate positive correlation ($r \leq 0.50$) with both right and left quadriceps strength.

TABLE 1: Correlation of dynamic balance and quadriceps strength with all the components of core stability (trunk flexors, trunk extensors, and right and left elbow plank)

CORE SYABILITY									
DYNAMIC BALANCE		TRUNK FLEXORS		TRUNK EXTENSORS		RIGHT ELBOW PLANK		LEFT ELBOW PLANK	
SIDE	DIRECTIONS	r	p	r	p	r	p	r	p
RIGHT	ANTERIOR	0.349	0.05	0.396	0.076	0.226	0.179	0.197	0.252
	POSTEROMEDIAL	0.311	0.05	0.332	0.045	0.283	0.09	0.299	0.072
	POSTEROLATERAL	0.425	0.009	0.256	0.126	0.293	0.078	0.286	0.094
LEFT	ANTERIOR	0.435	0.007	0.336	0.042	0.272	0.104	0.278	0.096
	POSTEROMEDIAL	0.394	0.016	0.343	0.037	0.252	0.132	0.295	0.076
	POSTEROLATERAL	0.426	0.009	0.394	0.016	0.341	0.039	0.359	0.029
SIDE	STRENGTH								
RIGHT	STRENGTH	0.213	0.206	0.352	0.033	0.297	0.074	0.255	0.136
LEFT	STRENGTH	0.179	0.289	0.388	0.018	0.454	0.005	0.355	0.003

The right elbow plank showed a weak positive correlation ($r \leq 0.30$) with all components of dynamic balance for both the right and left legs. However, a moderate positive correlation ($r = 3.41$) was observed specifically between the right elbow plank and the posterolateral component of the left leg. The right elbow plank demonstrated a weak positive correlation ($r = 0.297$) with right quadriceps strength, whereas a moderate positive correlation ($r = 0.454$) was observed with left quadriceps strength. The left elbow plank showed a weak positive correlation ($r \leq 0.30$) with all components of dynamic balance for both the right and left legs. However, a moderate positive correlation ($r = 0.359$) was observed between the left elbow plank and the posterolateral component of the left leg. The left elbow plank demonstrated a weak positive correlation ($r = 0.255$) with right quadriceps strength, whereas a moderate positive correlation ($r = 0.355$) was observed with left quadriceps strength.

DISCUSSION

Roller skating is recognized as a contemporary competitive sport that involves unique and complex body movements [1]. Unlike many other athletic activities, it operates on a limited base of support, distributed over four fixed wheels [1]. The diagonal motion across surfaces results in continual shifts in balance, making the activity inherently more unstable and challenging in terms of postural control [1].

Postural stability plays a critical role in both athletic performance and injury prevention [11]. It is maintained through the continuous interaction of internal mechanisms and external forces, including environmental influences [11]. Enhanced core stability can contribute to improved athletic output by offering a solid base for generating force efficiently through both the upper and lower limbs [11].

Postural control and balance rely on the coordinated function of the neural and musculoskeletal systems [10]. Sensory input from the proprioceptive, visual, and vestibular systems is transmitted to the central nervous system, which then initiates appropriate muscular responses, particularly in the trunk and lower limbs, to maintain stability [10].
The core is often conceptualized as a muscular cylinder, comprising the abdominal muscles anteriorly, the erector spinae and gluteal muscles posteriorly, the diaphragm forming the superior boundary, and the pelvic floor along with hip girdle muscles forming the base [10]. It serves as the central link within the kinetic chain, offering proximal stability that supports effective and controlled movement of the limbs [10]. Deficits in balance and core stability have been associated with a heightened risk of lower limb injuries [5]. Training interventions that incorporate neuromuscular, balance, and core stability exercises have consistently been shown to lower injury incidence while enhancing physical performance and functional abilities [5]. Research indicates that fatigue in the core musculature can impair trunk stability, which in turn may compromise balance control [10].
The correlation between core stability and quadriceps strength can be understood through both neuromuscular and biomechanical mechanisms. Studies show that the trunk stabilizes itself prior to any lower-limb movement-a phenomenon known as feedforward activation [12]. During tasks like single-leg squats, flexed trunk positions increase co-contraction of the quadriceps and hamstrings, preparing the knee for forceful action [12]. A strong core provides a stable base, enabling efficient force transmission from the torso to the legs. This stable platform minimizes unwanted movements such as pelvic tilting, allowing the quadriceps to generate force more directly and effectively during contractions [12]. Quadriceps strength itself correlates with dynamic balance measures [13]. Since core stability enhances postural alignment, the resulting synergy further supports quadriceps function [12, 13]. In other words, a stable core facilitates improved balance, which then allows quadriceps strength to manifest optimally [12, 13].
The positive correlation observed between core stability and both balance and quadriceps strength can be explained by the core's critical role in providing proximal stability during dynamic activities [14, 15]. A strong and stable core allows for efficient force transfer from the trunk to the lower extremities, enabling the quadriceps to function optimally during movement tasks [14]. Furthermore, enhanced core stability helps maintain proper postural alignment and control of the centre of mass, which is essential for dynamic balance [15]. When the core muscles effectively stabilize the trunk, the quadriceps can produce force without compensatory strategies, leading to improved strength output and balance performance [14, 15]. This integrated relationship suggests that deficits in core endurance may compromise lower limb function, while strengthening the core can contribute to better neuromuscular coordination, reduced fatigue, and injury prevention [14, 15].

CONCLUSION

The findings of the present study highlight a positive correlation between core stability and both dynamic balance and quadriceps strength in roller skaters. This suggests that improved core stability may contribute to enhanced postural control and greater force production in the lower extremities, supporting overall skating performance.

LIMITATION(s)

The limb dominance of the participants was not assessed. The absence of this information may have influenced the dynamic balance and quadriceps strength outcomes, as dominance can affect neuromuscular control and force generation patterns.

FUTURE RECOMMENDATIONS

It is suggested that limb dominance be considered in future research, as it may have a significant influence on neuromuscular control and force generation patterns, potentially affecting balance and strength outcomes.

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