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EFFECTIVENESS OF CORE STABILIZATION EXERCISES VS MAT PILATES TO IMPROVE BALANCE AND AGILITY IN TEENAGE SKATERS

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ABSTRACT

Background Roller skating demands exceptional dynamic balance and agility due to a narrow base of support, continuous centre-of-gravity shifts, and high demands on core control. Although both core stabilization exercises and mat Pilates are widely used to enhance trunk stability, their relative effectiveness in improving skating-specific performance in adolescents has not been directly compared.

Purpose To compare the effectiveness of a 6-week core stabilization exercise program versus mat Pilates in improving balance and agility in teenage roller skaters.

Materials and Methodology Thirty competitive skaters (12–18 years, BMI 18.5–24.9 kg/m²) were randomly allocated into two groups (n = 15 each). Group A performed structured mat Pilates and Group B performed core stabilization exercises. Both groups trained 3 days/week for 6 weeks. Outcome measures were Dynamic balance – Y-Balance Test ,For Agility Hexagon Test (time in seconds) and core strength with double leg lowering test . Assessments were conducted pre- and post-intervention.

Results Both interventions produced statistically significant improvements ($p < 0.0001$). However, the mat pilates group demonstrated superior gains. Post-intervention comparisons (independent t-test) showed significant between-group differences (all $p < 0.00001$). Mat Pilates (Group A) produced significantly greater reach distances on the Y-Balance Test compared to core stabilization exercises

(Group A) on both the dominant side (93.21 ± 1.74 cm vs. 88.34 ± 1.99 cm) and non-dominant side (87.15 ± 2.25 cm vs. 83.16 ± 1.53 cm), hexagonal Test (13.62 ± 0.22 vs. 12.53 ± 0.30) indicate improved agility and Double Leg Lowering Test (45.31 ± 1.66° vs. 38.79 ± 2.81°), indicating better core strength outcomes.

Conclusion mat Pilates are more effective than core stabilization exercises for enhancing balance and agility in teenage roller skaters and should be prioritised in training programmes aimed at performance optimisation and injury prevention.

Keywords: Core stabilization, Mat Pilates, roller skating, dynamic balance, agility, Y-Balance Test, Hexagon Test, adolescent athletes

INTRODUCTION

According to the latest Euro barometer survey, 55% of European Union citizens participate in sports, usually with the aim to improve health and/or fitness **[1, 2]**. A large majority of them do not do it regularly. Studies have shown that, by participating in sports, adults can reap a range of health benefits, such as reduced risk of premature mortality, type 2 diabetes and cardiovascular disease and improved lipid profile, body composition, muscle strength and functional capacity **[1, 3, 4]**. Therefore, recreational sports participation has a large potential to improve the health of the population.

Specific types of sport (e.g. endurance sports and strength sports) may have distinct health benefits owing to their differences in bio mechanical characteristics and physiological demands **[1, 5]**. For example, while endurance sports are more likely to improve cardiovascular function and aerobic fitness, strength sports are generally more likely to improve muscle function and bone health.

There may also be differences in health benefits between specific sports disciplines (e.g. tennis and basketball) because each sport entails a unique set of movements that are performed in specific physical, psychological, social and environmental contexts. Therefore, from a public health perspective, it is important to determine health outcomes associated with participation in specific sports. Experts argue that creating 'health profiles' of different sports would also facilitate the implementation of health-enhancing programmes in sports clubs. Such evidence may also motivate individuals to increase their participation in sports **[1-5]**.

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 **[6, 7]**. Roller skating is considered a lifelong fitness activity that benefits both

children and adults. As per the existing literature, balance, speed, and agility are essential components for optimal performance across various sports **[6, 8]**.

Skating requires athletes to adapt their body to a specific, unnatural movement, in which the point of support is reduced. Therefore, their support is based on four fixed, inline wheels that slide over a surface, drawing a straight line that is at an oblique angle to forward movement; this condition produces continuous changes of balance thereby causing a greater degree of instability compared to other sports **[6, 9]**.

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. 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 **[6, 10]**. Enhancing skating performance involves understanding the key biomechanical factors that contribute to it **[6, 8]**.

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. Postural stability has been shown to play a crucial role in athletic performance, with higher performing athletes typically demonstrating superior balance. Insufficient balance and poor core stability have been associated with an increased risk of lower extremity injuries **[6, 11]**.

Balance is the basic component in skating because it makes it possible to maintain an adequate technique and control in the execution of each sports gesture and, moreover, it limits the accessory movements that increase joint stress. The correct technique for roller speed skating is based on achieving maximum effectiveness and efficiency of the forces applied to the skate during the push, slide and recovery phases **[12, 13]**.

Balance and agility are two important parameters of motor proficiency for athletes and for the selection of athletes for any competition. The lack of good postural balance may lead to the wasteful use of these forces due to inefficient movements that finally affect sporting performance.

A person is said to have balance when they are able to keep their centre of gravity within their base of support with a minimal amount of postural sway **[9]**.

Balance and coordination are maintained by three different systems that are: the vestibular system, proprioceptive system and visual system. It is the major component of normal daily activities and can be classified as static and dynamic balance **[9]**.Since balance is such an important

aspect in competition, it is necessary to find suitable programs for maintaining proper balance. One such suggestion that has been made in an effort to balance is training. Training the core stability muscles especially has been hypothesized as an improvement program. Many researchers use this training for increasing dynamic balance **[14]**.

Agility is defined as an effective and quick coupling of braking, changing directions and accelerating while maintaining motor control in either a vertical or horizontal direction. An athlete who displays good agility will most likely possess other qualities such as, dynamic balance, spatial awareness, rhythm, as well as visual processing. Developing agility in children is a process that continues over a long period of time. Basic methodology of agility training implies the learning of a basic walking technique, running technique, change of direction, jumps and landings **[15]**.

According to the National Strength and Conditioning Association agility is the ability of an athlete to move his whole body in multiple directions with multiple changes in velocity as quickly as possible without affecting the effectiveness of the movement **[16]**. In figure skating a good agility translates into the capacity to “change directions and positions while maintaining balance and coordination” **[16]**.

The core is often described as the "powerhouse" of the body, serving as the foundation and driving force behind all limb movements. Effective muscular control in the lumbopelvic and hip regions is essential for maintaining functional stability. The core acts as the central component of the body’s kinetic chain, contributing significantly to overall movement efficiency.

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. 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. Core stability supports efficient limb movement, helps prevent back injuries, ensures proper use of muscle forces, and enhances overall athletic performance **[6, 17]**.

Core muscles are the kinetic link that transfers the torques and angular momenta between upper and lower extremities during the execution of whole-body movements **[18, 19]**. Global muscles (Rectus abdominis, external obliques and some parts of the erector spinae) are ideal for creating movement of the trunk and producing torque, because of their large moment arms and long levers as they are attached from the

thorax to the pelvis **[18, 20]**. These muscles are labelled as the prime movers for trunk or hip flexion, extension and rotation. During whole body movement stability of core spine is associated with Local muscles **[18, 21]**.

Core stabilization exercises help in improving neuromuscular control, strength and endurance of the muscles **[18, 22]**. Core stability training targets the muscles deep within the trunk which are connected to the spine, pelvis and shoulders and it assists in maintaining good posture and provides the foundation for arm and leg movements **[18, 23]**.

Exercises that target core muscles are effective for core stabilization and motor control training and thus are used for maintaining balance **[18, 24]**. The core strengthening exercises facilitate limb movements, prevent back injuries, facilitate proper utilization of muscle forces, and enhance performance. There are few studies done on core strengthening related to speed in different sports. The relationship between core stability and bowling speed has shown a significant improvement in bowling speed in well-developed core stability **[25]**.

Pilates exercises or Joseph Pilates method began developing his exercise system over a period of approximately 50 years in early 1900s. It is a whole-body conditioning programme which was initially used for managing low back pain and improving balance in elderly.

Now-a-days it is used for posture correction and fitness training. Pilates based exercise works on the principles of trunk stability, also known as "core stability" **[26]**. It is a popular form of exercise training programme which includes series of stretching and strengthening exercises with proper trunk control and breathing. It is associated with numerous health benefits like improved muscle strength, tone, flexibility, coordination, lung volumes and capacities through deep breathing **[26-28]**.

Pilates training method is based on 6 principles that are Centering (i.e., focussing on tightening the power house), Concentration, (i.e., mental focus and attention while performing exercise), Control (i.e., postural management while performing the exercise), Precision (i.e., accuracy of exercise techniques), Flow (i.e., smooth transition of movement within the exercise sequence), Breathing in coordination with the exercise **[26, 29]**.

Pilates improves posture, balance, increase core strength, peripheral mobility, which may be helpful for improving athletic performance **[26, 30]**. The main purpose of pilates is to organise the mind, body, and breathe to build up sleek and strong abdominal muscles and a strong and agile back. It improves flexibility, tonicity, strengthens core muscle groups, enhances

body awareness, prevents injury, develops posture and balance, and comfort of movement through daily life. Pilates gives equal importance to strengthening-body conditioning and the mind **[26, 31]**.

To the best of our knowledge, enhancing a young skater's capacity to manage dynamic stance, agility and speed could be a crucial factor, especially considering that junior skaters undergo a phase of development marked by improvements in various physical capabilities.

Hence, it is essential to analyze and train the parameters related to staking, aiming to enhance the competitive abilities of young skaters in terms of their technical skills. Therefore, following the above consideration, this study aims to compare the effectiveness of core stabilization exercises and mat Pilates in improving balance and agility among teenage skaters, thereby identifying the most efficient intervention to enhance performance and prevent injuries in this athletic population.

MATERIALS AND METHODOLOGY

This comparative study employed a simple random sampling technique to recruit 30 teenage roller skaters (aged 12–18 years, BMI 18.5–24.9 kg/m²) with right lower extremity dominance from a skating academy.

Participants were included if they had no chronic pain or surgery in the lower extremities, were not participating in any other exercise programs during the study period, and had no uncompensated limb length discrepancy.

Exclusion criteria encompassed lower limb injury or fracture within the previous 6 months, any soft tissue injury, abdominal or lower limb-related surgery, somatosensory or vestibular disorders affecting balance, ongoing regular exercise programs, or chronic pain.

After obtaining institutional ethical approval and informed consent, participants were randomly assigned to either the mat Pilates group or the core stabilization exercise group. Both interventions were conducted for 6 weeks, with sessions held 3 days per week. The overall study duration was 1 year, while the active intervention phase lasted 6 weeks.

Outcome measure was included in the study to check the improvement in the balance with Y balance test, agility with hexagonal test and double leg lowering test for core muscle strength.

INTERVENTION PROTOCOL

The study will be conducted after obtaining Institutional ethical Approval. The study commences by taking a written consent form. A detail explanation of the treatment and purpose of study will be given to the Athletes.

Based on inclusion criteria patient are divided into 2 groups.

Group A – Mat pilates

Group B – Core stabilization exercise

Group A -mat pilates

The protocol for Pilates training was structured in 3 phases, where each phase was followed for 2 weeks. The session length was initially 30 minutes, but by the end of week 6, it had been gradually extended to 45 to 55 minutes. The Pilates training protocol included several exercises and progression was made from week I to week VI in terms of no. of repetitions and sets (Table 1). In I st and II nd week, 2 sets of exercises with 10 repetitions were performed where rest period was provided in between each exercise (i.e. 30 sec) and between the different set of exercises (i.e. 60 sec) from phase I to phase VI during 6-week Pilates training. After the second week of training, the repetitions for each exercise were raised from 10 to 15, and roll-over exercise was added from III rd week. After the fourth week, the number of sets was raised to three, with each exercise being performed ten times. Pushups and shoulder bridge exercises were introduced to the training regime early in the fifth week.

Exercises	Ist & IInd week	IIIrd & IVth week	Vth & VIth week
Leg circle	2×10	2×15	3×10
Scissors	2×10	2×15	3×10
Sidekicks	2×10	2×15	3×10
The saw	2×10	2×15	3×10
Spine stretch	2×10	2×15	3×10
Single leg stretch	2×10	2×15	3×10
Heel squeeze	2×10	2×15	3×10
Roll over		2×15	3×10
Shoulder bridge			3×10
Push ups			3×10

Group B- Core stabilization exercise

1. Abdominal bracing - 30 repetitions with 8-seconds: Patients were instructed in supine lying position to perform drawing- in maneuver of the abdomen and hold it for 8 seconds, 30 times for 2 minutes.
2. Bracing with Heel Slides - 20 repetitions per leg with 4-seconds: Patients were instructed in supine lying position to perform drawing- in maneuver of the abdomen and hold it with sliding of the heel per leg for 4seconds, 20 times for 4 minutes.
3. Bracing with Leg Lift -20 repetitions per leg with 4-seconds: Patients were instructed in supine lying position to perform drawing - in maneuver of the abdomen and hold it with raising up the leg for 4 seconds, 20 times for 4 minutes.
4. Bracing with Bridging - 30 repetitions with 8-seconds, then progress to one leg: Patients were instructed in supine

lying position to perform drawing-in maneuver of the abdomen and gently lift up the buttock and hold it for 8seconds, 30 times for 2 minutes.

5. Bracing with Bridging and Leg Lift - 30 repetitions with 8-seconds, Patients were instructed in supine lying position to perform drawing-in maneuver of the abdomen and gently lift up the buttock and hold it with raising up the leg for 8seconds,30 times for 4 minutes.
6. Quadruped Arms Lifts with Bracing - 30 repetitions with 8 seconds on each side: Patients were instructed in prone kneeling position to perform drawing in maneuver of the abdomen, flex one upper extremity and hold it for 8 seconds, 30 times on each side for 4 minutes.
7. Quadruped Leg Lifts with Bracing- 30 repetitions with 8 seconds on each side: Patients were instructed in prone kneeling to perform the drawing- in maneuver of the abdomen, extend one lower extremity and lift it off exercise mat and hold it for 8 seconds, 30 times on each side for 4 minutes.
8. Quadruped Alternate Arm and Leg lift with Bracing - 30 repetition with 8seconds on each side: Patients were instructed in prone kneeling to perform the drawing- in maneuver of the abdomen, flex one upper extremity and extend contra lateral lower extremity and hold it for 8 seconds, 30 times for 4 minutes.

RESULTS

In order to evaluate and compare the effectiveness of core stabilization exercises versus mat Pilates in enhancing dynamic balance**,** agility, and core strength in teenage skaters, a comparative interventional study was conducted.

A total of 30 participants (teenage skaters) were randomly allocated into two groups **(**n=15 each): Group A (mat pilates) and Group B (core stabilization exercises). Both groups continued their regular skating training alongside the assigned intervention. Statistical analysis was performed using parametric tests. Paired t-test was used for within-group (pre vs post) comparison and independent t-test (two-sample assuming equal variances) was used for between-group comparisons.

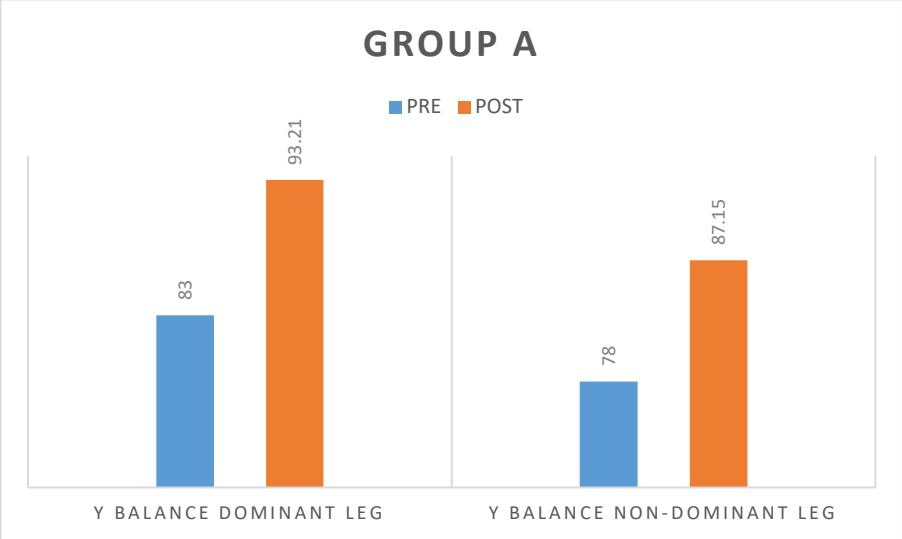
Table 1: shows comparison of outcomes measures pre and post within the Group A

Outcome Measure		Mean	SD	t-value	p-value
Y Balance Test (Dominant Side)	Pre	83	1.632	-37.08047248	<0.0001
	Post	93.21	1.736		
Y Balance Test (Non-Dominant Side)	Pre	78	1.632	-17.83234514	<0.0001
	Post	87.15	2.249		

Within-group comparison (Pre vs Post) – Group A (Table 1)

By analysis of Group A (core stabilization exercises), a paired t-test was employed for within-group comparisons (pre- vs. post-intervention).

For the Y Balance Test (Dominant Side), the mean pre-intervention value was 83.00 cm and the mean post-intervention value was 93.21 cm. The calculated t-value was 51.014 with $p < 0.0001$. For the Y Balance Test (Non-Dominant Side), the mean pre-intervention value was 78.00 cm (SD = 1.63) and the mean post-intervention value was 87.15 cm (SD = 2.25). The calculated t-value was 38.750 with $p < 0.0001$.



Graph 1: Within the group analysis of Y Balance Test for Group A

Table 2: shows comparison of outcomes measures pre and post within the Group B.

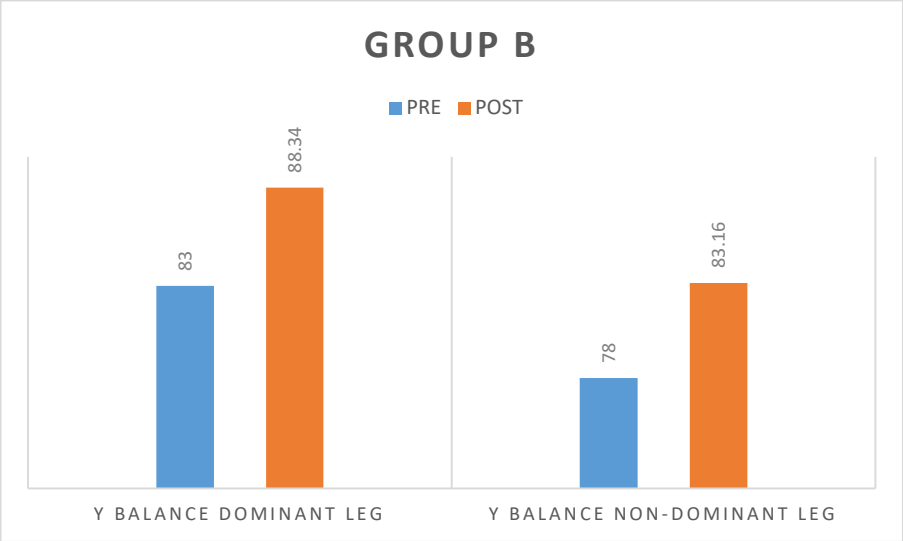
Outcome Measure		Mean	SD	t-value	p-value
Y Balance Test (Dominant Side)	Pre	83	1.63	-32.0251	<0.0001
	Post	88.34	1.99		
Y Balance Test (Non-Dominant Side)	Pre	78	1.63	-47.033	<0.0001
	Post	83.16	1.53		

Within-group comparison (Pre vs Post) – Group B (Table 2)

By analysis of Group B, a paired t-test was employed for within-group comparisons (pre- vs. post-intervention).

For the Y Balance Test (Dominant Side), the mean pre-intervention value was 83.00 cm (SD = 1.63) and the mean post-intervention value was 88.34 cm (SD = 1.99). The calculated t-value was -32.0251 with $p < 0.0001$.

For the Y Balance Test (Non-Dominant Side), the mean pre-intervention value was 78.00 cm (SD = 1.63) and the mean post-intervention value was 83.16 cm (SD = 1.53). The calculated t-value was -47.033 with $p < 0.0001$.



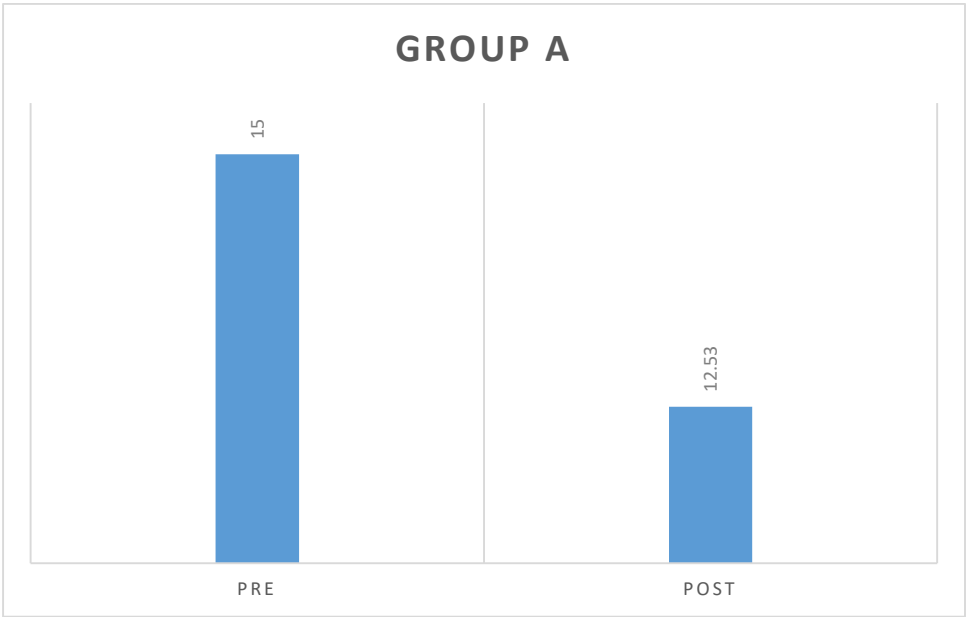
Graph 2: Within the group analysis of Y Balance Test for Group B

Table 3: shows comparison of outcomes measures pre and post within the Group A.

Outcome Measure		Mean	SD	t-value	p-value
Hexagonal Test	Pre	15	0.163299	-152.5715285	<0.0001
	Post	12.53333	0.298142		

Within-group comparison (Pre vs Post) – Group A (Table 3)

By analysis of the Hexagonal Test, a paired t-test was employed for within-group comparisons (pre vs. post-intervention). The mean pre intervention value was 15.00 (SD = 0.163299) and the mean post-intervention value was 12.53333 (SD = 0.298142). The calculated t-value was -152.5715285 with $p < 0.0001$.



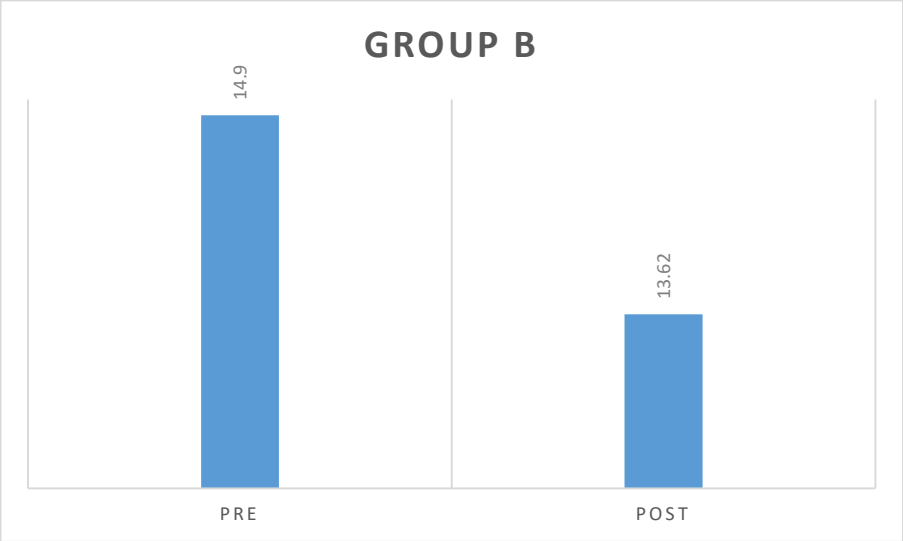
Graph 3: Within the group analysis of Hexagonal Test for Group A

Table 4: shows comparison of outcomes measures pre and post within the Group B.

Outcome Measure		Mean	SD	t-value	p-value
Hexagonal Test	Pre	14.9	0.163299316	-190.043	<0.0001
	Post	13.62	0.219697		

Within-group comparison (Pre vs Post) – Group B (Table 4)

By analysis of the Hexagonal Test, a paired t-test was employed for within-group comparisons (pre- vs. post-intervention). The mean pre-intervention value was 14.9 (SD = 0.163299316) and the mean post-intervention value was 13.62 (SD = 0.219697). The calculated t-value was -190.043 with $p < 0.0001$.



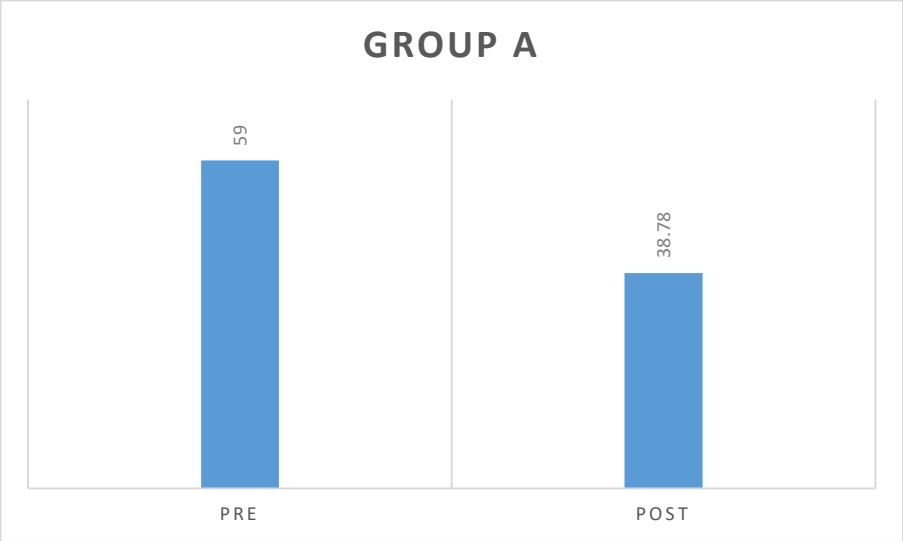
Graph 4: Within the group analysis of Hexagonal Test for Group B

Table 5: shows comparison of outcomes measures pre and post within the Group A

Outcome Measure		Mean	SD	t-value	p-value
Double Leg Lowering Test	Pre	59	1.632993	-29.0703499	<0.0001
	Post	38.78667	2.813744		

Within-group comparison (Pre vs Post) – Group A (Table 5)

By analysis of the Double Leg Lowering Test, a paired t-test was employed for within-group comparisons (pre- vs. post-intervention). The mean pre-intervention value was 59 (SD = 1.632993) and the mean post-intervention value was 38.78667 (SD = 2.813744). The calculated t-value was -29.0703499 with $p < 0.0001$.



Graph 5: Within the group analysis of Double Leg Lowering Test for Group A

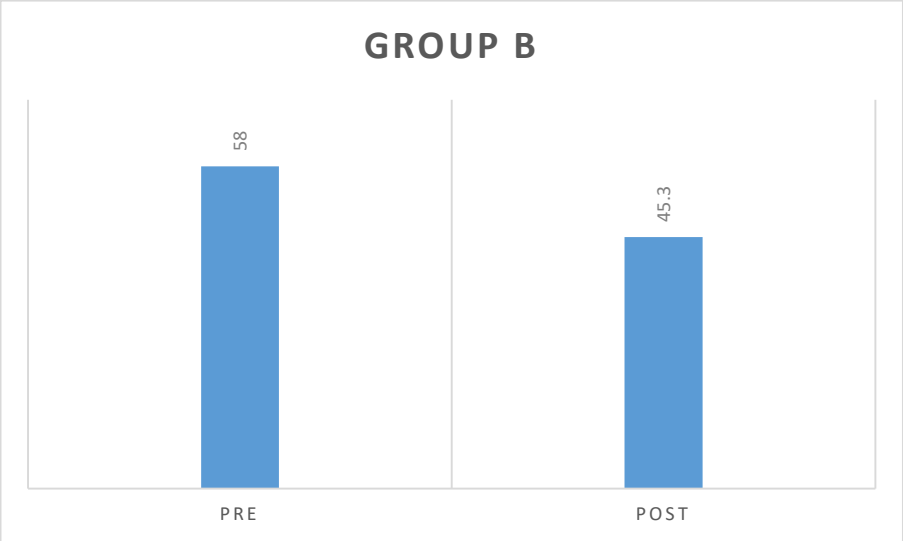
Table 6: Shows comparison of outcomes measures pre and post within the Group B

Outcome Measure		Mean	SD	t-value	p-value
Double Leg Lowering Test	Pre	58	1.632993	-47.8128	<0.0001
	Post	45.30667	1.662715		

Within-group comparison (Pre vs Post) – Group B (Table 6)

By analysis of the Double Leg Lowering Test, a paired t-test was employed for within-group comparisons (pre- vs. post-intervention).

The mean pre-intervention value was 58 (SD = 45.30667) and the mean post-intervention value was 1.632993 (SD = 1.662715). The calculated t-value was -47.8128 with $p < 0.0001$.



Graph 5: Within the group analysis of Double Leg Lowering Test for Group B

Table 7: shows comparison of Y Balance Test between the Group AB.

Outcome measure	Group A	Group B	t value	p value
Y Balance Test (Dominating Side)	93.21 ± 1.736	88.34 ± 1.99	-43.43755067	<0.00001
Y Balance Test (Non Dominating Side)	87.15 ± 2.249	83.16 ± 1.53	-36.55789566	<0.00001
HexagonalTest	12.53333 ± 0.298142	13.62 ± 0.219697	-113.0062968	<0.00001
Double Leg Lowering Test	38.78667 ± 2.813744	45.30667 ± 1.662715	0.902399569	<0.00001

Between-group comparison of post-intervention values – Group A vs Group B (Table 7)

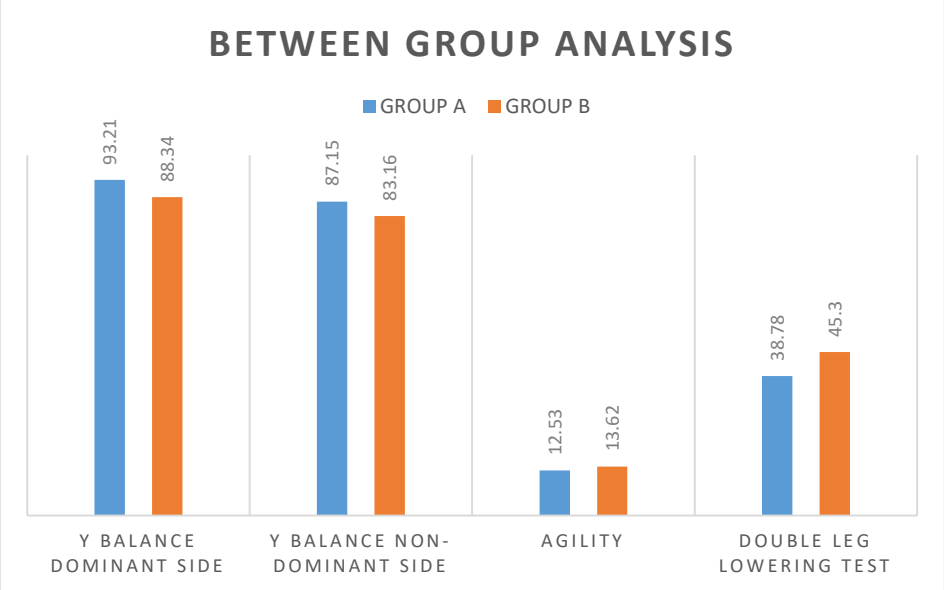
By inter-group analysis between Group A and Group B, an independent t-test was employed for between-group comparisons on the post-intervention values.

For the Y Balance Test (Dominant Side), the mean value in Group A was 93.21 cm (SD = 1.736) and the mean value in Group B was 88.34 cm (SD = 1.99). The calculated t-value was -43.43755067 with $p < 0.00001$.

For the Y Balance Test (Non-Dominant Side), the mean value in Group A was 87.15 cm (SD = 2.249) and the mean value in Group B was 83.16 cm (SD = 1.53). The calculated t-value was -36.55789566 with $p < 0.00001$.

For the Hexagonal Test, the mean value in Group A was 12.53333 (SD = 0.298142) and the mean value in Group B was 13.62 (SD = 0.219697). The calculated t-value was -113.0062968 with $p < 0.00001$.

For the Double Leg Lowering Test, the mean value in Group A was 38.78667 (SD = 2.813744) and the mean value in Group B was 45.30667 (SD = 1.662715). The calculated t-value was 0.902399569 with $p < 0.00001$.



Graph 7: Between the group analysis for Group A and B

DISCUSSION

The purpose of this study was to evaluate and compare the effectiveness of core stabilization exercises vs mat Pilates to improve balance and agility in teenage skaters. Thirty teenage skaters within the age group of 12–18 years were taken who are practicing daily.30 participant divided into 2 groups, Group A (mat pilates)=15 participant and group B(core stabilization exercises)=15 participant who underwent for 6 week of training programme with 3 session per week to predict the outcome measure i.e., balance with Y balance test , agility with hexagon test and core strength with double leg lowering test.

Both groups demonstrated highly significant within-group improvements ($p < 0.0001$) across all assessed parameters, underscoring the efficacy of targeted core training in enhancing foundational motor abilities critical for skating performance. However, the magnitude of improvement was markedly different. Group A (mat pilates) showed the largest gain in Y balance (dominant side) =93.21 cm and (non-dominant side) =87.15 cm, in agility =12.53 sec and in double leg lowring test = 38.78, followed by group B (core stabilization exercises) in Y balance (dominant side) =88.34 cm and (non-dominant side) =83.16 cm, in agility =13.62 sec and in double leg lowring test = 45.3.

Between-group analysis of post-intervention values revealed that mat pilates were significantly superior to the core stabilization exercises in Y balance test, hexagonal test and in double leg lowering test ($p < 0.00001$ for all comparisons) , making mat pilates the superior choice for improving balace, agility and enhancing core strength in this population.

Results of the study are similar to study by Yadav P *et al*., A pilot study was done on the efficacy of Pilates on agility and coordination skills in badminton players. It was concluded that there was a significant improvement in agility and coordination skills as measured by shuttle run test and hand eye coordination test by 41% and 63% respectively after an intervention of 5 weeks. The study concluded that Pilates training can enhance the control of trunk movement and improves the neuromuscular coordination of movements. The result of the adjacent study is consistent with the previously discussed research **[32]**.

Johnson EG *et al*., found the effects of Pilates-based exercise on dynamic balance in healthy adults. The 5-week Pilates-based exercise session improved core stability and subjects became more kinesthetically aware of how to reduce faulty movement patterns, resulting in improved motor control. He concluded that ten sessions of a Pilates based exercise improved dynamic balance

as measured by the Functional Reach Test in healthy adults **[33]**.

Moreover, Esteban Garcia *et al*., (2021) concluded that the exercises like front bridge, Side bridge (both sides) and Supine bridges used in this study proved to be very much effective in decreasing the body fatness and improving the core strength. Furthermore, the bridge exercises for abdominal and core muscles improve the back muscle strength and strengthening exercise like prone plunk, bridging, one leg bridging, side plunk, knee to chest exercise used for this side may have improved thought by Mayo Clinic Staff, (2020) which may be the reason behind the better performance core muscle strength **[34, 35]**.

The present study also agrees with Tarik Ozmen *et al*. (2015)20 investigated the effectiveness of core strength training on dynamic balance and agility in 20 adolescent badminton players. The results indicated that a six week of CST led to significant increase in CMET and SEBT (A, PL, PM) but less or no significant increase in agility. This study shows Core strengthening training (Pilates) is effective in increasing players dynamic balance and agility which is constant in the current study **[36]**.

In a review study encompassing 21 studies related to sports where postural stability is essential, including team sports such as football, basketball, and hockey, as well as individual sports such as tennis, running, and cycling, Zemkova *et al* investigated whether core stability exercises contribute to improving sport-specific performance. They found that the CST program contributed to significantly improved balanced dynamic visual-motor tasks in football players **[37]**.

In a study conducted by Hoskikawa *et al*., involving 28 male football players aged 12–13, which investigated the effect of a CST program on core muscles and physical performance, the TG followed a core stability exercise program four times a week for six weeks in addition to routine training, whereas the CG followed routine training only. The cross-sectional areas of the core muscles (rectus abdominis/obliques, psoas major, quadratus lumborum, erector spina) were measured using magnetic resonance imaging, and squat and countermovement jump heights were determined. Sprint speed was measured via a 15 m sprint test, and dynamic strength was assessed with an isokinetic dynamometer. Consequently, significant differences were found between the TG and CG in hip extension torque, as well as squat and countermovement jump heights. However, no significant differences were observed in the cross-sectional areas of the core muscles, sprint speed, and hip flexion torque **[38]**.

In a study evaluating the effect of a specific core exercise program on sprint speed and direction change maneuverability in male football players, Muria and Garrido Gena

implemented the core stability exercise program, including football-specific exercises, to the TG, and the standard core stability exercise program to the CG for 20 minutes twice a week for eight weeks. Although they observed more improvement in the TG, they found no significant difference between the groups in sprint speed measured using a 10m sprint test and direction change maneuverability measured using a v-cut test **[39]**.

As a matter of fact, studies conducted in other sports have yielded varied results regarding the impact of core exercises on sport-specific parameters. In one such study examining the effects of core strengthening training on physical and athletic performance in elite handball players, significant improvements were observed in physical components, but not in handball-specific athletic performance **[40]**. Similarly, a study investigating the effects of core exercises on functional movement patterns in adult tennis players reported significant changes in all functional movement screen test results **[41]**. Lust *et al*. **[42]** also found that a six-week training program, combining open and closed kinetic chain plyometric exercises with core stability exercises, improved core endurance in baseball athletes **[42]**.

Pilates method offers exercises in various starting positions with multidimensional movements in which skeletal muscles are activated in a manner conducive not only to development of their strength but also endurance, flexibility and neuromuscular coordination. Therefore, this system, with appropriate supervision and adjustment of the degree of difficulty of the exercises to be performed without losing the flow of movement and dynamic stabilization of the deep muscles system appears to be appropriate in the eradication of unwanted muscle imbalance **[43]**.

In the present study, the cause of improvement in the balance of skaters could be due to improvement in core strength of the skater, where double leg lowering test was used to measure core muscle strength in each skater while Y balance test was use to check balance pre- and post-exercise.

There is a growing popularity of stabilization exercises proposed to enhance athletic performance and to develop muscles of the trunk hence, core strengthening is becoming a major trend. Since sports activity involves movement in three cardinal planes, core musculature must be assessed and trained these planes. However, clinical outcomes of core strengthening programs are lacking in the research, even though core stabilization programs are increased **[44]**.

Coordination and balance are crucial factors in sports training. The posture control system in skating is regulated by visual, vestibular and somatosensory cues. Proprioceptive receptors sense the body's

sway movement to maintain postural control. Balance in speed skating enhances motor abilities and relies on strength; it modifies the body's resting state or movement (static or dynamic balancing) at a given time. Improvements in motor skills can be achieved through balance training even in non-elite athletes **[45]**.

Taube W *et al* showed that core strengthening, specifically the trunk flexor, was strongly and positively correlated with both dynamic and static balance, while the trunk extensor was either weakly or moderately correlated with different components of dynamic and static balance. Balance training enhances spinal reflex excitement via raising supraspinal-induced presynaptic inhibition **[46]**.

The statistical findings of study by Yeole UL *et al*., on the effect of core strengthening on dynamic balance and agility in badminton players showed that compared to group that performed conventional exercises, Pilates training group had significant improvements in agility, core strength, neuromuscular coordination and dynamic balance at the end of 4 week of training **[43]**.

The result of our study is consistent with the findings of the study by Shavikloo J *et al*., **[24]**. They concluded that 6 week Pilates training programme was more effective than conventional training in improving anterior, posterio-lateral and posterio-medial components of dynamic balance as measured by Y balance test in futsal players. Pilates training resulted in enhanced stability of vertebral column, neuromuscular coordination and hence dynamic balance **[44]**.

The superior result of the present study can be explained as "Pilates is kind of exercise that uses a combination of muscle that increases power, stretches muscle and also concentrate on breathing to develop strength of the trunk muscles and restore muscle balance for physical fitness. In Pilates one will have to activate several group of muscles at the same time. Which works on the co – activation and co - ordination of the muscles" **[45]**.

CONCLUSION

Both mat Pilates and core stabilization exercises significantly improved dynamic balance, functional balance, and core endurance in teenage roller skaters after 6 weeks (all $p < 0.0001$). Mat Pilates produced greater gains in Y-Balance Test reach distances on both dominant (93.21 cm vs. 88.34 cm) and non-dominant sides (87.15 cm vs. 83.16 cm), indicating better dynamic postural control. Core stabilization exercises, however, showed superior results in Star Excursion Balance Test (13.62 vs. 12.53) and Double Leg Lowering Test (45.31° vs. 38.79°), reflecting enhanced multi-directional balance and core strength/endurance.

Overall, mat Pilates appears more effective for skating-specific dynamic reach and balance, while core stabilization training excels in core control and functional stability. Tailoring the intervention to specific performance needs—or combining both—may optimize outcomes for adolescent skaters.

In conclusion, the present study shows that teenage skaters can be trained with the given intervention which is mat pilates and core stabilization exercise, but mat pilates was more effective than the core stabilization exercises as it shows better improvement in balance, agility and core strengthening in the same population.

REFERENCES

[1] Oja P, Memon AR, Titze S, Jurakic D, Chen ST, Shrestha N, Em S, Matolic T, Vasankari T, Heinonen A, Grgic J. Health benefits of different sports: a systematic review and meta-analysis of longitudinal and intervention studies including 2.6 million adult participants. Sports medicine-open. 2024 Dec;10(1):1-7.

[2] TNS Opinion & Social. Special Eurobarometer 525: Sport and physical activity: Brussels, Belgium: European Commission;2022

[3] Murray AD, Daines L, Archibald D, Hawkes RA, Schiphorst C, Kelly P, *et al*. The relationships between golf and health: a scoping review. Br J Sports Med. 2017;51(1):12–19. doi: 10.1136/bjsports-2016-096625. [DOI] [PMC free article] [PubMed] [Google Scholar]

[4] Burtscher M, Federolf PA, Nachbauer W, Kopp M. Potential health benefits from downhill skiing. Front Physiol. 2018;9:1924. doi: 10.3389/fphys.2018.01924. [DOI] [PMC free article] [PubMed] [Google Scholar]

[5] Oja P, Kelly P, Pedisic Z, Titze S, Bauman A, Foster C, *et al*. Associations of specific types of sports and exercise with all-cause and cardiovascular-disease mortality: a ohort study of 80 306 British adults. Br J Sports Med. 2017;51(10):812–817. doi: 10.1136/bjsports-2016-096822. [DOI] [PubMed] [Google Scholar]

[6] Bhatt N, Zaiwala K. Correlation of Core Stability with Dynamic Balance and Quadriceps Strength in Adolescent Roller Skaters – An Observational Study. International Journal For Multidisciplinary Research. 2025 Jul 25;7(4).

[7] Bhardwaj M, Arora S, Sharma A, Kumari S, Raza M. Correlation between core stability and balance in teenage female roller skaters. VOL 3 ISSUE 5 APRIL 2018. 2018 Apr:34.

[8] Sehgal S, Chahal A, Esht V, Alshehri MM, Beg RA, Shaphe MA, Alajam RA,

Kashoo FZ, Alghadir AH, Khan M. Unleashing potential and optimizing adolescent roller skating performance through a structured exercise program–a randomized controlled trial. BMC Sports Science, Medicine and Rehabilitation. 2023 Sep 21;15(1):117

[9] Pinzón-Romero S, Vidarte A, Carlos J. Effects of a proprioceptive physical exercise program on balance in young skaters aged between 11 to 15 years. 2020 May 18;

[10] Wei Z, Jia X, Changquan W, Lijuan H. Roller skating promotes the physical health of children and adolescents-meta analysis. Biomedical Journal of Scientific & Technical Research. 2022;42(1):33198- 209.

[11] Hernández-Rovira E, Rebullido TR, Alonso-Aubin DA, Ortiz DC. Effects of Hypopressive Exercise on Dynamic Neuromuscular Control in Female Roller-Skaters. International Journal of Exercise Science. 2024 Jan 1;17(6):252.

[12] Aggarwal N, Sharma M. To Compare the Effect of Modified Pilates and Core Stabilization Exercise on Balance, Core Muscle Endurance and Lumbopelvic Flexibility in Elderly Women. International Journal of Health Sciences and Research. 2023 May 11;13(5):119–27.

[13] Lee NR, Yun SJ, Choi KS. The effect of pilates exercises on isokinetic muscular strength and balance in lower limb's for young aged women. Journal of the Korea Academia-Industrial cooperation Society. 2016 Nov 30;17(11):691–700.

[14] Chung EJ, Kim JH, Lee BH. (2013) The effects of core stabilization exercise on dynamic balance and gait function in stroke patients. Phys Ther Sci 25(7): 803–806

[15] Dizajdizi LZ, Nourbakhsh P, Sepasi H. Effects of core stability exercises on selected motor profi ciency indices and self-confi dence in teenage girl roller-skaters. Bioscience Biotechnology Research Communications. 2016 Jun 25;9(2):266–72.

[16] Ionescu A, Ionescu V. The Relationship of Agility and Balance Tests Results of Young Female Skaters with Competition Scores in Figure Skating. Bulletin of the Transilvania University of Braşov Series IX: Sciences of Human Kinetics [Internet]. 2022 Jan 4 [cited 2024 Feb 2];11–20. Available from: https://webbut.unitbv.ro/index.php/Series_IX/article/view/745

[17] Ahammed N, Motimath B, Chivate D. Effect of core muscle strengthening on roller skating speed in competitive teenage skaters: An experimental study. Saudi Journal of Sports Medicine. 2018 Sep 1;18(3):113-8.

[18] Effect of Core Stabilization Exercises on Balance Performance in Older Adults.

International Journal of Contemporary Medicine. 2021 Apr 2;

[19] Granacher U, Gollhofer A, Hortoba´gyi T, Kressig R, Muehlbauer T. The Importance of Trunk Muscle Strength for Balance, Functional Performance, and Fall Prevention in Seniors: A Systematic Review. Sports Med 2013, April ; 627–41.

[20] Amira A, Abdallah A, BeltagiA. Effect of Core Stability Exercises on Trunk Muscle Balance in Healthy Adult Individuals. International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering 2014;8(5): 243-248.

[21] Nicole K. The Effects of Core Stability Training on Balance Testing in Young, Healthy Adults.Toledo: Thomas; 2009.

[22] Moon H, Choi K, Kim D, Kim H, Cho Y, Lee K *et al*. Effects of Core Stabilization and Dynamic Core Strengthening On Patients with Chronic Low Back Pain. Ann Rehab Med 2013; 37 (1):110-117

[23] Suri P, Kiely D, Leveille S, Frontera W, Bean J. Trunk Muscle Attributes Are Associated with Balance and Mobility in Older Adults: A Pilot Study. USA: National Institute of Health Public Access; 26-2009 October. 9 p.

[24] Kang K, Choi J, Lee S. Effects of Core Strengthening Exercises on Symmetrical Double Limb Support And Balance Ability For The Older adults. J IntAcad Phy Ther Res 2012, January;3(1):345-411.

[25] Hilligan BK The Relationship Between Core Stability and Bowling Speed in Asymptomatic Male Indoor Action Cricket Bowlers (Doctoral dissertation). 2008

[26] Preeti, Kalra S, Yadav J, Pawaria S. Effect of Pilates on Lower Limb Strength, Dynamic Balance, Agility and Coordination Skills in Aspiring State Level Badminton Players. Journal Of Clinical And Diagnostic Research. 2019;13(7).

[27] Akuthata V, Nadler SF. Core strengthening. Arch Phys Med Rehabi. 2004;85(1):86-92.

[28] Niehues JR, Gonzales I, Lemos RR, Haas P. Pilates method for lung function and functional capacity in Obese Adults. Altern Ther Health Med. 2015;21(5):73-80

[29] Bernardo LM. The effectiveness of Pilates training in healthy adults: An appraisal of the research literature. J Bodyw Mov Ther. 2007;11(2):106-10.

[30] Anderson BD, Spector A. Introduction to Pilates-based rehabilitation. Orthop Phys Ther Clin N Am. 2000;9(3):395-410.

[31] Tarpey RM. The Effect of Core Strengthening on Lower Leg Functional Stability in Football Players (Doctoral

dissertation, California University of Pennsylvania). 2005.

[32] Yadav P, Kalra S, Pawaria S. The effect of Pilates on agility and coordination skill in badminton players. International Journal of Medical Science and Diagnosis Research. 2019;3(1):90-95.

[33] Johnson EG, Larsen A, Ozawa H, Wilson CA, Kennedy KL. The effects of Pilates-based exercise on dynamic balance in healthy adults. J Bodyw Mov Ther. 2007;11(3):238-42.)

[34] Esteban Garcia, P., Jimenez Diaz, J.F., Abian Vicen, J., Bravo Sanchez, A. & Rubio Arias, J.A. (2021) Effect of 12 Weeks Core Training on Core Muscle Performance in Rhythmic Gymnastics. Biology 2021, 10(11), 1210. https://doi.org/10.3390/biology10111210

[35] Mayo Clinic Staff. (2020). Core exercises: Why you should strengthen your core muscles, Retrieved from: https: https://www.mayoclinic.org/healthylifestyle/fitness/in-depth/coreexercises/art20044751

[36] Ozmen T, Aydogmus M. Effect of core strength training on dynamic balance and agility in adolescent badminton players. J Bodyw Mov Ther.2016;20(3):565–70.)

[37] Zemková E, Zapletalová L. The Role of neuromuscular control of postural and core stability in functional movement and athlete performance. Front Physiol. 2022; 24;13:796097. pmid:35283763; PMCID: PMC8909639.

[38] Hoshikawa Y, Iida T, Muramatsu M, Ii N, Nakajima Y, Chumank K, *et al*. Effects of stabilization training on trunk muscularity and physical performances in youth soccer players. J Strength Cond Res. 2013; 27 (11): 3142–49. pmid:23442276.

[39] Brull-Muria E, Beltran-Garrido JV. Effects of a specific sore stability program on the sprint and change-of-direction maneuverability performance in youth, male soccer players. Int J Environ Res Public Health. 2021; 26;18(19):10116. pmid:34639418; PMCID: PMC8507702

[40] Bauer J, Muehlbauer T. Effects of a 6 week core strengthening training on measures of physical and athletic performance in adolescent male sub-elite handball players. Front Sports Act Living. 2022; 7;4:1037078. pmid:36419671; PMCID: PMC9676223.

[41] Majewska J, Kołodziej-Lackorzyńska G, Cyran-Grzebyk B, Szymczyk D, Kołodziej K, Wądołkowski P. Effects of Core Stability Training on Functional Movement Patterns in Tennis Players. Int J Environ Res Public Health. 2022;

30;19(23):16033. pmid:36498108; PMCID: PMC9740142.

[42] Lust KR, Sandrey MA, Bulger SM, Wilder N. The effects of 6-week training programs on throwing accuracy, proprioception, and core endurance in baseball. J Sport Rehabil. 2009; 18(3):407–26. pmid:19827504.

[43] Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ. The effect of 6- week plyometric training program on agility. J Sport Sci Med. 2006;5(3):459-65

[44] McGill SM, Childs A, Liebenson C. Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database Arch Phys Med Rehabil. 1999;80:941–4

[45] Zhao K, Hohmann A, Chang Y, Zhang B, Pion J, Gao B. Physiological, Anthropometric, and Motor Characteristics of Elite Chinese Youth Athletes From Six Different Sports. Front Physiol. 2019 Apr 12;10:405. doi: 10.3389/fphys.2019.00405. PMID: 31105576; PMCID: PMC6499036.)

[46] Taube W, Gruber M, Gollhofer A. Spinal and supraspinal adaptations associated with balance training and their functional relevance. Acta Physiol (Oxf). 2008 Jun;193(2):101-16. doi: 10.1111/j.1748-1716.2008.01850.x. Epub 2008 Mar 12. PMID: 18346210.