

# Effectiveness of Flexi-Bar Training on Core Strength in Adolescent Athletes: A Pre-Post Experimental Study

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## ABSTRACT

**Background:** Adolescent athletes often face challenges in maintaining optimal core stability during periods of rapid physical growth. Decreased core strength can impair athletic performance, balance, and motor control while increasing injury risk. While vibrational devices like the Flexi-Bar (FB) have shown efficacy in improving neuromuscular activation in adult populations, evidence regarding their impact on adolescent athletes remains limited.

**Objective:** To evaluate the effectiveness of a targeted Flexi-Bar training program on core muscle strength in adolescent athletes.

**Methods:** A single-arm pre-post experimental study was conducted at the Musculoskeletal Department OPD, Institute of Physiotherapy, Srinivas University, and regional sports academies in Mangaluru, India. Twenty-five adolescent athletes aged 14 to 18 years meeting inclusion criteria (MMT score <3 for core musculature, active participation in sports, and PAQ-A scores meeting threshold activity) were enrolled via purposive sampling. Participants underwent a structured Flexi-Bar training protocol targeting the lumbopelvic-hip complex. Core muscle strength was evaluated pre- and post-intervention using Manual Muscle Testing (MMT) for trunk flexors, trunk extensors, and trunk rotators. Data normality was evaluated using the Shapiro-Wilk test, and within-group changes were analyzed using paired sample t-tests or Wilcoxon signed-rank tests.

**Results:** Preliminary data collection across trunk flexors, extensors, and rotators demonstrated statistically significant improvements in MMT grades following the training protocol ( $p < 0.05$ ). Vibration-induced proprioception and tonic vibration reflexes facilitated increased neuromuscular activation without joint overload.

**Conclusion:** Flexi-Bar training is a safe, effective, low-impact intervention for enhancing core muscle strength in adolescent athletes. Incorporating FB exercise into youth athletic conditioning programs may optimize performance and assist in injury prevention.

**Keywords:** Flexi-Bar, Core Stability, Adolescent Athletes, Manual Muscle Testing, Trunk Activation, Proprioception.

## INTRODUCTION

Core stability is defined as the capacity to regulate the posture and movement of the trunk over the pelvis to optimize the production, transfer, and absorption of forces between proximal and distal body segments during dynamic activities [1]. The core—geometrically conceptualized as the lumbopelvic-hip complex—functions as a dynamic, three-dimensional cylinder. It is bounded superiorly by the diaphragm, inferiorly by the pelvic floor and hip girdle musculature, anterolaterally by the rectus abdominis, internal/external obliques, and transversus abdominis, and posteriorly by the paraspinal and gluteal muscles [2].

In competitive sports, high core stability provides a stable base of support, enabling rapid, coordinated extremity movements essential for athletic performance across disciplines such as hockey, basketball, tennis, and badminton [3,4]. During adolescence, individuals experience rapid somatic growth, changes in center of gravity, and altered spatial relationships between body segments. These rapid physical modifications frequently result in temporary deficits in postural control, motor coordination, and trunk stability, raising injury susceptibility and decreasing athletic performance efficiency [5,6].

Traditional training regimens utilize static planks, curl-ups, weight training, or unstable surfaces like Swiss balls to enhance trunk control [5,7]. However, vibrational training instruments—specifically the Flexi-Bar (FB)—offer an alternative dynamic mechanism. The Flexi-Bar is a double-oscillating, low-frequency (5 Hz) vibrational bar that induces a tonic vibration reflex (TVR) in entheses and deep postural musculature [8,9]. While FB training has demonstrated positive outcomes in adult, healthy, and postpartum populations [8,10], limited empirical research addresses its utility in adolescent athletic cohorts. Therefore, this study aimed to evaluate the effectiveness of Flexi-Bar training on core muscle strength among adolescent athletes. Primary Objective: To evaluate the effect of a Flexi-Bar training program on trunk muscle strength (flexors, extensors, and rotators) in adolescent athletes. Secondary Objective: To assess the feasibility and safety of vibrational core training in a youth sports population.

## MATERIALS AND METHODS

**Study Design and Setting:** This single-arm pre-post experimental study was conducted between 2025 and 2026 within the Musculoskeletal Department Outpatient Clinic at the Institute of Physiotherapy, Srinivas University, and various sports academies in and around Mangaluru, Karnataka, India. Ethical clearance was obtained from the Institutional Ethics Board of Srinivas University prior to initiation. Official administrative permission was secured from local school and college principals, as well as sports department heads, following comprehensive demonstrations of the training protocol. Written informed consent detailing procedural steps, benefits, and potential risks was acquired from all participants and their guardians. The investigation was administered by a trained investigator from the Institute of Physiotherapy, Srinivas University.

### Participant Selection and Sample Size

Participants were recruited using a purposive sampling strategy. Sample size calculation was established using G-power software. Eligible participants met the following inclusion criteria: male and female adolescent athletes aged 14–18 years, absence of active musculoskeletal pathology, baseline core muscle strength demonstrating weakness (Manual Muscle Testing [MMT] score < Grade 3), and validated physical activity engagement confirmed via the Physical Activity Questionnaire for Adolescents (PAQ-A). Individuals were excluded if they had an acute medically diagnosed injury or surgery in the preceding three months, were taking medications interfering with physical performance, were not actively participating in organized physical activity or sports, were concurrently undergoing physical therapy, or failed to complete all diagnostic evaluations.

**Measurement Protocols and Screening:** Initial screening gathered demographic parameters including age,

height, body mass, body mass index (BMI), athletic duration (years), and competitive level. Physical activity levels were quantified using the 7-day recall PAQ-A scale (summary scores >2.9 for boys and >2.7 for girls confirmed eligibility). Baseline and post-intervention core strength were measured using standardized MMT protocols for trunk flexors, extensors, and rotators.

**Intervention Protocol:** Participants underwent supervised core strengthening using a standard 152 cm Flexi-Bar (FB), generating dynamic 5 Hz low-frequency vibrations. Hand placement required a loose, relaxed grip at the center of the rubber handle to prevent premature distal limb fatigue. Participants maintained an upright trunk posture with engaged pelvic and abdominal musculature while initiating oscillations via slight manual pushes. The training routine comprised six progressive exercises: Exercise 1 (Lower Back & Gluteals): Performed in a deep shoulder-width squat with weight distributed through the heels and a slight forward trunk lean; the FB was held forward in line with the upper body and oscillated in a sagittal (forward-backward) plane. Exercise 2 (Abdominals): Executed via a slow dynamic crunch maintaining lower back contact with the mat while holding the FB parallel to the thighs at chest height with wide elbows for a 15-second sagittal oscillation. Exercise 3 (Middle & Upper Back): Positioned in a wide-base stance with weight in the heels, slight knee flexion, and retracted shoulders; the FB was positioned overhead and oscillated vertically (up-down). Exercise 4 (Deep Core & Obliques): Performed in a wide stance holding the FB vertically in front of the body, oscillating laterally (left-right) under sustained body tension. Exercise 5 (Abdominals, Gluteals & Thighs): Executed from a deep dynamic lunge with forward trunk lean and back leg elevation (avoiding lumbar lordotic compensation), oscillating the FB parallel to the floor in a sagittal plane bilaterally. Exercise 6 (Multi-planar Abdominals & Obliques): Performed by introducing slow lateral upper-body rotation to both sides during active sagittal FB oscillation.



Fig 1: Lower Back, Bottom - Forward & Backward.



Fig 2: Abdominals - Forward & backward.



Fig 3: Middle & Upper Back - Up and down.



Fig 4: Core Muscles (abs, obliques, deep muscles of back) Swing the flexi-bar from left to right. Requires substantial body tension.



Fig 5: Abdominals, Gluteal, Thighs - Backwards and Forwards, parallel to the floor.



Fig 6: Abdominals, obliques - Forward & backward



## Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics (Version 25.0). Data distribution normality was determined via the Shapiro-Wilk test. Continuous demographic variables (age, height, weight, BMI) were summarized using means and standard deviations. Non-parametric ordinal MMT scores pre- and post-intervention were compared using the Wilcoxon signed-rank test. Continuous parametric outcome scores were compared using paired sample t-tests. Statistical significance was set at  $p < 0.05$ .

## RESULTS

### Participant Flow & Demographics

A total of 25 adolescent athletes completed the screening and baseline assessment. Participant characteristics are detailed in Table 1.

Table 1: Baseline Demographic Characteristics of Participants (N = 25)

| Parameter   | Mean $\pm$ SD / Frequency |
|-------------|---------------------------|
| Age (years) | 16.2 $\pm$ 1.4            |

|                           |             |
|---------------------------|-------------|
| Gender (Male / Female)    | 14 / 11     |
| Height (cm)               | 167.4 ± 8.2 |
| Weight (kg)               | 58.6 ± 7.1  |
| BMI (\$kg/m^2\$)          | 20.9 ± 1.8  |
| Sports Experience (years) | 3.1 ± 1.2   |
| PAQ-A Baseline Score      | 3.21 ± 0.42 |

### Outcome Evaluation: Core Strength (MMT)

Significant improvements in manual muscle test grades were observed across all evaluated trunk muscle groups following the completion of the Flexi-Bar intervention protocol.

Table 2: Comparison of Pre- and Post-Intervention Core Muscle Strength (MMT)

| Muscle Group    | Pre-Intervention (Mean ± SD) | Post-Intervention (Mean ± SD) | Absolute Change | Z-value / t-value | p-value  |
|-----------------|------------------------------|-------------------------------|-----------------|-------------------|----------|
| Trunk Flexors   | 2.64 ± 0.49                  | 4.12 ± 0.53                   | +1.48           | -4.18             | < 0.001* |
| Trunk Extensors | 2.72 ± 0.46                  | 4.24 ± 0.44                   | +1.52           | -4.26             | < 0.001* |
| Trunk Rotators  | 2.52 ± 0.51                  | 3.96 ± 0.54                   | +1.44           | -4.09             | < 0.001* |

\*Statistically significant at \$p < 0.05\$.

## DISCUSSION

This study demonstrated that a targeted Flexi-Bar training program significantly improved trunk flexor, extensor, and rotator muscle strength in adolescent athletes. These findings align with prior research highlighting the effectiveness of dynamic vibrational training devices in eliciting neuromuscular adaptations [8,10].

The physiological mechanism underlying these gains centers on the tonic vibration reflex (TVR). When oscillating at a resonant frequency of approximately 5 Hz, the Flexi-Bar introduces low-amplitude perturbations to the upper extremities and lumbopelvic region. These oscillations stimulate muscle spindles, triggering rapid involuntary reflex contractions of the deep stabilizing musculature—including the transversus abdominis, multifidus, and internal obliques [9,10].

Adolescent athletes during pubertal maturation often exhibit structural changes in lever arms and center of mass that temporarily compromise static and dynamic balance. Traditional heavy resistance training carries specific load-management considerations in developing skeletal systems. In contrast, Flexi-Bar exercises provide high neuromuscular activation with minimal axial compressive loading, making them a suitable conditioning tool for young athletes [5,8].

Injury Prevention implication included Strengthening the lumbopelvic-hip complex enhances force dissipation during high-velocity directional changes, reducing kinetic chain overload. Performance Enhancement will Increased trunk rotational and extensor strength improves proximal-to-distal force transfer, supporting throwing, jumping, and sprinting actions. Feasibility can be improved with Flexi-Bar routines and require minimal equipment and space, allowing easy integration into warm-ups or athletic conditioning sessions.

Limitations include the lack of a randomized control group (e.g., traditional planking or Swiss ball exercises) limits direct comparative conclusions. Manual Muscle Testing is an ordinal clinical tool; future investigations should utilize surface Electromyography (sEMG) or isokinetic dynamometry to quantify muscle activation rates directly.

## CONCLUSION

Flexi-Bar training significantly improves trunk muscle strength across flexor, extensor, and rotator groups in adolescent athletes. Given its dynamic vibrational feedback and minimal joint stress, Flexi-Bar training is an effective intervention for optimizing core stability in youth athletic development programs.

## REFERENCES

1. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. *Sports Med.* 2006;36(3):189-198.
2. Hibbs AE, Thompson KG, French D, Wrigley A, Spears I. Optimizing performance by improving core stability and core strength. *Sports Med.* 2008;38(12):1017-1033.
3. De Bruin M, Coetzee D, Schall R. The relationship between core stability and athletic performance in female university athletes. *S Afr J Sports Med.* 2021;33(1):1-6.
4. Nuhmani S. Correlation between core stability and upper-extremity performance in male collegiate athletes. *Medicina (Kaunas).* 2022;58(5):612.
5. Kumar R, Zemková E. The effect of 12-week core strengthening and weight training on muscle strength, endurance and flexibility in school-aged athletes. *Appl Sci.* 2022;12(15):7510.
6. Bhawra J, Khadilkar A, Krishnaveni GV, et al. The 2022 India report card on physical activity for children and adolescents. *J Exerc Sci Fit.* 2023;21(1):74-82.
7. Lee SJ, Kim YN, Lee DK. The effect of flexi-bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties. *J Phys Ther Sci.* 2016;28(3):973-977.
8. Sonwane AN, Shetty S, Shekhar S. Flexi Bar training for restoring muscle strength in postpartum women: A pre-post design. *Indian J Community Med.* 2025;50(2):220-224.
9. Kim JH, So KH, Bae YR, Lee BH. A comparison of flexi-bar and general lumbar stabilizing exercise effects on muscle activity and fatigue. *J Phys Ther Sci.* 2014;26(1):119-123.
10. Chung JS, Park S, Kim J, Park JW. Effects of flexi-bar and non-flexi-bar exercises on trunk muscles activity in different postures in healthy adults. *J Phys Ther Sci.* 2015;27(7):2271-2273.