PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Effect of 8-week dynamic vs. static stretching on sprint performance and injury prevention in college students

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Abstract

Background and Study Aim Stretching is a fundamental component of athletic warm-up routines. Both dynamic stretching (DS) and static stretching (SS) are widely practiced. However, their comparative effects on sprint performance and injury prevention in adolescent sprinters remain insufficiently explored, particularly in South Asian settings. This study aimed to compare the effects of DS and SS on sprint performance and injury incidence among adolescent male athletes enrolled in postsecondary colleges in Pakistan.

Material and Methods A total of 36 male postsecondary sprinters aged 17–19 were randomly assigned to either DS (n = 18) or SS (n = 18) groups. The 8-week intervention included five sessions per week of assigned stretching protocols following a standardized warm-up. Sprint performance was assessed using 20m and 40m dash times recorded via electronic timing gates. Injury incidence was monitored and categorized by type and severity. Statistical analyses included paired and independent t-tests, ANOVA, and chi-square tests ($p < 0.05$).

Results The DS group demonstrated significant improvements in sprint performance (20m: -7.2%, 40m: -5.8%, $p < 0.001$), while the SS group showed minimal change. Injury incidence was 60% lower in the DS group compared to SS (4 vs. 10 injuries; $p = 0.038$). Effect sizes indicated a large impact of DS on both performance and injury prevention outcomes.

Conclusions Dynamic stretching was more effective than static stretching in improving sprint performance and reducing injury incidence among adolescent male sprinters. These findings support the integration of dynamic stretching into collegiate warm-up protocols and provide practical recommendations for injury prevention and performance optimization in physical education and sports training programs.

Keywords: dynamic stretching, static stretching, sprint performance, injury prevention, adolescent athletes

Introduction

Warming up is a standard component of athletic preparation, especially in sprinting, where muscle readiness and neuromuscular activation influence performance and injury occurrence. Stretching is commonly integrated into warm-up routines and is believed to contribute to joint mobility and muscle-tendon function. Among various stretching approaches, dynamic stretching (DS) and static stretching (SS) are frequently implemented, but their specific effects on sprint outcomes and injury patterns remain under investigation.

Stretching is a frequently applied component of warm-up routines and is often considered important for preparing the body for physical exertion. From a physiological standpoint, stretching may facilitate neuromuscular function and contribute to reducing the likelihood of soft tissue injury. Among the common approaches, dynamic stretching (DS) involves active movements through the full range of motion [1, 2], whereas static stretching (SS) consists of holding muscles in elongated positions, typically for durations between 15 and 60 seconds per muscle group [3].

Current research presents mixed findings regarding the performance-related effects of these modalities, particularly in sprinting disciplines. Some evidence suggests that DS supports sprint-specific attributes such as acceleration, power, and agility by increasing muscle temperature, enhancing the stretch-shortening cycle, and promoting

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neuromuscular efficiency [2]. Conversely, SS applied for prolonged durations has been linked with temporary reductions in sprint speed, strength, and power output, potentially due to increased muscle stiffness and neuromotor inhibition [3, 4].

Much of the existing research has been conducted in high-resource settings, which may limit generalizability to athletes from underrepresented regions. Factors such as climate, training infrastructure, and athletic conditioning practices may influence stretching outcomes but remain insufficiently studied in developing or transitional environments [5, 6].

Sprint performance is multifactorial and depends on elements such as stride mechanics, explosive power, and muscle-tendon properties – all of which may be affected by pre-exercise stretching. In adolescent populations, physiological maturation processes may increase vulnerability to musculoskeletal strain, particularly due to imbalances between skeletal growth and muscular development [7, 8]. Moreover, insufficient warm-up procedures have been associated with a notable proportion of sports-related injuries in youth, with estimates suggesting up to 37% of cases may be preventable through appropriate pre-activity routines [9].

The effects of dynamic and static stretching on sprint performance among adolescent athletes remain insufficiently explored, particularly in underrepresented regions such as South Asia. Few studies have addressed these modalities in the context of Pakistani youth athletes, despite their participation in sprint-based disciplines. Although some research suggests that DS improves acceleration capacity and maximum speed [10], other investigations have reported minimal or no significant advantages over SS [11]. These discrepancies may be attributed to methodological variations, short-term versus long-term measurement windows, and differing athletic populations.

Another area of uncertainty concerns the dose-response characteristics of stretching protocols. The optimal duration, intensity, and frequency of DS for performance and injury prevention outcomes have not been consistently defined in the literature. Moreover, adaptation to stretching may vary depending on athlete profiles, such as level of training, baseline flexibility, and sport-specific demands. However, such population-specific responses are rarely examined systematically.

Analysis of research findings has shown that dynamic and static stretching influence sprint performance and injury occurrence through distinct physiological mechanisms, yet reported outcomes vary depending on protocol parameters and participant characteristics. The topic remains relevant in the context of adolescent athletes, whose developmental profiles and training exposure may mediate the effects of different warm-up strategies. These considerations highlight the need to examine stretching modalities under controlled conditions in educational sport environments.

While previous studies have investigated dynamic versus static stretching in elite or adult athletes, few have focused on adolescent populations in low-resource or transitional regions such as South Asia. Variations in climate, training conditions, and access to sports medicine may influence stretching-related outcomes, yet are often overlooked in the literature. This study contributes to filling that gap by evaluating both performance and injury-related outcomes in male youth athletes within Pakistani postsecondary institutions. In doing so, it addresses the contextual adaptation of warm-up strategies and explores their dual role in sprint enhancement and injury prevention.

Accordingly, the present study aimed to compare the effects of dynamic stretching and static stretching on sprint performance and injury incidence among adolescent male athletes enrolled in postsecondary colleges in Pakistan. It was hypothesized that dynamic stretching would lead to greater performance improvement and a lower rate of injury compared to static stretching.

Materials and Methods

Participants

Thirty-six male participants aged 17 to 19 years were recruited from two postsecondary institutions in Lahore, Pakistan. All participants were engaged in organized sprint training as part of their college-level athletic programs. The study was approved by the Ethics Committee of the Department of Sports Sciences and Physical Education, Faculty of Allied Health Sciences, The University of Lahore (approval code: DSSPE/ECA/2025-63). Written informed consent was obtained from all participants prior to enrolment.

Inclusion and Exclusion Criteria

Inclusion criteria were: (1) age between 17 and 19 years; (2) at least two years of structured sprint training; (3) enrolment in a postsecondary academic institution; and (4) absence of injury in the six months preceding the study. Exclusion criteria included: (1) any cardiovascular, respiratory, or neuromuscular condition limiting performance; (2) participation in concurrent training or stretching interventions; and (3) non-compliance with the scheduled intervention protocol.

Research Design

This study employed an experimental research design to compare the effects of dynamic and static stretching protocols on sprint performance and injury incidence. Following baseline assessments, participants were stratified by sprint times and randomly allocated to either the dynamic stretching group (DS, $n = 18$) or the static stretching group (SS, $n = 18$) using computer-generated randomization. All intervention sessions were conducted outdoors under standardized conditions at the same time of day (4:00–5:30 PM) to minimize environmental and circadian variability.

Each group followed an 8-week intervention program consisting of five sessions per week. Both programs began with a 10-minute light jogging warm-up, followed by either dynamic or static stretching exercises. The stretching routines targeted major lower-body muscle groups using sport-specific movements or static holds, respectively. Details of the intervention content for each group are provided in Table 1.

Sprint performance was assessed using 20-meter and 40-meter dash tests, recorded with electronic timing gates (Brower Timing Systems, USA) with a precision of ±0.01 s. Each participant performed three trials at each distance, and the best time was retained for analysis. Injury incidence was recorded throughout the intervention by a licensed physiotherapist, who documented injury type, severity, and mechanism based on clinical observation and athlete report.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Data were first tested for normality using the Shapiro-Wilk test. Homogeneity of variance was assessed using Levene's test prior to applying parametric comparisons. Within-group differences between pre- and post-intervention sprint performance were analyzed using paired *t*-tests. Between-group differences were examined using independent *t*-tests and one-way analysis of variance (ANOVA), depending on variable type.

Injury data, which did not meet normality assumptions, were analyzed using the chi-square test for independence. Effect sizes were calculated using Cohen's *d*, with values > 0.8 interpreted as large. The statistical significance threshold was set at $p < 0.05$ for all analyses.

Results

The statistical analysis was conducted to evaluate the effects of dynamic and static stretching interventions on sprint performance and injury incidence. Results are presented in three sections: (1) assessment of data distribution, (2) within- and between-group comparisons of sprint times, and (3) injury frequency during the intervention period.

Normality of distribution for sprint performance variables was verified using the Shapiro-Wilk test. As shown in Table 2, all sprint-related variables demonstrated non-significant *p*-values ($p > 0.05$), indicating normal distribution in both groups. In contrast, injury data deviated from normality, requiring non-parametric testing.

Sprint performance outcomes before and after the intervention are presented in Table 3. Paired *t*-tests revealed statistically significant improvements in both 20-meter and 40-meter sprint times for the dynamic stretching (DS) group ($p < 0.001$), whereas the static stretching (SS) group did not exhibit significant changes ($p > 0.05$). The mean performance gains in the DS group reached 7.2% and 5.8% for the 20-meter and 40-meter sprints, respectively.

In Table 3, effect size calculations indicated large improvements for the DS group and negligible effects for the SS group [12]. Cohen's *d* for the 20-meter sprint improvement in the DS group was 1.15 (95% CI: 0.82–1.48), and for the 40-meter sprint, 1.02 (95% CI: 0.69–1.36), both indicating large effects. These findings are consistent with the neuromuscular benefits of dynamic stretching, which may support enhanced motor unit recruitment

Table 1. Stretching Intervention Protocols for DS and SS Groups

Component	Dynamic Stretching (DS) Group	Static Stretching (SS) Group
Warm-up	10 minutes of light jogging	10 minutes of light jogging
Stretching Activities	Sports-specific dynamic exercises performed through the full range of motion: • Leg swings (2×10 reps/leg) • High knees (2×20m) • Walking lunges with rotation (2×8 reps) • Lateral skips (2×10m/side)	Static holds for major muscle groups: • Hamstrings • Quadriceps • Calves Each stretch is held for 30 seconds and repeated twice
Cool-down	Simple stretching	Simple stretching
Duration of Intervention	8 weeks	8 weeks
Frequency	5 sessions per week	5 sessions per week
Session Length	60–90 minutes	60–90 minutes

Table 2. Shapiro-Wilk Test Results for Normality Assessment (N = 36 per group)

Variable	Group	W	p-value	Normality Conclusion	Statistical Implications
20m Sprint Time (Pre)	Dynamic	0.972	0.543	Normal	Parametric tests appropriate
	Static	0.961	0.412	Normal	
20m Sprint Time (Post)	Dynamic	0.966	0.487	Normal	
	Static	0.958	0.389	Normal	
40m Sprint Time (Pre)	Dynamic	0.969	0.502	Normal	
	Static	0.963	0.452	Normal	
40m Sprint Time (Post)	Dynamic	0.971	0.531	Normal	
	Static	0.955	0.321	Normal	
Injury Incidence Rate	Dynamic	0.924*	0.038*	Non-normal	Non-parametric tests recommended
	Static	0.901*	0.021*	Non-normal	

Key: W = Shapiro-Wilk test statistic (values closer to 1 indicate normality); p < .05 (marked with *) indicates significant deviation from normality; Normal distribution threshold: p > 0.05

Table 3. Pre-Post Intervention Sprint Performance Changes (Mean ± SD)

Group	20m Sprint (s) Pre	20m Sprint (s) Post	% Change	40m Sprint (s) Precision	40m Sprint (s) Post	% Change	p-value
DS (n=18)	3.41 ± 0.21	3.16 ± 0.18*	-7.2%	6.12 ± 0.34	5.76 ± 0.29*	-5.8%	<0.001
SS (n=18)	3.38 ± 0.19	3.32 ± 0.17	-1.8%	6.08 ± 0.31	6.01 ± 0.30	-1.1%	0.213

Note. * = statistically significant (p < 0.05)

and muscle-tendon elasticity [13].

Injury data were collected throughout the 8-week intervention to document muscle strains, ligament sprains, and overuse injuries. Group-wise comparisons were conducted using the chi-square test due to the non-normal distribution of the injury data. The results are summarized in Table 4.

In Table 4, the dynamic stretching (DS) group reported a total of 4 injuries, compared to 10 in the static stretching (SS) group. Chi-square tests showed significantly fewer muscle strains in the DS group ($p = 0.042$). The overall injury rate per 100 training hours was also lower for DS (0.8 vs. 2.1, $p = 0.025$). Total injuries were 60% lower in the DS group ($p = 0.038$), consistent with findings by van Dyk et al. [14], who reported that DS may reduce hamstring injury risk by improving dynamic muscle stability.

In the SS group, six injuries were classified as muscle strains, two as ligament sprains, and two as overuse-related injuries. In the DS group, two muscle strains, one ligament sprain, and one overuse injury were recorded. No severe injuries were reported in either group. All cases were managed without withdrawal from training.

Between-group comparisons of post-intervention outcomes were analyzed using one-way ANOVA. The comparisons included sprint times and injury incidence between the dynamic and static stretching groups. The statistical results are presented in Table 5.

In Table 5, statistically significant differences were observed between the groups for both 20-meter ($F = 18.72$, $p < 0.001$) and 40-meter sprint times ($F = 15.89$, $p < 0.001$), favoring the dynamic stretching group. Injury incidence also differed significantly between groups ($F = 4.56$, $p = 0.042$), with the dynamic group exhibiting lower injury frequency. These findings are aligned with prior research on adolescent athletes that reported positive effects of dynamic stretching on sprint mechanics and musculoskeletal resilience [7, 15].

Overall, the findings indicate that participants in the dynamic stretching group demonstrated greater improvements in sprint performance and experienced fewer injuries compared to those in the static stretching group. The results were consistent across both sprint distances and injury categories, with statistically significant between-group differences observed. These outcomes provide a comparative overview of the two

Table 4. Injury Incidence During 8-Week Intervention

Group	Muscle Strains	Ligament Sprains	Overuse Injuries	Total Injuries	Injury Rate per 100h
DS (n=18)	2	1	1	4	0.8
SS (n=18)	6	2	2	10	2.1
p-value	0.042*	0.341	0.341	0.038*	0.025*

Note. * = statistically significant ($p < 0.05$)

Table 5. Between-Group Comparisons (ANOVA Results)

Variable	F-value	p-value	Effect Size (η^2)	Group Differences (DS vs. SS)
20m Sprint Time	18.72	<0.001*	0.42	DS improved 5.4% more (*p < 0.001*)
40m Sprint Time	15.89	<0.001*	0.38	DS improved 4.7% more (*p < 0.001*)
Muscle Strains	4.56	0.042*	0.21	DS had 67% fewer strains (*p = 0.042*)

Note. * = statistically significant ($p < 0.05$)

stretching modalities and their measurable effects on adolescent sprinters.

Discussion

Interpretation of Sprint Performance Outcomes

This study identified a statistically significant improvement in sprint performance in the dynamic stretching (DS) group compared to the static stretching (SS) group. Participants in the DS group demonstrated a 7.2% reduction in 20-meter sprint time and a 5.8% reduction in 40-meter sprint time. These improvements align with previous findings reporting that dynamic stretching enhances performance by increasing muscle temperature, improving neural drive, and optimizing stretch-shortening cycle efficiency [3, 13, 16, 17].

By contrast, the SS group did not show statistically significant gains. This is consistent with evidence suggesting that static stretching, especially when sustained beyond 60 seconds per muscle group, may temporarily reduce force output and neuromuscular reactivity [18]. While SS can improve flexibility and may be more beneficial in endurance sports, its immediate benefits for explosive sprinting performance appear limited.

Injury incidence during the 8-week intervention was markedly lower in the DS group. The total number of injuries was reduced by 60%, and muscle strains were 30% lower compared to the SS group. These outcomes support prior findings that dynamic stretching improves joint stability and neuromuscular control, thereby lowering the risk of non-contact injuries [8, 19].

Dynamic protocols, characterized by progressive movement patterns, are likely better suited for preparing the neuromuscular system for rapid direction changes and forceful accelerations typical in sprinting. In contrast, the static modality does not engage the active motor pathways needed for injury resilience.

Though static stretching confers long-term flexibility, it appears insufficient in delivering acute protective benefits against sports injuries. However, endurance athletes may still benefit from static stretching due to its potential role in improving muscle-tendon compliance and power output during sustained activities [20]. Although some evidence suggests hybrid stretching (combining DS and SS) may be effective for complex disciplines like gymnastics or martial arts [2, 21], this study focused solely on linear sprinting performance.

Contextual Implications for Adolescent Training

The results have implications for adolescent athletes in postsecondary institutions, particularly in underrepresented regions such as South Asia. Climatic differences, resource limitations, and training culture may alter the impact of stretching modalities compared to high-resource environments. The study extends prior research by evaluating stretching effects in a context where empirical data are scarce.

Effect size analysis indicated large performance gains in the DS group (Cohen's d = 1.15 for 20m; 1.02 for 40m), highlighting the practical relevance of the findings. These results suggest that dynamic stretching can be a feasible, low-cost intervention for optimizing sprint outcomes and minimizing injuries in youth training environments.

While the physiological effects of stretching modalities are well-documented, empirical data from adolescent populations in underrepresented regions remain limited. By examining male college athletes in Pakistan, this study provides context-specific validation of previously established stretching principles. It contributes to the understanding of how environmental, institutional, and developmental factors may mediate the effectiveness of dynamic versus static stretching in real-world training contexts.

Findings of the study also align with recommendations by McGowan and Pyne [22], who emphasized the benefits of dynamic movement preparation in sprint-specific warm-ups. Incorporating such strategies into adolescent athletic training may support performance development and reduce injury risk, although broader implementation should be guided by context-specific evaluation.

The present study provides comparative evidence that dynamic stretching offers greater short-term benefits than static stretching in enhancing sprint performance and reducing injury incidence among adolescent male athletes. These findings contribute to a growing body of research on warm-up optimization and highlight the potential relevance of movement-specific preparation in sprint-oriented activities within postsecondary athletic contexts.

Limitations of the Study

Several limitations should be considered when interpreting the findings of this study. First, the sample included only male adolescent sprinters, which limits the generalizability of the results to female athletes, older age groups, elite performers, and those involved in endurance-based sports. Physiological and hormonal differences across populations may result in different responses to stretching protocols.

Second, the duration of the intervention was restricted to eight weeks, which may not reflect long-term adaptation or sustainability of the observed effects. The relatively short follow-up also limits conclusions regarding delayed onset of injuries or cumulative exposure to risk.

The study did not evaluate the potential effects of combined or hybrid stretching protocols. Future research may consider extended longitudinal designs with diverse populations to examine whether integrated stretching approaches yield consistent performance and injury prevention outcomes across different athletic contexts.

Conclusions

This study examined the comparative effects of dynamic and static stretching on sprint performance and injury incidence among adolescent male athletes in postsecondary colleges in Pakistan. The findings suggest that dynamic stretching may offer greater short-term benefits in this population and context. These results contribute to the contextual validation of existing stretching protocols and may inform warm-up design in similar educational and training settings.

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Conflicts of interest

The authors declare no conflict of interest.

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