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Comparison of Static and Dynamic Stretching on Hamstring Flexibility in Adolescents: A Systematic Review

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Abstract
Background: Hamstring flexibility is an important component of musculoskeletal fitness that contributes to movement efficiency, postural control, and injury prevention. Reduced hamstring flexibility is frequently observed in adolescents, particularly among those with sedentary lifestyles. Static stretching (SS) and dynamic stretching (DS) are commonly used to improve flexibility; however, evidence regarding their comparative effectiveness in adolescents remains inconsistent.
Objective: This systematic review aimed to compare the effects of SS and DS on hamstring flexibility in adolescents.
Methods: This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Literature searches were conducted in PubMed, Scopus, and Google Scholar for studies published between 2019 and 2025. Eligible studies included adolescents with reduced hamstring flexibility who received SS and/or DS interventions. Randomized controlled trials and quasi-experimental studies published in English were included. Due to heterogeneity in intervention protocols and outcome measures, data were synthesized narratively.
Results: Six studies met the inclusion criteria. Both SS and DS significantly improved hamstring flexibility. DS generally produced greater short-term improvements in flexibility and functional performance, whereas SS showed beneficial effects when performed consistently over longer periods. Flexibility outcomes were mainly assessed using the sit and reach test and the Active Knee Extension Test.
Conclusion: Both SS and DS are effective for improving hamstring flexibility in adolescents. DS may provide greater short-term benefits, while SS remains effective for long-term flexibility improvement. Further high-quality randomized controlled trials with standardized protocols are needed.

Keywords
Hamstring Flexibility; Static Stretching; Dynamic Stretching; Adolescent; Range of Motion

Introduction

Hamstring flexibility is an important component of musculoskeletal fitness that contributes to optimal movement efficiency, postural stability, functional mobility, and injury prevention.[1] Adequate flexibility of the hamstring muscle group is essential for normal biomechanical function during activities involving hip flexion and knee extension.[2] Conversely, reduced hamstring flexibility has been associated with limited range of motion, altered movement patterns, decreased functional performance, and an increased risk of musculoskeletal disorders, including low back pain and lower extremity injuries.[3]

Adolescence represents a critical developmental stage characterized by rapid physical growth, behavioral adaptation, and lifestyle changes that may influence musculoskeletal health. In recent years, sedentary behavior among adolescents has increased substantially due to prolonged use of smartphones, computers, tablets, and other digital devices.[4] Sedentary behavior is associated with reduced physical activity levels and has been shown to negatively affect several components of physical fitness, including flexibility, muscular endurance, and overall functional capacity.[4]

Previous studies have demonstrated that adolescents with low physical activity levels tend to exhibit decreased hamstring extensibility compared with physically active individuals.[5] Reduced flexibility may occur due to prolonged sitting posture, decreased neuromuscular activation, and adaptive shortening of muscle tissue, which collectively contribute to increased muscle stiffness and impaired movement efficiency.[3] Over time, these physiological adaptations may increase susceptibility to musculoskeletal discomfort and functional limitations. Therefore, interventions targeting flexibility improvement are considered important in maintaining adolescent musculoskeletal health.

Stretching exercises are commonly used interventions to improve muscle flexibility and joint mobility. Physiologically, stretching may improve flexibility through increased stretch tolerance, reduced passive muscle stiffness, and adaptations in the viscoelastic properties of muscle tendon units.[6] Static stretching and dynamic stretching are the two most frequently applied stretching techniques in rehabilitation and sports settings. Static stretching involves maintaining a muscle in an elongated position for a specific duration, usually between 10 and 30 seconds, to facilitate gradual increases in muscle length and flexibility.[7,8] In contrast, dynamic stretching consists of controlled active movements performed through the available range of motion, which may additionally increase muscle temperature, circulation, and neuromuscular activation.[9]

Current evidence suggests that both static and dynamic stretching can improve hamstring flexibility; however, the comparative effectiveness of these interventions remains inconclusive.[6,10] Some studies reported that dynamic stretching provides greater short term improvements in flexibility and functional performance due to enhanced neuromuscular activation and movement preparation.[9] Conversely, static stretching appears to be beneficial for long term flexibility adaptation when performed consistently over time.[7] Variability in intervention duration, stretching intensity, participant characteristics, and outcome measures has contributed to inconsistent findings across studies.[6]

Although numerous studies have investigated stretching interventions, many have focused predominantly on athletic populations. Evidence specifically addressing adolescents and young individuals with reduced flexibility or sedentary lifestyles remains comparatively limited. This gap highlights the need for a focused synthesis of current evidence regarding the comparative effects of static and dynamic stretching on hamstring flexibility in adolescent populations.

Therefore, this systematic review aimed to compare the effects of static and dynamic stretching on hamstring flexibility in adolescents. It was hypothesized that both stretching methods would improve hamstring flexibility, with dynamic stretching potentially demonstrating greater short-term improvements in flexibility and functional performance.

Methods

This study was conducted as a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) 2020 guidelines to ensure transparency, reproducibility, and methodological rigor throughout the review process. A comprehensive literature search was performed using three electronic databases, namely PubMed, Scopus, and Google Scholar, to identify relevant studies published between January 2019 and December 2025. Only articles published in English were considered eligible for inclusion. The search strategy was developed using combinations of Medical Subject Headings (MeSH) terms and free text keywords related to hamstring flexibility and stretching interventions. The primary search terms included “hamstring flexibility,” “range of motion,” “static stretching,” “dynamic stretching,” “adolescent,” and “youth.” These keywords were combined using Boolean operators as follows: (("hamstring flexibility" OR "range of motion") AND ("static stretching" OR "dynamic stretching") AND ("adolescent" OR "youth")). In addition to electronic database searches, manual screening of the reference lists from eligible articles was conducted to identify potentially relevant studies not retrieved during the initial search process.

Study eligibility was determined using the PICOS framework, which consisted of population, intervention, comparison, outcomes, and study design components. The population included adolescents and young individuals with reduced hamstring flexibility or limited range of motion. Studies involving professional athletes, individuals with neurological disorders, severe musculoskeletal injuries, or post-surgical conditions were excluded to maintain population homogeneity. Eligible interventions included static stretching and/or dynamic stretching specifically targeting the hamstring muscles. Studies comparing both stretching interventions or evaluating stretching effects against baseline measurements or alternative flexibility interventions were included. The primary outcomes of interest were hamstring flexibility and range of motion assessed using standardized measurement tools such as the sit and reach test, Active Knee Extension Test (AKET), and goniometric assessment. Only randomized controlled trials and quasi-experimental studies published in peer-reviewed journals were included, whereas review articles, systematic reviews, meta-analyses, conference abstracts, editorials, case reports, and non-English publications were excluded from the review process.

All records identified through database searches were imported into Mendeley reference management software to facilitate organization and duplicate removal. After duplicates were removed, the screening process was conducted in three sequential stages consisting of title screening, abstract screening, and full text eligibility assessment. Two independent reviewers evaluated all retrieved studies according to the predefined inclusion and exclusion criteria to minimize selection bias and improve objectivity. Any disagreements between reviewers were resolved through discussion and consensus. The initial search process identified 120 records from the selected databases. Following duplicate removal and screening procedures, six studies fulfilled the eligibility criteria and were ultimately included in the qualitative synthesis.

Data extraction was performed using a standardized extraction form to ensure consistency and completeness across all included studies. The extracted variables included author and publication year, study design, participant characteristics, intervention type, intervention duration, frequency of stretching sessions, outcome measures, and the main findings related to hamstring flexibility. The methodological quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale, which evaluates methodological rigor based on several criteria, including randomization, allocation concealment, baseline comparability, blinding procedures, adequacy of follow-up, and statistical reporting. Based on the PEDro scores, studies were categorized into low, moderate, or high methodological quality. The results of this quality assessment were used to support the interpretation of findings and identify potential methodological limitations among the included studies.

Due to substantial heterogeneity across studies in terms of intervention protocols, stretching duration, frequency, outcome measurements, and participant characteristics, a quantitative meta-analysis was not conducted. Instead, findings were synthesized narratively to compare the effects of static and dynamic stretching on hamstring flexibility and range of motion. The synthesis focused on identifying trends in intervention effectiveness, reported statistical significance, and differences in flexibility outcomes across the included studies. This review utilized secondary data obtained from previously published studies; therefore, ethical approval and informed consent were not required.

Results

The literature search process identified a total of 120 records from PubMed, Scopus, and Google Scholar databases. After duplicate removal and screening procedures, six studies fulfilled the eligibility criteria and were included in the qualitative synthesis. The study selection process was conducted systematically according to the PRISMA 2020 guidelines through title screening, abstract screening, and full-text eligibility assessment. Studies excluded during the screening process were primarily removed due to inappropriate population characteristics, non-relevant interventions, unsuitable outcome measures, or insufficient methodological information. The detailed study selection process is presented in Figure 1.

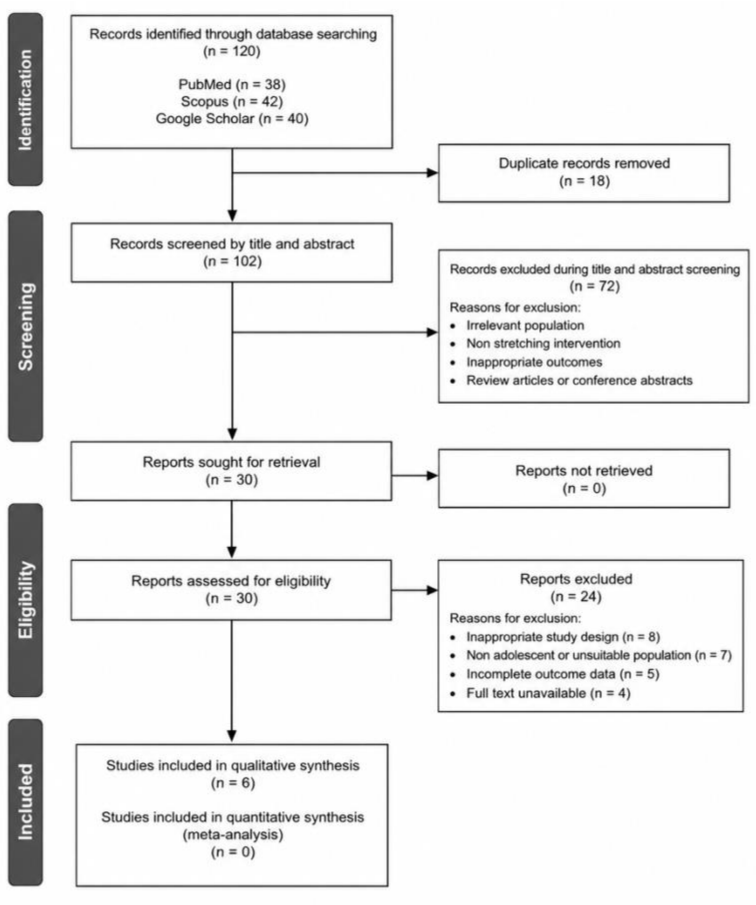

Figure 1. PRISMA Flow Diagram of Study Selection

The included studies consisted predominantly of randomized controlled trials and quasi-experimental studies evaluating the effects of static stretching and dynamic stretching on hamstring flexibility. The populations investigated across studies included adolescents, female students, healthy individuals, and physically active populations with reduced hamstring flexibility or limited range of motion. Intervention duration varied considerably between studies, ranging from acute intervention protocols to structured stretching programs lasting up to five weeks. Flexibility outcomes were primarily assessed using the sit and reach test, although several studies additionally utilized the Active Knee Extension Test (AKET) and other range of motion assessments to evaluate hamstring extensibility. The characteristics of the included studies are summarized in Table 1.

Table 1. Characteristics of Included Studies

Author (Year)	Study Design	Population	Intervention	Outcome Measures	Main Findings
Shin et al. (2023)[11]	Randomized controlled trial	Adolescents with reduced hamstring flexibility	Static stretching vs dynamic stretching	Sit and reach test, dynamic balance, lower extremity function	Both interventions significantly improved hamstring flexibility and lower extremity function, although dynamic stretching demonstrated greater improvement in functional outcomes.
Cai et al. (2023)[12]	Systematic review and meta analysis	Healthy individuals and athletes from included studies	Dynamic stretching vs static stretching	Hamstring flexibility and muscle stiffness	Both stretching modalities improved flexibility. Dynamic stretching demonstrated greater short term flexibility improvement, whereas static stretching showed greater effects on reducing muscle stiffness.
Ismaningsih et al. (2025)[8]	Quasi experimental	Female students	Static stretching program for five weeks	Sit and reach test	Static stretching significantly improved hamstring flexibility after five weeks of intervention.
Lestari et al. (2023)[10]	Experimental study	Badminton athletes	Static stretching vs dynamic stretching	Flexibility assessment	Dynamic stretching demonstrated greater flexibility improvement compared with static stretching.
Sarich et al. (2025)[7]	Quasi experimental	Factory workers	Static stretching with different durations (15 vs 30 seconds)	Active Knee Extension Test (AKET)	Both stretching durations significantly improved hamstring flexibility, with slightly greater improvement observed following 15 second stretching.
Takeuchi et al. (2023)[9]	Systematic review and meta analysis	Healthy individuals from included intervention studies	Long term static stretching	Muscle stiffness and flexibility	Long term static stretching significantly reduced muscle stiffness and improved flexibility outcomes.

Notes: AKET = Active Knee Extension Test.

Overall, the findings consistently demonstrated that both static stretching and dynamic stretching significantly improved hamstring flexibility. However, several studies reported that dynamic stretching produced greater short-term improvements in flexibility and functional performance compared with static stretching. Shin et al. reported that both interventions improved hamstring flexibility and lower extremity function, although dynamic stretching demonstrated superior improvement in functional outcomes. Similarly, Cai et al. reported that both stretching modalities effectively improved flexibility and reduced muscle stiffness, with dynamic stretching demonstrating greater short-term effectiveness in flexibility enhancement. Lestari et al. also demonstrated greater flexibility improvement following dynamic stretching compared with static stretching among badminton athletes.

In contrast, studies investigating static stretching programs demonstrated that static stretching remained effective in improving hamstring flexibility when performed consistently over longer intervention periods. Ismaningsih et al. reported significant improvements in hamstring flexibility following a five-week static stretching program in female students. Likewise, Takeuchi et al. demonstrated that long-term static stretching interventions significantly reduced muscle stiffness and improved flexibility across multiple populations. Sarich et al. additionally reported that both 15-second and 30-second static stretching durations significantly improved hamstring flexibility, although the shorter duration demonstrated slightly greater improvement. These findings indicate that static stretching may provide beneficial long-term adaptations despite the relatively greater short-term effects observed following dynamic stretching interventions.

Variability in intervention duration, stretching frequency, participant characteristics, and flexibility assessment methods contributed to heterogeneity across studies. Studies implementing longer intervention periods generally demonstrated greater flexibility improvements regardless of stretching modality. Furthermore, differences in baseline flexibility levels, physical activity status, and adherence to stretching protocols may have influenced the magnitude of improvement observed among participants. Due to this methodological heterogeneity, quantitative meta-analysis was not considered appropriate, and the findings were synthesized narratively.

The methodological quality assessment using the PEDro scale demonstrated that most included studies possessed moderate methodological quality. Several studies adequately reported randomization procedures, baseline comparability, and statistical analyses; however, blinding procedures were generally not feasible due to the nature of stretching interventions. The methodological quality assessment of the included studies is summarized in Table 2.

Table 2. Methodological Quality Assessment Based on PEDro Scale

Study	Randomization	Baseline Comparability	Blinding	Follow Up Adequacy	Statistical Reporting	Overall Quality
Shin et al. (2023)[11]	Yes	Yes	No	Yes	Yes	Moderate to High
Ismaningsih et al. (2025)[8]	No	Yes	No	Yes	Yes	Moderate
Lestari et al. (2023)[10]	Yes	Yes	No	Yes	Yes	Moderate
Sarich et al. (2025)[7]	No	Yes	No	Yes	Yes	Moderate
Takeuchi et al. (2023)[9]	Yes	Yes	No	Yes	Yes	High

Notes: Blinding of participants and assessors was generally not feasible due to the nature of stretching interventions.

Discussion

The present systematic review aimed to compare the effects of static stretching and dynamic stretching on hamstring flexibility in adolescents and young populations. Overall, the findings demonstrated that both stretching modalities significantly improved hamstring flexibility and range of motion. However, dynamic stretching showed a more consistent tendency to produce greater short-term improvements in flexibility and functional performance, whereas static stretching appeared to provide beneficial long-term adaptations when performed consistently over extended intervention periods.[12] These findings support the growing body of evidence suggesting that stretching interventions play an important role in maintaining musculoskeletal function and improving movement efficiency among adolescents and young individuals with reduced flexibility.

The improvement in hamstring flexibility observed across the included studies may be explained through several physiological mechanisms. Static stretching primarily improves flexibility by increasing stretch tolerance and reducing passive muscle stiffness through viscoelastic adaptations within the muscle-tendon unit.[13] Prolonged and repeated stretching exposure may additionally contribute to structural adaptations that enhance muscle extensibility over time. In contrast, dynamic stretching involves active repetitive movements performed through the available range of motion, which may increase muscle temperature, stimulate circulation, and facilitate neuromuscular activation.[14] These mechanisms likely contribute to the greater short-term improvements in flexibility and functional performance reported following dynamic stretching interventions.[15]

Several included studies demonstrated superior short-term outcomes following dynamic stretching interventions. Shin et al. reported that both static and dynamic stretching improved hamstring flexibility and lower extremity function; however, dynamic stretching resulted in greater improvements in functional outcomes.[11] Similar findings were reported by Lestari et al., who demonstrated greater flexibility improvement following dynamic stretching compared with static stretching.[10] These findings are consistent with previous evidence suggesting that dynamic stretching enhances movement preparation and neuromuscular efficiency, thereby improving immediate flexibility and functional performance outcomes.[15] Furthermore, dynamic stretching may be particularly beneficial before physical activity because it prepares the musculoskeletal system for movement without substantially reducing muscle performance.[15]

Although dynamic stretching demonstrated greater short-term effects, static stretching remained effective in improving hamstring flexibility, particularly when performed consistently over longer durations. Ismaningsih et al. demonstrated significant improvements in hamstring flexibility after a five-week static stretching program in female students.[8] Similarly, Takeuchi et al. reported that long-term static stretching significantly reduced muscle stiffness and improved flexibility outcomes across multiple populations.[9] These findings suggest that static stretching remains clinically relevant, especially in rehabilitation settings and long term flexibility programs aimed at improving muscle extensibility and reducing stiffness gradually over time.

The findings of this review also demonstrated considerable heterogeneity among the included studies. Variations in intervention duration, stretching frequency, stretching intensity, participant characteristics, and flexibility assessment methods contributed to differences in reported outcomes.[16] Studies implementing longer intervention durations generally demonstrated greater flexibility improvements regardless of stretching modality, suggesting that training volume and intervention consistency may substantially influence flexibility adaptation.[16] Additionally, differences in baseline flexibility levels and physical activity status may have affected participant responsiveness to stretching interventions.[16] These methodological differences limited direct comparison across studies and prevented quantitative meta-analysis.

Several methodological limitations should also be considered when interpreting the findings of this review. Although most included studies demonstrated moderate methodological quality based on PEDro assessment, blinding procedures were generally not feasible because of the nature of stretching interventions. Furthermore, some included studies utilized relatively small sample sizes and short intervention durations, which may reduce the generalizability of findings. Another important limitation is that several included studies involved physically active individuals rather than exclusively sedentary adolescents, potentially introducing variability in neuromuscular adaptation and flexibility responses. Consequently, the findings should be interpreted cautiously, particularly when generalizing to broader adolescent populations.

Despite these limitations, this review provides several important clinical implications. Dynamic stretching appears to be more appropriate as part of warm-up routines due to its beneficial effects on functional performance, neuromuscular activation, and immediate flexibility enhancement. In contrast, static stretching may be more suitable for cool down sessions, rehabilitation programs, and long-term flexibility development. Integrating both stretching modalities within a structured exercise program may therefore provide complementary benefits for flexibility improvement and musculoskeletal health maintenance.

Future research should prioritize well-designed randomized controlled trials involving homogeneous adolescent populations and standardized stretching protocols. Additional investigation examining the combined effects of static and dynamic stretching, optimal intervention duration, stretching frequency, and long-term functional outcomes would further strengthen the current evidence base. Moreover, future studies should include larger sample sizes and more consistent outcome measurements to improve comparability across studies and facilitate future quantitative synthesis.

Conclusion

The findings of this systematic review demonstrate that both static stretching and dynamic stretching are effective interventions for improving hamstring flexibility and range of motion in adolescents and young populations. Dynamic stretching consistently demonstrated greater short-term improvements in flexibility and functional performance, likely due to its effects on neuromuscular activation, movement preparation, and muscle temperature enhancement. In contrast, static stretching remained effective for improving flexibility when implemented consistently over longer intervention periods and appeared particularly beneficial for reducing muscle stiffness and supporting long-term flexibility adaptation.

These findings suggest that the selection of stretching interventions should be adjusted according to the intended clinical or functional objectives. Dynamic stretching may be more appropriate as part of warm-up routines and activities requiring immediate functional readiness, whereas static stretching may be more suitable for rehabilitation programs, cool-down sessions, and long-term flexibility maintenance. The integration of both stretching modalities within a structured flexibility program may provide complementary benefits for musculoskeletal health and functional performance.

Nevertheless, the findings of this review should be interpreted with consideration of the methodological heterogeneity identified among the included studies, including differences in intervention duration, stretching frequency, participant characteristics, and flexibility assessment methods. Further high-quality randomized controlled trials involving homogeneous adolescent populations and standardized intervention protocols are required to strengthen the current evidence base and establish more definitive recommendations regarding optimal stretching strategies for hamstring flexibility improvement.

Author Contribution

Ananda Sakinah Istanti: Conceptualization, Methodology, Literature search, Study selection, Data curation, Formal analysis, Writing original draft, Writing review and editing.
Pipin Suparmi: Supervision, Methodological guidance, Writing review and editing.

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Conflict of Interest Statement

The authors declare no conflict of interest related to this study.

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Ethics Statement

This study utilized secondary data obtained from previously published studies; therefore, ethical approval and informed consent were not required.

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