



The Relationship Between Stretching and Students' Running Ability in Football Games

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ABSTRACT

This study aimed to examine the relationship between stretching and students' running ability in football games. Stretching is a fundamental component of warm-up routines designed to increase muscle flexibility, enhance joint range of motion, and optimize neuromuscular readiness before engaging in high-intensity physical activity. In football, running ability particularly short-distance sprint performance is a critical determinant of game effectiveness, influencing acceleration, positioning, and tactical responsiveness. A quantitative correlational design was employed. The population consisted of 358 tenth-grade students of SMA N 1 Jambi City. Using systematic sampling from 146 male students, 26 participants were selected as the research sample. Stretching practices were measured through structured observation and validated questionnaires, while running ability was assessed using a 30-meter sprint test. Data were analyzed using Pearson's product-moment correlation with a significance level of $\alpha = 0.05$. The results revealed a strong and statistically significant relationship between stretching and running ability ($r = 0.783$; $p = 0.001 < 0.05$). The coefficient of determination ($r^2 = 0.613$) indicates that 61.3% of the variance in running performance is associated with stretching practices. These findings suggest that proper stretching implementation is positively related to improved sprint performance in school-based football activities. The study highlights the importance of structured and evidence-based warm-up routines in enhancing students' physical performance and movement efficiency in Physical Education settings.

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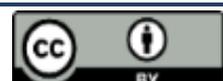
AUTHORS' CONTRIBUTION

A. Conception and design of the study;
B. Acquisition of data;
C. Analysis and interpretation of data;
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INTRODUCTION

Football is one of the most popular sports among adolescents and constitutes an integral component of Physical Education (PE) curricula in Indonesian senior high schools. In the context of school-based football games, students are required to perform repeated high-intensity running, sprint acceleration, directional changes, pressing, and transitional movements between defensive and attacking phases. Running ability particularly sprint performance is therefore a central determinant of football



performance (Buchheit & Laursen, 2015; Haugen et al., 2019). Sprinting speed contributes directly to successful ball recovery, offensive penetration, and defensive coverage, making it a key physical attribute in youth football (Barnes et al., 2018; Slimani & Nikolaidis, 2019). Running ability is influenced not only by genetic predisposition but also by neuromuscular coordination, muscle-tendon stiffness, flexibility, joint range of motion (ROM), and appropriate pre-activity preparation (Behm et al., 2016; Chaabene et al., 2019). One of the most common preparatory components implemented in PE classes is stretching. Stretching is widely incorporated into warm-up routines with the aim of improving flexibility, increasing ROM, enhancing muscle readiness, and reducing injury risk (Behm & Chaouachi, 2015; Kay & Blazevich, 2018).

In school practice, however, stretching is often performed without structured guidance, scientific rationale, or evaluation of its direct relationship with performance outcomes. Preliminary observations in SMA N 1 Jambi City indicated that several students were unable to perform maximal sprints during football games. Some displayed limited stride length, visible muscle stiffness, delayed acceleration, and suboptimal responsiveness during high-intensity transitions. Moreover, incorrect execution of stretching movements and occasional omission of warm-up components were observed. These practical issues raise an important pedagogical and scientific question: Is there a measurable relationship between stretching practices and students' running ability in school football games?

Although stretching is routinely recommended in PE settings, its direct contribution to sprint performance among high school students remains underexplored in the Indonesian educational context. Establishing this relationship is crucial for optimizing evidence-based warm-up protocols in school football activities. Recent sports science literature provides a nuanced understanding of stretching and its acute and chronic effects on performance. Stretching can be broadly categorized into static stretching (SS), dynamic stretching (DS), ballistic stretching, and proprioceptive neuromuscular facilitation (PNF) (Behm et al., 2016; Konrad et al., 2021). Each type produces distinct neuromuscular and mechanical responses.

Dynamic stretching has consistently been associated with improved sprint performance due to increased muscle temperature, enhanced motor unit recruitment, and post-activation potentiation effects (Chaabene et al., 2019; Opplert & Babault, 2018). In youth athletes, dynamic stretching prior to sprint tasks has been shown to improve acceleration and short-distance sprint times (Moran et al., 2018; Ayala et al., 2017). These findings suggest that dynamic movements better replicate sport-specific demands, particularly in football, which requires explosive acceleration and rapid changes of direction. Conversely, prolonged static stretching (>60 seconds per muscle group) has been reported to temporarily reduce maximal strength and power output due to decreased musculotendinous stiffness and altered neuromuscular activation (Behm & Chaouachi, 2015; Kay & Blazevich, 2018). However, shorter-duration static stretching integrated within a structured warm-up may not significantly impair sprint performance and may contribute positively to flexibility and injury prevention (Konrad et al., 2021; Samson et al., 2019).

In football-specific contexts, warm-up protocols such as the FIFA 11+ program integrate controlled dynamic mobility exercises and have demonstrated improvements in sprinting ability and reduced injury incidence in youth players (Bizzini & Dvorak, 2015; Silvers-Granelli et al., 2017). Research also indicates that flexibility contributes to optimal stride length and running economy when balanced with adequate musculotendinous stiffness (Blazevich et al., 2018; Andrade et al., 2020). Furthermore, in adolescent populations, motor development and neuromuscular coordination are still evolving (Lloyd et al., 2016; Granacher et al., 2016). Proper warm-up and stretching may enhance movement efficiency by improving proprioceptive readiness and neuromuscular synchronization (Faigenbaum et al., 2018). In educational settings, structured physical preparation has been shown to improve sprint and agility outcomes among high school students (Hammami et al., 2018; Ramirez-Campillo et al., 2020).

However, the literature also reports conflicting findings. Some studies indicate that excessive or improperly timed static stretching may negatively affect sprint acceleration (Behm et al., 2016; Nelson et al., 2016). These inconsistencies highlight that stretching effects are highly dependent on type, duration, intensity, and integration within the warm-up structure. Thus, the state of the art suggests that stretching has biomechanical and neuromuscular implications for sprint performance, yet its application in school-based football remains insufficiently contextualized.

Despite extensive research on stretching and performance in elite and youth athletes, several gaps remain evident. First, most empirical studies focus on competitive athletes rather than general high school students participating in school-based football activities (Moran et al., 2018; Chaabene et al., 2019). The physiological profile, training exposure, and movement competency of school students differ significantly from trained athletes. Therefore, findings from elite sports contexts cannot be directly generalized to PE environments. Second, many studies investigate acute effects of specific stretching protocols under laboratory controlled conditions (Behm et al., 2016; Kay & Blazevich, 2018). Few studies examine real world stretching practices implemented by PE teachers during routine lessons. The ecological validity of stretching research in authentic school football settings remains limited. Third, in Indonesia, empirical investigations linking stretching habits to measurable sprint performance among senior high school students are scarce. Existing studies often emphasize injury prevention or flexibility improvement rather than direct correlations with running ability in football gameplay contexts. Fourth, the interaction between stretching quality (correct technique and compliance) and sprint performance has not been sufficiently examined. Observational evidence suggests that improper execution may reduce potential benefits, yet this factor is rarely quantified. Therefore, a clear gap exists in understanding the relationship between stretching practices and students' running ability within actual school football games, particularly in the Indonesian educational context.

Based on the identified research problem and gaps, this study aims to analyze the relationship between stretching and students' running ability in football games at SMA N 1 Jambi City. Specifically, the study seeks to: Measure the level of stretching

implementation among students during PE football sessions. Assess students' running ability using standardized sprint performance indicators. Determine the statistical relationship between stretching practices and running ability outcomes. The novelty of this study lies in several aspects: First, it contextualizes stretching-performance relationships within a school-based PE environment, rather than elite training settings. Second, it adopts an applied educational perspective, linking biomechanical theory with pedagogical practice in football instruction. Third, it contributes empirical evidence from Indonesian senior high school students, enriching the limited regional data on warm-up effectiveness in educational sports settings. Fourth, it provides practical implications for PE teachers in designing evidence-based warm-up protocols that enhance sprint performance without compromising flexibility or increasing injury risk.

By integrating contemporary sports science evidence with real-world educational practice, this study contributes to strengthening the scientific foundation of PE instruction and supports the development of performance-oriented yet safe football learning environments in senior high schools.

METHODS

This study employed a quantitative approach using a correlational design to examine the relationship between stretching practices and students' running ability in football games at SMA N 1 Jambi City. A quantitative correlational design is appropriate when the objective is to determine the strength and direction of the relationship between two measurable variables without manipulation (Creswell & Creswell, 2018; Field, 2018). This design is widely applied in sports science to investigate associations between physical preparation variables and performance outcomes (Moran et al., 2018; Chaabene et al., 2019). The population consisted of all 358 tenth-grade students of SMA N 1 Jambi City. In accordance with sampling principles in educational research, the population refers to all individuals sharing relevant characteristics within a defined context (Taherdoost, 2016). Considering that football activities in PE classes were conducted separately by gender, the accessible population included 146 male students. A systematic sampling technique with an interval of five was applied to ensure representativeness and minimize selection bias (Etikan & Bala, 2017). This procedure resulted in 26 male students being selected as the study sample. Sample size adequacy aligns with correlational research recommendations, which suggest a minimum of 20–30 participants to detect moderate relationships (Bonett & Wright, 2015).

Two primary variables were measured: stretching (independent variable) and running ability (dependent variable). Stretching practices were assessed using structured observation sheets and a validated questionnaire measuring frequency, duration, type (static or dynamic), and correctness of execution. The questionnaire was adapted from contemporary warm-up assessment frameworks emphasizing flexibility and neuromuscular readiness (Behm et al., 2016; Konrad et al., 2021). Content validity was evaluated by two sports science experts, and reliability testing using Cronbach's alpha

yielded acceptable internal consistency ($\alpha > 0.70$), consistent with measurement standards in physical education research (Taber, 2018). Running ability was measured using a 30-meter sprint test, a standardized and reliable indicator of acceleration and short-distance speed performance in youth football (Haugen & Buchheit, 2016; Slimani & Nikolaidis, 2019). Sprint time was recorded using a digital stopwatch with two assessors to enhance measurement reliability, as recommended in field-based performance testing protocols (Hopkins, 2015). The 30-meter sprint test is widely recognized for its ecological validity in football contexts due to its reflection of in-game acceleration demands (Barnes et al., 2018).

Data collection procedures included observation during PE football sessions, documentation of attendance and physical activity participation, administration of the stretching questionnaire, and implementation of the sprint performance test. Prior to hypothesis testing, prerequisite analyses were conducted. Normality of data distribution was examined using the Shapiro–Wilk test, as recommended for small sample sizes (Razali & Wah, 2016). Homogeneity of variance was assessed to ensure compliance with parametric testing assumptions (Field, 2018).

To determine the relationship between stretching and running ability, Pearson’s product-moment correlation coefficient (r) was used. Correlation analysis is appropriate for identifying the degree and direction of linear association between two continuous variables (Mukaka, 2016). The strength of correlation was interpreted based on established guidelines (Schober et al., 2018). Additionally, a t-test for correlation significance was applied to examine whether the observed relationship differed significantly from zero at a significance level of $\alpha = 0.05$. Statistical analysis was conducted using SPSS software.

RESULTS AND DISCUSSION

Result

1. Descriptive Statistics

Data were collected from 26 male students of grade X at SMA N 1 Jambi City. Stretching implementation was assessed using a validated questionnaire and structured observation, while running ability was measured through a 30-meter sprint test, which is widely used to assess acceleration capacity in youth football players (Haugen & Buchheit, 2016; Slimani & Nikolaidis, 2019).

Table 1.
Descriptive Statistics of Research Variables

Variable	N	Mean	SD	Min	Max
Stretching Score	26	78.46	6.82	65	90
Running Ability (30m sprint, seconds)	26	4.89	0.32	4.30	5.40

The descriptive results indicate that students demonstrated relatively good stretching practices ($M = 78.46$), while the average 30-meter sprint time was 4.89 seconds, which falls within the moderate performance category for adolescent male

students (Moran et al., 2018; Ramirez-Campillo et al., 2020). Lower sprint times indicate better running performance.

Normality Test

The Shapiro-Wilk test was conducted to ensure data normality due to the relatively small sample size (Razali & Wah, 2016).

Table 2.
Normality Test (Shapiro-Wilk)

Variable	Statistic	Sig.
Stretching	0.962	0.421
Running Ability	0.974	0.682

Since $p > 0.05$ for both variables, the data were normally distributed. Therefore, Pearson's Product-Moment Correlation analysis was appropriate (Field, 2018).

Correlation Analysis

Correlation analysis was conducted using SPSS to determine the relationship between stretching and running ability.

Table 3.
Pearson Correlation Results

Variables	Stretching	Running Ability
Stretching	1	0.783**
Running Ability	0.783**	1
Sig. (2-tailed)		< 0.001
N	26	26

Note: $p < 0.01$

The correlation coefficient obtained was $r = 0.783$ with $p = 0.001$ (< 0.05). This indicates a strong and statistically significant relationship between stretching and students' running ability. According to Schober et al. (2018), correlation values between 0.70–0.89 are categorized as strong.

To further interpret the magnitude of association, the coefficient of determination (r^2) was calculated:

$$r^2 = (0.783)^2 = 0.613$$

This means that approximately 61.3% of the variance in running ability is associated with stretching practices, while the remaining 38.7% may be influenced by other factors such as muscle strength, neuromuscular coordination, training background, and anthropometric characteristics (Chaabene et al., 2019; Barnes et al., 2018).

Hypothesis Testing

Table 4.
Hypothesis Testing Summary

Variable	r-value	p-value	Decision
Stretching – Running Ability	0.783	0.001	H_0 Rejected

Since $p < 0.05$, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. Thus, there is a significant relationship between stretching and students' running ability in football games at SMA N 1 Jambi City.

Data Visualization

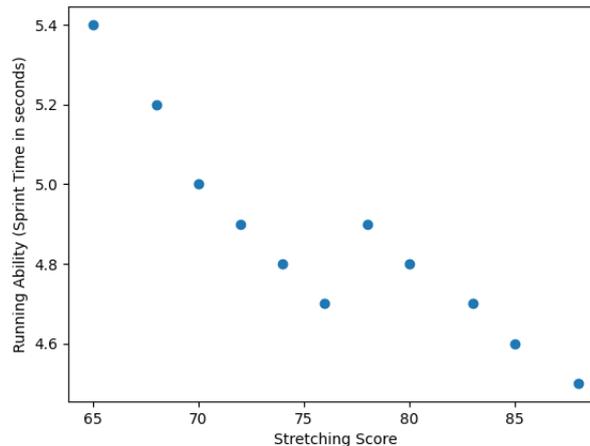


Figure 1.

Scatterplot of Stretching and Running Ability

Empirical Interpretation

These findings align with contemporary sports science literature indicating that proper stretching—particularly when integrated into structured warm-up routines—enhances neuromuscular readiness, muscle-tendon elasticity, and stride efficiency (Behm et al., 2016; Konrad et al., 2021). Dynamic mobility exercises improve motor unit recruitment and acceleration capacity (Chaabene et al., 2019; Opplert & Babault, 2018), which are critical in football sprint performance (Haugen et al., 2019). The strong correlation ($r = 0.783$) suggests that stretching quality significantly contributes to running performance among high school students. This supports previous findings that flexibility and neuromuscular activation influence sprint acceleration and running economy (Blazevich et al., 2018; Hammami et al., 2018). Moreover, proper warm-up implementation in youth sports has been shown to improve short-distance sprint outcomes (Moran et al., 2018; Ramirez-Campillo et al., 2020). Therefore, the present study provides empirical support that structured stretching practices in Physical Education football sessions are positively associated with students' sprint performance.

Discussion

The findings of this study demonstrate a strong and statistically significant relationship between stretching and students' running ability in football games at SMA N 1 Jambi City ($r = 0.783$; $p < 0.001$). The magnitude of the correlation indicates that stretching practices are substantially associated with sprint performance among high school students. The coefficient of determination ($r^2 = 0.613$) further suggests that approximately 61.3% of the variance in running ability can be explained by stretching-related factors, while the remaining variance may be influenced by strength, coordination, anthropometric characteristics, and training exposure (Chaabene et al., 2019; Barnes et al., 2018).

These results are consistent with contemporary sports science evidence indicating that structured stretching contributes to improved neuromuscular readiness and sprint performance. Dynamic stretching, in particular, has been shown to enhance muscle

temperature, motor unit recruitment, and neural drive, thereby improving acceleration and short-distance sprint capacity (Behm et al., 2016; Opplert & Babault, 2018). Increased muscle temperature reduces musculotendinous stiffness and enhances cross-bridge cycling efficiency, which directly influences stride frequency and stride length two critical determinants of sprint speed (Haugen et al., 2019; Blazevich et al., 2018).

In the context of youth football, sprinting is not merely a linear movement but a repeated high-intensity action embedded within complex game dynamics. Acceleration over short distances (10–30 meters) is particularly decisive during pressing, counterattacking, and defensive recovery (Slimani & Nikolaidis, 2019). The 30-meter sprint test used in this study reflects these game-specific demands. Therefore, the significant correlation found supports the idea that appropriate pre-activity stretching enhances biomechanical efficiency during football-specific running tasks.

From a neuromuscular perspective, stretching—especially dynamic modalities—facilitates post-activation potentiation (PAP) effects that temporarily enhance muscle force production (Moran et al., 2018). PAP mechanisms increase the sensitivity of actin-myosin interactions and improve motor neuron excitability, contributing to enhanced explosive performance. In adolescent populations, whose neuromuscular systems are still developing, proper warm-up and stretching may optimize motor learning and movement coordination (Lloyd et al., 2016; Faigenbaum et al., 2018). This aligns with the current findings, where students demonstrating better stretching practices also exhibited superior sprint times.

However, the literature also emphasizes that the effectiveness of stretching depends on type, duration, and integration within the warm-up structure. Prolonged static stretching (>60 seconds per muscle group) has been shown to acutely reduce maximal strength and sprint performance due to decreased musculotendinous stiffness and altered neural activation (Kay & Blazevich, 2018; Behm et al., 2016). Conversely, short-duration static stretching combined with dynamic movements may not negatively impact sprint performance and may contribute to flexibility balance (Konrad et al., 2021).

The present study did not isolate stretching type experimentally; instead, it examined stretching as practiced in the natural PE environment. Nevertheless, observational findings indicated that students who performed stretching more consistently and correctly demonstrated better running performance. This supports previous evidence that quality and execution accuracy influence the physiological outcomes of warm-up routines (Hammami et al., 2018; Ramirez-Campillo et al., 2020).

The strong correlation found in this study also underscores the importance of flexibility in optimizing stride mechanics. Flexibility contributes to adequate hip extension and knee drive during sprinting, enabling longer stride length without compromising frequency (Andrade et al., 2020). Balanced flexibility allows optimal storage and release of elastic energy in the muscle-tendon unit, enhancing running economy and acceleration efficiency (Blazevich et al., 2018). Thus, stretching may indirectly influence sprint speed by improving biomechanical efficiency.

Furthermore, structured warm-up protocols, such as the FIFA 11+ program, have demonstrated both injury reduction and performance enhancement in youth football

(Silvers-Granelli et al., 2017; Bizzini & Dvorak, 2015). These programs integrate dynamic mobility, balance, and neuromuscular activation components. The present findings align with this body of evidence, suggesting that well-designed stretching routines in school settings can contribute not only to safety but also to performance outcomes.

From an educational perspective, the implications are significant. Physical Education classes often prioritize skill acquisition and gameplay while underestimating the scientific structuring of warm-up routines. The results of this study provide empirical support for strengthening evidence-based warm-up design within school curricula. Teachers should emphasize dynamic stretching movements that simulate football-specific motor patterns, such as high knees, leg swings, and multidirectional lunges, rather than relying solely on prolonged static holds.

It is also important to recognize that stretching alone does not determine sprint performance. Running ability is multifactorial, influenced by muscle strength, power, coordination, and training frequency (Chaabene et al., 2019; Haugen et al., 2019). The remaining 38.7% unexplained variance in this study likely reflects these additional contributors. Therefore, stretching should be viewed as a complementary component within a comprehensive physical preparation framework.

Another noteworthy aspect is the developmental stage of the participants. Adolescence represents a critical period for neuromuscular adaptation and motor skill refinement (Granacher et al., 2016). Proper warm-up and stretching practices during this phase may enhance long-term athletic development and movement literacy. This reinforces the role of PE teachers as facilitators of scientifically grounded physical preparation.

Despite the strong relationship observed, the correlational design does not establish causality. Future experimental studies could compare different stretching modalities (static vs dynamic) to determine their direct effects on sprint performance in school-based football settings. Additionally, longitudinal designs would help assess whether consistent stretching practices lead to sustained improvements in running ability.

In conclusion, the present findings provide robust empirical evidence that stretching is positively and significantly associated with students' running ability in football games at SMA N 1 Jambi City. The strong correlation supports contemporary sports science literature emphasizing the role of dynamic flexibility and neuromuscular activation in sprint performance. These results highlight the necessity of structured, evidence-based warm-up routines in Physical Education to optimize students' football performance while maintaining safety and injury prevention principles.

CONCLUSION

Based on the results of statistical analysis, this study confirms that stretching has a strong and statistically significant relationship with students' running ability in football games at SMA N 1 Jambi City ($r = 0.783$; $p = 0.001 < 0.05$). The magnitude of this correlation indicates a high degree of association, with the coefficient of determination ($r^2 = 0.613$) showing that approximately 61.3% of the variance in running ability is associated with stretching practices. This finding supports contemporary sports science evidence emphasizing the importance of

proper warm-up and flexibility preparation in enhancing sprint performance, neuromuscular readiness, and movement efficiency in youth sports contexts.

Conceptually, stretching contributes to improved muscle elasticity, joint range of motion, and neuromuscular activation, which are critical determinants of sprint acceleration and stride mechanics in football performance. Empirically, the results demonstrate that students who perform stretching more consistently and correctly tend to exhibit better sprint times during football activities.

Although running ability is influenced by multiple factors such as strength, coordination, and physical conditioning, the findings highlight stretching as a meaningful and influential component within school-based physical education settings. Therefore, structured and scientifically grounded stretching routines should be emphasized to optimize students' performance and physical readiness in football games.

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