USFD Journal
of Physical Education Pedagogy and Sports Performance

Original Research Article

The Influence of Warm-Up Routine and Perceived Stress on the Lateral Hip Joint Flexibility of Senior High School Students

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Received: December 11, 2025
Accepted: December 12, 2025
Published: January 19, 2026

Cite this article:

Simbre, C. L. S. (2026). The influence of warm-up routine and perceived stress on the lateral hip joint flexibility of senior high school students. *USFD Journal of Physical Education Pedagogy and Sports Performance, 2*(1), 1-10. https://doi.org/10.64339/USFD-p4m7sv48

Abstract: Flexibility is an essential component that enhances performance and prevents injury, particularly in movements involving the hips. This study examined the influence of the frequency and consistency of warm-up duration and perceived stress on lateral hip joint flexibility among senior high school students. A descriptive-correlational research design was employed to gather data from 333 Grade 11 students at a private learning institution in Cagayan de Oro City during the first semester of SY 2025–2026. The Self-Reported Warm-Up Routine Profiling Questionnaire, Perceived Stress Scale (PSS-10), and Isosceles Triangle Test were used to measure warm-up behaviors, perceived stress, and lateral hip joint flexibility. Descriptive statistics and multiple linear regression were used to analyze the data. Results showed that participants performed warm-ups at a moderate frequency, were consistent in warm-up duration, and reported a moderate level of perceived stress. Flexibility outcomes were generally outstanding for both male and female students. Regression analysis revealed that consistency of warm-up duration was the only significant predictor of lateral hip joint flexibility, indicating that regularly performing warm-ups with adequate, stable duration contributes more meaningfully to joint mobility than session frequency or stress levels. These findings underscore the importance of structured, time-anchored warm-up routines in promoting flexibility, especially in online learning environments where students perform physical tasks independently. Physical Education teachers may incorporate explicit guidelines for warm-up duration to enhance students' preparation and safety. Future researchers are encouraged to explore additional behavioral, physiological, or environmental factors that may interact with warm-up duration and stress in shaping flexibility outcomes.

Keywords: Warm-Up Routine, Frequency, Consistency of Duration, Perceived Stress, Lateral Hip Joint Flexibility, Senior High School Students, Online Physical Education

Introduction

Flexibility, especially in the lateral plane of the hips, is important in functional movement, daily mobility, and physical performance (Bennett *et al.*, 2022). Adequate lateral hip flexibility helps maintain balance, stability, and efficient movement patterns required for various physical activities (Horii *et al.*, 2024). However, recent evidence suggests a decline in flexibility among adolescents and young adults, with more young adults failing to meet recommended levels (Lima *et al.*, 2022; Huang *et al.*, 2023), with approximately 41% of youth failing to meet recommended flexibility levels (Ludwig-Walz *et al.*, 2025). This decline has raised concerns about students' physical readiness and movement capacity, particularly in educational settings where opportunities for structured physical activity may be limited (Lee *et al.*, 2022).

Flexibility is determined by several factors, including behavioral practices related to physical preparation and the psychological conditions experienced by learners (Silva *et al.*, 2020). Warm-up routines, particularly those involving frequency and duration, are widely recognized preparation practices associated with movement readiness and joint mobility (Behm *et al.*, 2021). At the same time, psychological factors such as perceived stress have been associated with more movement-based physical functioning and outcomes, which raises the possibility that mental/emotional demands are concurrent with physical performance outcomes (Özcan & Bedir, 2023). These concerns have been further accentuated by increased sedentary behavior and psychological stress associated with online and modular learning environments (Wang

& Zhang, 2023), necessitating investigation of both behavioral and psychological correlates of student flexibility (Farooq *et al*., 2025).

Internationally, issues related to warm-up routines and flexibility-oriented practices have attracted sustained attention in physical education and sports programs (Behm *et al*., 2021). In the United States, dynamic warm-up strategies are widely recommended to improve mobility and reduce the risk of injury (Faigenbaum *et al*., 2022). European physical education curricula also have flexibility-focused activities as part of the adolescent health promotion and injury prevention initiatives (Abade *et al*., 2023). Research in South Korea has documented associations between stress levels and lower-body movement efficiency among students (Jeoung *et al*., 2020). These studies together highlight the importance of warm-up behavior and psychological states within the context of flexibility (Silva et al., 2020).

In the Philippine context, however, empirical literature specifically addressing lateral hip joint flexibility remains very limited (Catiil & Gomez, 2024). Available studies have reported high levels of stress among Filipino senior high school students, which may be related to the physical demands of performance (Serrano *et al*., 2023). Other local research has shown that warm-up routines in physical education classes are not consistently implemented due to time constraints or insufficient instructional focus (Almario *et al*., 2024). Furthermore, a decline in physical activity participation during remote learning has been linked to reduced flexibility and overall physical activity among students (Cruz *et al*., 2022; Lim *et al*., 2022). Despite these observations, few studies have evaluated the influence of warm-up behaviors on perceived stress and flexibility outcomes (Farooq *et al*., 2025).

These conditions emphasize the need to investigate the influence of warm-up frequency, consistency of warm-up duration, and perceived stress on lateral hip joint flexibility among students in self-directed learning environments (Behm *et al*., 2021). In many remote or modular physical education settings, students complete activity sheets and performance tasks independently, resulting in limited real-time supervision (Mercier *et al.* 2021). Such learning arrangements might be accompanied by variability in the warm-up practices and time allocation for physical preparation (Abade *et al*., 2023). When combined with these academic demands and reduced access to social interaction, this raises important questions about their relationship to students' capacity for movement and physical readiness (Wang & Zhang, 2023).

Although research on distance learning and student well-being has grown in recent years, most studies have focused primarily on learner satisfaction (Turan *et al*., 2022) and mental health outcomes in virtual environments (Wang, 2023). Physical outcomes remain underexplored, particularly those related to flexibility (Silva *et al*., 2020). Moreover, to the best of the researchers' knowledge, no study has examined the association between warm-up routine characteristics and perceived stress and lateral hip joint flexibility in the Philippines, particularly in online or modular physical education settings (Catiil & Gomez, 2024). This gap suggests the need for empirical investigation that incorporates both behavioral and psychological aspects of student physical functioning (Farooq *et al*., 2025).

In response to these gaps, the purpose of this study was to examine the associations of warm-up frequency, consistency of warm-up duration, and perceived stress with lateral hip joint flexibility among Grade 11 senior high school students at a private learning institution in Cagayan de Oro City. The study was anchored in Dynamic Systems Theory (Thelen, 1989) and Psychophysiological Stress Theory (Selye, 1976) to provide a theoretically grounded explanation of how physical and psychological factors are related to flexibility outcomes in self-directed learning environments. This research aligns with global and national priorities, including Sustainable Development Goals 3 (Good Health and Well-being) and 4 (Quality Education), as well as Department of Education initiatives that promote physical fitness and psychosocial well-being. The study aims to generate evidence that can inform more responsive and health-oriented physical education practices in changing educational contexts.

Dynamic Systems Theory (DST) conceptualizes flexibility as an emergent motor outcome resulting from the interaction of multiple constraints—namely, the individual, the task, and the environment—rather than as a fixed physical attribute (Thelen, 1989). In this quantitative study, DST provides the theoretical basis for examining warm-up behaviors as predictor variables. Warm-up frequency denotes repeated exposure to preparatory movement tasks, whereas consistency of warm-up duration reflects the stability of a critical temporal constraint that supports neuromuscular and connective tissue adaptation. According to DST, consistent and sufficiently sustained task conditions facilitate the self-organization of movement patterns over time. The study operationalizes DST through measurable behavioral indicators and tests whether stable preparatory conditions are associated with higher flexibility outcomes (Behm *et al*., 2021; Silva *et al*., 2020).

Conflict of Interest: *The author declares that there is no conflict of interest regarding the publication of this article.*

Acknowledgements: *The researcher extends his sincere gratitude to Almighty God for His wisdom and grace, to his thesis mentor, professors, and panellists for their invaluable guidance and support, and to his family and loved ones for their unwavering love and encouragement, to whom all glory is humbly offered.*

Funding: *This research received no external funding and was supported solely by the personal resources of the primary author.*

Ethical Approval: *The study was reviewed and approved by the Ethics Committee of Lourdes College, Inc., the researcher's academic institution, in accordance with the ethical standards outlined in the Belmont Report. Informed assent was obtained from student participants, alongside written parental consent, ensuring full ethical compliance.*

AI Declaration: *This study utilized artificial intelligence tools to assist in preparing this article. Specifically, ChatGPT was used to convert the full thesis manuscript into a reduced journal article format, with human supervision and editing, to ensure academic rigor and integrity. Additionally, ChatGPT and Grammarly AI were used to enhance the language quality, clarity, and tone of the final manuscript. The author carefully reviewed and edited all outputs to maintain scholarly standards.*

Data Availability Statement: *The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Requests for access will be evaluated in accordance with ethical guidelines and data privacy policies.*

Psychophysiological Stress Theory (PST) explains how psychological stress influences physical functioning through physiological responses, including increased muscle tension and stress-hormone activity (Selye, 1976). In this study, perceived stress is treated as an individual-level psychological variable that may be associated with variability in physical outcomes such as joint flexibility. PST suggests that when stress levels remain moderate, individuals may continue to function within the resistance phase of adaptation, whereas prolonged or excessive stress may contribute to physiological strain that restricts movement efficiency. Within a predictive correlational framework, the present study does not assume causality; instead, it examines whether differences in perceived stress are statistically associated with differences in lateral hip joint flexibility. This theoretical lens is particularly relevant in self-directed learning environments, where academic demands and reduced supervision may influence students' stress experiences and, consequently, their physical readiness (Knauft *et al.*, 2021; Özcan & Bedir, 2023).

DST and PST jointly justify the inclusion of both behavioral and psychological predictors in the quantitative model. DST explains how consistency in physical preparation may support the development of flexibility, whereas PST explains how psychological states may enable or constrain physical functioning. The study conceptualizes lateral hip joint flexibility as an outcome shaped by the dynamic interaction between warm-up behaviors and psychophysiological conditions, and empirically examines this interaction using correlational and regression analyses.

Moreover, the study examined the influence of the warm-up routine, specifically its frequency and consistency of duration, and perceived stress levels on lateral hip joint flexibility among senior high school students. Specifically, it answered the following questions:

1. What is the level of warm-up routine of the participants in terms of:
    1.1 Frequency;
    1.2 Consistency of Duration?
2. What is the level of perceived stress of the participants?
3. What is the level of lateral hip joint flexibility of the participants?
4. Do the participants' warm-up routine frequency and consistency of duration and their perceived stress levels significantly influence their lateral hip joint flexibility?

Methods and Materials

The study was done in a private learning institution in Cagayan de Oro City. For confidentiality, the institution's name is not disclosed. A descriptive-correlational research design was used to investigate the influence of warm-up frequency, consistency of warm-up duration, and perceived stress levels on lateral hip joint flexibility among Grade 11 senior high school students. This design was appropriate because it permitted examination of relationships among variables without manipulating conditions or inferring causality.

A total of 333 Grade 11 students were selected using simple random sampling to ensure that each member of the population had an equal probability of selection. This sampling technique has been used to minimise selection bias and enhance representativeness. Demographic information, such as age and sex, was obtained to characterize the respondents.

Data collection was conducted face-to-face after the research protocol was approved by the relevant authorities. Informed parental consent and student assent were obtained before participation. The questionnaires were administered during scheduled class periods to encourage the completeness and accuracy of responses. Lateral hip joint flexibility measurements were performed individually in a designated testing area on campus, following standardized procedures, and scores were recorded immediately to ensure measurement accuracy.

Three instruments were used to collect data. The Self-Reported Warm-Up Routine Profiling Questionnaire, developed and validated, assessed the consistency of warm-up frequency and duration using a five-point response scale. Warm-up frequency was interpreted as 5 = Always, 4 = Often, 3 = Sometimes, 2 = Rarely, and 1 = Never, and consistency of warm-up duration was interpreted as 5 = Very Consistent, 4 = Consistent, 3 = Moderately Consistent, 2 = Less Consistent, and 1 = Not Consistent. Perceived stress was assessed with the Perceived Stress Scale (PSS-10) developed by Cohen *et al.* (1983) and which consists of 10 items rated on a 5-point Likert scale that is interpreted as 5 = Very Often, 4 = Fairly Often, 3 = Sometimes, 2 = Almost Never, and 1 = Never. Internal consistency reliability for the questionnaire-based instruments was assessed using Cronbach's alpha, which demonstrated excellent reliability for the warm-up routine components—frequency ($\alpha = 0.924$) and consistency of warm-up duration ($\alpha = 0.947$)—and good reliability for the perceived stress scale ($\alpha = 0.861$), indicating strong internal consistency across all measured constructs. Lateral hip joint flexibility was evaluated using the Isosceles Triangle Test (Catiil & Gomez, 2024), a field-based measure of hip abduction range of motion, according to standard procedures; higher scores indicate greater lateral hip joint flexibility.

Descriptive statistics, such as weighted means and standard deviations, were used to assess the frequency of warm-ups, consistency of warm-up duration, perceived stress, and lateral hip joint flexibility. Multiple linear regression analysis was used to examine the statistical associations among warm-up frequency, consistency of warm-up duration, perceived stress,

and lateral hip joint flexibility. Before inferential analysis, normality assumptions were tested by using the Kolmogorov-Smirnov test and Q-Q plots. All statistical analyses were conducted using IBM SPSS Statistics (version 27).

The study was limited to Grade 11 students at a single private institution and addressed only warm-up behaviors, perceived stress, and lateral hip joint flexibility. Other variables that may be associated with flexibility, such as sleep quality, nutritional status, physical activity level, and athletic training history, were not included and warrant investigation in future studies.

Results

Table 1 presents the frequency of warm-up routines among participants. The results show that nearly half of respondents (48.95%) reported sometimes performing warm-up activities, whereas 27.93% reported doing so most of the time. Only a small proportion reported always warming up (5.11%), whereas 17.72% reported rarely doing warm-up exercises, and less than 1% indicated never engaging in warm-ups.

Table 1

Frequency, Percentage, and Mean Distribution of the Level of Warm-up Routine in Terms of Frequency

Score Range	Description	Interpretation	Frequency	Percentage
4.51 – 5.00	Always	Very high	17	5.11
3.51 – 4.50	Most of the Time	High	93	27.93
2.51 – 3.50	Sometimes	Moderate	163	48.95
1.51 – 2.50	Rarely	Low	59	17.72
1.00 – 1.50	Never	Very low	1	0.30
	Total		333	100

No.	Indicators	Mean	SD	Description
1.	I warm up before every physical activity I do.	3.79	1.05	Most of the Time
2.	I perform warm-up exercises multiple times a week.	3.09	0.98	Sometimes
3.	I follow a weekly schedule that includes consistent warm-up sessions.	2.77	0.99	Sometimes
4.	I make time in my schedule to regularly warm up.	2.95	1.10	Sometimes
5.	I have developed a habit of warming up as part of my fitness routine.	3.27	1.18	Sometimes
6.	I perform warm-ups regardless of the length or intensity of the activity.	3.33	1.05	Sometimes
7.	I consistently include warm-ups in both individual and group workouts.	3.57	1.06	Most of the Time
8.	I treat warm-ups as essential to every phase of my weekly physical routine.	3.38	1.10	Sometimes
9.	I regularly perform warm-ups even during light or recovery days.	3.01	1.05	Sometimes
10.	I consistently engage in warm-up activities as part of my overall exercise habit.	3.43	1.09	Sometimes
	Mean	3.26		
	Interpretation	Moderate		
	SD	0.74		

The overall mean score of 3.26 (SD = 0.74) corresponds to a moderate level of warm-up frequency. This suggests that while participants generally recognized the importance of warming up, their engagement was not consistently embedded across all physical activity sessions. The moderate standard deviation indicates some variability in behavior; however, responses remained relatively clustered around the mean, implying a generally similar pattern of intermittent warm-up practice across participants.

Item-level analysis further supports this finding. Participants most frequently reported warming up before every physical activity (M = 3.79, SD = 1.05) and including warm-ups in group and individual workouts (M = 3.57, SD = 1.06). In contrast, lower mean scores were observed for items related to structured scheduling and habitual integration of warm-ups, indicating that warm-up practices were more situational than routine-based.

Table 2 presents the level of the warm-up routine with respect to the consistency of duration. The largest proportion of participants (43.24%) reported being consistent in their warm-up duration, followed by 38.14% who were moderately consistent. Only 6.61% reported very consistent warm-up duration, whereas 12.01% reported being less consistent or inconsistent.

Table 2

Frequency, Percentage, and Mean Distribution of the Level of Consistency of Warm-up Routine in Terms of Duration

Score Range	Description	Interpretation	Frequency	Percentage
4.51 – 5.00	Always	Very Consistent	22	6.61
3.51 – 4.50	Most of the Time	Consistent	144	43.24
2.51 – 3.50	Sometimes	Moderately Consistent	127	38.14
1.51 – 2.50	Rarely	Less Consistent	38	11.41
1.00 – 1.50	Never	Not Consistent	2	0.60
	Total		333	100

No.	Indicators	Mean	SD	Description
1	I consistently spend at least 10-15 minutes on my warm-up.	3.41	1.11	Sometimes
2	I allot enough time to complete each part of my warm-up properly.	3.32	1.01	Sometimes
3	I am confident that my warm-up time is adequate to prepare me physically.	3.36	1.05	Sometimes
4	I manage my schedule to consistently allow enough time for a complete warm-up.	3.26	1.11	Sometimes
5	My warm-up duration follows the recommended time based on my physical activity needs.	3.37	1.03	Sometimes
6	I increase the time spent on warm-ups when preparing for intense physical activities.	3.42	1.02	Sometimes
7	I regularly dedicate sufficient time for warm-ups before starting any workout.	3.50	1.07	Sometimes
8	I modify the duration of my warm-up depending on my physical condition that day.	3.54	1.05	Most of the Time
9	I ensure that my warm-up time allows for full-body preparation.	3.80	1.06	Most of the Time
10	I structure my warm-up to fit within my planned workout time without rushing.	3.62	1.07	Most of the Time
	Overall Mean	3.46		
	Interpretation	Moderately Consistent		
	SD	0.75		

The overall mean score of 3.46 (SD = 0.75) indicates a moderately consistent warm-up duration. This suggests that participants generally allocated time for warm-ups, although the duration was not consistently maintained across activity sessions. The observed variability reflects differences in how participants adjusted warm-up duration in response to context, intensity, or scheduling constraints.

At the indicator level, higher mean scores were observed for items related to full-body preparation (M = 3.80, SD = 1.06) and structuring warm-ups without rushing (M = 3.62, SD = 1.07). Conversely, items related to scheduling management and adherence to recommended warm-up durations yielded comparatively lower mean scores, reinforcing the finding that consistency was present but not optimal.

Moreover, *Table 3* presents participants' perceived stress levels based on selected items from the Perceived Stress Scale (PSS-10). Most respondents (71.17%) reported experiencing stress sometimes, whereas 22.82% reported experiencing it fairly often. Only 5.71% reported low stress, and none reported very low stress.

Table 3

Frequency, Percentage, and Mean Distribution of the Level of Perceived Stress of the Participants

Score Range	Description	Interpretation	Frequency	Percentage
4.51 – 5.00	Very Often	Very high Stress	1	0.30
3.51 – 4.50	Fairly Often	High Stress	76	22.82
2.51 – 3.50	Sometimes	Moderate Stress	237	71.17
1.51 – 2.50	Almost Never	Low Stress	19	5.71
1.00 – 1.50	Never	Very low Stress	0	0.00
	Total		**333**	**100**

No.	Indicators In the last month, how often have you…	Mean	SD	Description
1	Been upset because of something that happened unexpectedly?	3.62	1.09	Fairly Often
2	Felt that you were unable to control the important things in your life?	3.54	1.02	Fairly Often
3	Felt nervous and stressed?	3.78	1.12	Fairly Often
4	Felt confident about your ability to handle your personal problems?*	2.48	1.09	Almost Never
5	Felt that things were going your way?*	2.79	1.02	Sometimes
6	Found that you could not cope with all the things that you had to do?	3.32	1.06	Sometimes
7	Been able to control irritations in your life?*	2.80	1.13	Sometimes
8	Felt that you were on top of things?*	3.13	1.13	Sometimes
9	Angered because of things that happened that were outside of your control?	3.49	1.17	Sometimes
10	Felt difficulties were piling up so high that you could not overcome them?	3.50	1.17	Sometimes
	Mean	3.25		
	Interpretation	Moderate Stress		
	SD	0.46		

Note. Items marked with an asterisk (*) are negatively stated and were reversely scored following the PSS-10 scoring guidelines.

The overall mean score of 3.25 (SD = 0.46) indicates a moderate level of perceived stress among participants. The relatively low standard deviation suggests minimal dispersion, indicating that perceived stress levels were fairly homogeneous across the sample.

Item-level results revealed that participants frequently experienced nervousness and stress (M = 3.78, SD = 1.12) and were upset by unexpected events (M = 3.62, SD = 1.09). Reverse-scored items showed lower means, suggesting limited confidence in managing stressors, which further supports the classification of moderate stress.

Table 4 presents the level of lateral hip joint flexibility of the participants by sex. Results indicate that both male and female participants were classified under an outstanding level of flexibility. Male participants obtained a higher mean score (M = 134.24, SD = 26.23) compared to females (M = 124.67, SD = 24.08), although both fell within the same interpretive category.

Table 4

Frequency, Percentage, and Mean Distribution of the Level of Lateral Hip Joint Flexibility of the Participants

Score Range	Interpretation	Male		Score Range	Female	
		f	%		f	%
123 – 180	Outstanding	90	67.16	123 – 180	94	47.24
111 – 122	Very Good	14	10.45	109 – 122	48	24.12
101 – 110	Good	17	12.69	99 – 108	29	14.57
92 – 100	Fair	7	5.22	87 – 98	23	11.56
55 – 91	Poor	6	4.48	47 – 86	5	2.51
Total		134	100		199	100
Mean		134.24			124.67	
Interpretation		Outstanding			Outstanding	
SD		26.23			24.08	

The distribution across categories shows that a majority of males (67.16%) and nearly half of females (47.24%) were classified as outstanding. The standard deviations indicate moderate variability within each group, suggesting that high flexibility was not limited to a small subset but was evident across most participants.

Although raw scores did not fully satisfy normality assumptions, the large sample size (n = 333) justified the application of parametric analyses under the central limit theorem.

Table 5 presents the regression analysis examining the influence of warm-up routine and perceived stress on lateral hip joint flexibility among male participants. The overall model was statistically significant, $F(3, 130) = 7.54$, $p < .001$, explaining 14.8% of the variance in hip joint flexibility ($R^2 = 0.148$). Thus, H_{01} was rejected.

Table 5

Regression Analysis of Warm-up Routine and Perceived Stress on Hip Joint Flexibility Among Male Participants

Predictor	Unstandardized Coefficients		β	95% CI		t	p
	B	SE		Lower	Upper		
Constant	125.60	20.73		84.60	166.61	6.06*	<.001
Frequency	-1.85	4.67	-0.054	-11.09	7.40	-0.396	0.693
Consistency of Duration	13.63	4.69	0.393	4.36	22.91	2.908*	0.004
Perceived Stress	-10.85	5.53	-0.164	-21.79	0.08	-1.964	0.052

Model Summary

R = 0.385	R2 = 0.148	Adjusted R2 = 0.129	F(3,130) = 7.54*	p<.001

*Note. B = unstandardized beta coefficient, SE = standard error, β = standardized beta coefficient, 95% CI = 95% confidence interval, t = t statistic, p = probability value. *Significant at 0.05 two-tailed alpha level.*

Model Equation: H = 13.63D + 125.60

Legend: H = Hip Joint Flexibility, D = Consistency of Duration

Among the predictors, consistency of warm-up duration was the only significant predictor ($\beta = 0.393$, $p = .004$), indicating that greater consistency in warm-up duration was associated with higher hip joint flexibility. Warm-up frequency ($p = .693$) and perceived stress ($p = .052$) were not significant predictors. Accordingly, H_{02} was rejected, while H_{03} could not be rejected for male participants.

Meanwhile, *Table 6* presents the regression analysis for female participants. The overall model was statistically significant, $F(3, 195) = 2.68$, $p = .048$, explaining 4.0% of the variance in hip joint flexibility ($R^2 = 0.040$). Therefore, H_{01} was rejected.

As in the male group, the consistency of warm-up duration was the only significant predictor ($\beta = 0.229$, $p = .028$). Warm-up frequency ($p = .639$) and perceived stress ($p = .556$) did not significantly predict hip joint flexibility. Thus, H_{02} was rejected, while H_{03} could not be rejected among female participants.

Across both sexes, warm-up duration was the strongest predictor of lateral hip joint flexibility, whereas warm-up frequency and perceived stress were not significant predictors. These findings underscore the importance of quality and temporal adequacy of warm-ups, rather than mere repetition or psychological stress levels, in influencing hip joint flexibility.

Table 6

Regression Analysis of Warm-up Routine and Perceived Stress on Hip Joint Flexibility Among Female Participants

Predictor	Unstandardized Coefficients		β	95% CI		t	p
	B	SE		Lower	Upper		
Constant	97.32	15.34		67.07	127.57	6.345*	<.001
Frequency	-1.67	3.55	-0.049	-8.67	5.33	-0.469	0.639
Consistency of Duration	7.51	3.39	0.229	0.82	14.20	2.215*	0.028
Perceived stress	2.13	3.61	0.042	-4.99	9.25	0.590	0.556
Model Summary							
R = 0.199	R2 = 0.040		Adjusted R2 = 0.025	F(3,195) = 2.68*		p=0.048	

*Note. B = unstandardized beta coefficient, SE = standard error, β = standardized beta coefficient, 95% CI = 95% confidence interval, t = t statistic, p = probability value. *Significant at 0.05 two-tailed alpha level.*

Model Equation: H = 7.51D + 97.32

Legend: H = Hip Joint Flexibility, D = Consistency of Duration

Discussion

This study examined the predictive influence of warm-up routine characteristics and perceived stress on lateral hip joint flexibility among senior high school students. Guided by Dynamic Systems Theory (DST) and Psychophysiological Stress Theory (PST), the findings indicate that consistency of warm-up duration—rather than warm-up frequency or perceived stress—was the most meaningful predictor of hip joint flexibility across sexes. This pattern underscores the importance of sustained preparatory exposure over repeated but irregular engagement in flexibility-related outcomes.

Findings on warm-up frequency (*Table 1*) indicated moderate engagement, with participants more likely to warm up immediately before activity than to follow a structured schedule. From a DST perspective (Thelen, 1989), flexibility is an emergent property resulting from repeated, stable interactions among the individual, task, and environment. Sporadic warm-up frequency may fail to provide the consistent task constraints necessary for neuromuscular and connective tissue adaptation. Empirical evidence supports this interpretation, as Abade *et al.* (2023) and Eken and Bayer (2022) reported that warm-up frequency alone is often inconsistent in unsupervised or non-elite settings and does not reliably translate into measurable gains in flexibility.

In contrast, warm-up duration consistency (*Table 2*) demonstrated greater behavioral regularity and was a significant predictor of hip joint flexibility in regression models for both males and females (*Tables 5* and *6*). Within DST, sustained exposure time is critical for the self-organization of movement patterns and tissue adaptation. Adequate warm-up duration allows for gradual increases in muscle temperature, viscoelastic deformation, and neuromuscular activation, all of which facilitate joint range of motion. Behm e*t al.* (2021) and Lee *et al.* (2024) emphasized that warm-up durations within the 8–15-minute range optimize flexibility responses without inducing fatigue. Similarly, Sobrinho *et al.* (2023) and Silva *et al.* (2020) demonstrated that structured, well-timed preparatory routines are associated with improved hip mobility and functional movement outcomes. Farooq *et al.* (2025) further supported this finding by linking high-flexibility profiles to sustained preparatory movement practices rather than to mere repetition.

The non-significant predictive role of warm-up frequency observed in the regression analyses suggests that repetition without temporal adequacy may be insufficient for flexibility adaptation. While frequent warm-ups may increase awareness or readiness, they may not impose sufficient physiological demand unless they are of sufficient duration. This interpretation aligns with Abade *et al.* (2023), noting that warm-up frequency often reflects behavioral intent rather than effective physiological preparation, particularly in self-directed physical activity contexts.

Moreover, perceived stress, as measured in *Table 3*, was not a significant predictor of lateral hip joint flexibility in either male or female participants. According to PST (Selye, 1976), physiological impairment due to stress occurs primarily under conditions of sustained or excessive stress that exceed adaptive capacity. In the present study, stress levels were moderate and relatively homogeneous, suggesting that participants were largely operating within the resistance phase rather than the exhaustion phase of the stress response. Knauft *et al.* (2021) similarly found that moderate stress levels were not reliably associated with decrements in physical performance or flexibility. Jeoung (2020) further noted that stress-related reductions in joint mobility are more pronounced under chronic or high-intensity stress conditions, which may not have been present in the current sample.

From a psychophysiological standpoint, moderate stress may not generate sufficient muscle tension or cortisol-mediated effects to restrict joint range of motion. Özcan and Bedir (2023) emphasized that psychological stress affects physical flexibility primarily when it overwhelms coping resources, resulting in sustained muscle guarding and reduced movement efficiency. The lack of a significant association between perceived stress and hip flexibility in this study may therefore reflect an adaptive stress profile rather than the absence of a theoretical relationship.

Descriptive findings on lateral hip joint flexibility (*Table 4*) indicated outstanding flexibility levels among both male and female participants. These results are consistent with prior studies reporting high hip mobility among individuals exposed to dynamic movement tasks and flexibility-oriented activities. Bouguezzi *et al.* (2023) and Afshari *et al.* (2023) documented elevated hip range of motion in populations with favorable flexibility profiles, while Donti *et al.* (2020) observed that targeted hip mobility training produced significant gains even among individuals with initially low flexibility. These findings suggest that the high baseline flexibility observed in the present study does not diminish the relevance of predictive analysis; rather, it highlights the role of qualitative differences in preparatory behavior.

The convergence of findings across sexes strengthens the conclusion that consistency of warm-up duration is a robust predictor of lateral hip joint flexibility, regardless of baseline flexibility levels. Within DST, this consistency represents a stable task constraint that facilitates adaptive reorganization of the motor system over time. Conversely, PST provides a framework for understanding why perceived stress did not exert a measurable influence under moderate conditions, reinforcing the idea that psychological factors interact with physical outcomes in a threshold-dependent manner.

Overall, the findings support a multifactorial but asymmetric model of flexibility development, in which physical preparation—specifically, sustained warm-up duration—plays a more prominent predictive role than perceived stress in non-clinical adolescent populations. These results suggest that interventions aimed at improving lateral hip joint flexibility should prioritize structured, time-adequate warm-up routines, while stress management strategies may be more relevant in populations experiencing higher or chronic stress levels. Lastly, the present study provides a theoretically grounded explanation for the differential predictive power of physical and psychological variables in flexibility outcomes, integrating DST and PST.

Conclusion

This study examined the associations of behavioral factors—warm-up frequency and consistency of warm-up duration—and a psychological factor—perceived stress—with lateral hip joint flexibility among senior high school students engaged in online physical education, drawing on Dynamic Systems Theory (DST) and Psychophysiological Stress Theory (PST) to interpret flexibility outcomes in an autonomous learning environment. The findings showed that the consistency of warm-up duration was the only variable significantly associated with lateral hip joint flexibility in both male and female participants, with students who reported more consistent warm-up duration tending to demonstrate higher flexibility levels. Although causality cannot be inferred, this association is theoretically coherent from a DST perspective, as temporal consistency functions as a key control parameter supporting neuromuscular coordination and adaptive movement organization. In contrast, warm-up frequency was not significantly associated with flexibility, suggesting that intermittent or moderate engagement may be insufficient to promote adaptation without consistent duration, while perceived stress also showed no significant association, indicating that the generally moderate stress levels reported by participants may not have reached a threshold sufficient to disrupt physiological functioning or joint mobility as posited by PST. Overall, participants demonstrated good-to-excellent lateral hip joint flexibility across sexes despite independent task execution in an online setting, underscoring that consistency in warm-up duration was the most salient behavioral factor associated with flexibility under conditions of self-directed online physical education.

The findings indicate that consistent time allocation during warm-up activities is significantly associated with lateral hip joint flexibility among senior high school students participating in online physical education. These results contribute to the growing body of evidence suggesting that quality and temporal stability of physical preparation, rather than frequency alone, are central to flexibility outcomes in autonomous learning contexts. For practice, physical education teachers may emphasize recommended warm-up durations in activity instructions and provide brief visual or video-based guides to support consistent warm-up execution at home. School administrators may support these efforts by integrating standardized, time-based warm-up resources into physical education programs across delivery modes. In future research, studies may examine alternative warm-up delivery formats (e.g., video-guided or app-based routines), compare warm-up durations experimentally, or explore additional behavioral and lifestyle factors that may influence flexibility. Students may be encouraged to allocate approximately 8–15 minutes to structured warm-up routines that incorporate simple dynamic mobility exercises and timing aids to support consistency.

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