Optimizing flexibility in 5-6-year-old preschool girls by integrating stretching exercises and a play-based approach using the “Stretching for kids” digital platform: an experimental study

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Abstract

Purpose: The purpose of this study is to evaluate the effectiveness of a holistic pedagogical model, which integrates stretching exercises and a play-based approach via the "Stretching for Kids" digital platform, in optimizing flexibility in 5-6-year-old preschool girls.

Methods: The study was conducted using a quasi-experimental design. A total of 72 girls aged 5-6 years from six preschool educational institutions in the Andijan and Namangan regions of Uzbekistan participated. The participants were divided into an experimental group (n=36) and a control group (n=36). The experimental group followed a weekly program, training 3 times a week with each session lasting 25-30 minutes. The program integrated static and dynamic stretching exercises, playful activities based on animal imitations, and interactive video instructions via the "Stretching for Kids" web platform. Flexibility was measured using 10 standard tests (including the wrist and thumb flexibility test, "Sit-and-Reach," bridge position, and forward, right, and left splits tests), anthropometric indicators, and a comprehensive assessment system based on scores and percentage indicators. The data were analyzed using descriptive statistics, t-tests, and percentage change calculations ($p < 0.05$).

Results: Overall flexibility indicators in the experimental group improved significantly: an increase of 48.4% was observed in 5-year-olds and 52.2% in 6-year-olds ($p < 0.001$). The most substantial improvements were recorded in the splits tests (87.0-91.8%) and the "Sit-and-Reach" test (56.16%). In the control group, the increase was minimal (5-year-olds: 6.8%; 6-year-olds: 1.17%). The differences between the groups were found to be statistically significant.

Conclusion: Combining stretching with a game-based approach, supported by digital tools, has proven highly effective in developing flexibility in preschool-aged girls. This method is safe, motivating, and age-appropriate. The “Stretching for Kids” platform enhanced visualization, individual monitoring, and the opportunity for at-home practice. The results obtained support the implementation of the developed model into physical education classes at preschool institutions.

Keywords: flexibility, stretching exercises, game-based pedagogical approach, preschool-aged girls, digital educational platform, motor skills.

Introduction

Flexibility is recognized as one of the primary components of physical fitness and plays a crucial role in the harmonious motor development of children, especially during the preschool years when the musculoskeletal system possesses high plasticity (Malina et al., 2004; Lloyd and Oliver, 2012). In 5-6 year-old children, an adequate level of flexibility contributes to the formation of correct posture, improves motor coordination, reduces the risk of injury, and creates the necessary functional foundation for future physical activity and sports (Faigenbaum, 2009; Behm and Chaouachi, 2011).

Recent scientific literature indicates that the preschool age (5-6 years) is a sensitive "window of opportunity" for developing flexibility. This period is characterized by the high elasticity of muscles, tendons, and ligaments, as well as the ongoing formation of the neuromuscular system (Donti et al., 2022; Ohtaka et al., 2024). However, physical education classes in preschool institutions often lack systematic, age -appropriate, and engaging methods, resulting in the insufficient development of flexibility. This situation requires a special approach that considers gender-specific characteristics, particularly for girls, who naturally tend to have higher baseline flexibility (Nuzzo, 2024; Wee et al., 2014).

Stretching exercises have been widely studied as an effective means of increasing range of motion (ROM). Static and dynamic stretching protocols have been proven to have a positive effect on flexibility in children, but their acute and chronic effects differ (Behm et al., 2011; Chaouachi et al., 2010; Samson et al., 2012). When applied appropriately, static stretching is particularly effective at increasing passive range of motion and muscle extensibility (Kay and Blazevich, 2012; Magnusson et al., 1996). Dynamic stretching, on the other hand, helps to maintain or improve functional performance and is recommended during the warm-up phase (Turki et al., 2011; Opplert and Babault, 2018).

Nevertheless, purely mechanical stretching approaches are insufficient for maintaining children's motivation long-term, especially at the preschool age when play is considered the leading form of activity (Vygotsky, 1978; Elkonin, 1978). Game-based approaches integrate stretching exercises with animal impersonations, role-playing, and competitive elements, which significantly increases children's emotional engagement, participation, and the pedagogical effectiveness of the activities (Pellegrini, 2009; Côté and Hancock, 2016; Zosh et al., 2022). Such integration transforms stretching from a simple exercise into a fun and meaningful activity that aligns with the psychological characteristics of children.

The emergence of digital technologies is opening up new opportunities for enhancing physical education. Interactive platforms, video tutorials, animations, and real-time monitoring serve to improve visualization, individualization, and the partnership between kindergarten and home (Casey and Goodyear, 2017; Baert et al., 2020; Swindle et al., 2022). At an early age, digital tools, when combined with play-based learning, can support the development of motor skills without replacing physical activity (Plowman and Stephen, 2014; Johnston, 2021).

Although numerous studies have been dedicated to stretching and play-based activities, there is no experimentally validated, holistic model that integrates static/dynamic stretching, a play-based approach, and digital support, especially for girls aged 5-6. Most research focuses on school-aged children or athletes and does not pay sufficient attention to gender-specific characteristics and digital integration at the preschool level (Dvorkina et al., 2025; Merino-Marban et al., 2025).

In Uzbekistan, state policy is focused on modernizing preschool education, ensuring physical development, and implementing innovative technologies (Presidential Decrees PD-5198, PD-4312, PD-152). However, the practical implementation of scientifically-based flexibility development programs remains insufficient, particularly those considering the anatomical, physiological, and psychological characteristics of girls.

To address this gap, the present study has developed and experimentally tested a holistic pedagogical model that combines stretching exercises with a game-based approach, supported by a dedicated digital platform, "Stretching for Kids." The model is designed to optimize flexibility, enhance motivation, and ensure the safety of 5-6-year-old girls, taking into account their age, gender, and individual characteristics.

The objectives of the research are as follows:

To develop an integrative model for flexibility development;

To evaluate its effectiveness through a pedagogical experiment involving 72 girls;

To scientifically substantiate the didactic and motivational significance of the digital platform.

This study contributes to the field of sports science and physical education by providing evidence-based recommendations for preschool institutions, enriching the theoretical foundations of flexibility development in early childhood, and demonstrating practical ways to integrate modern digital tools into traditional play-based pedagogy.

Methods

This study was conducted using a quasi-experimental design (experimental and control groups with pre- and post-test measurements) to evaluate the effectiveness of a holistic pedagogical model aimed at developing flexibility in preschool girls aged 5-6. The model combined static and dynamic stretching exercises with a play-based approach and was supported by the interactive "Stretching for Kids" digital platform.

The study involved 72 healthy girls aged 5-6 (mean age 5.6 ± 0.5 years) from six public preschool educational institutions in the Andijan and Namangan regions of Uzbekistan. The participants were divided into two equal groups: an experimental group (EG, n=36) and a control group (CG, n=36). The groups were matched by age, baseline flexibility level, and anthropometric indicators.

Inclusion Criteria: regular attendance at the preschool institution, absence of acute or chronic diseases affecting motor function, and written consent from parents.

Exclusion Criteria: The presence of medical contraindications to physical activity. The study was approved by Andijan State University, and written consent was obtained from parents or guardians in accordance with the Declaration of Helsinki.

Intervention Program. The experimental group exercised according to the specially developed "Stretching for Kids" program 3 times a week, with each session lasting 25-30

Fig. Screenshots of the "Stretching for Kids" digital platform's main page.



Note: *These images show the user-friendly, colorful, and child-oriented design of the "Stretching for Kids" digital platform, including motivational elements (stars, rockets, emoji icons) and the popular exercises section.*

minutes. Each session consisted of the following stages:

Warm-up Stage (5 minutes) - light dynamic movements and games based on animal impersonations;

Main Part (15-20 minutes) - combining static and dynamic stretching exercises through playful activities (e.g., "Cat-Cow," "Downward -Facing Dog," and "Frog" poses, role-playing, and team relay exercises);

Cool-down Stage (5 minutes) - relaxation and breathing exercises.

The program was implemented through the "Stretching for Kids" web platform. The platform provided interactive video demonstrations, animated instructions, real-time monitoring, and an opportunity for parents to facilitate exercises at home. The platform's interface is available in Uzbek and English (screenshots of the platform are provided in Figure 1). Static stretching was primarily used at the end of sessions for deeper muscle stretching, while dynamic stretching and game elements predominated in the main part to maintain high motivation and functional movement. The program included 20 stretching exercises presented as animal poses and 8 games, such as "Tunnel," "Colored Cones," "Magic Statue," and "Animal Stretching." This program has been officially registered with the Ministry of Justice of the Republic of Uzbekistan as a computer program (Certificate No. DGU 56188, dated 10.11.2025).

The control group followed the standard physical education program used in conventional preschools, which included general games and simple movements. No systematic stretching exercises or digital support were provided for them.

Flexibility Assessment. Flexibility was measured before and after the intervention using a complex test battery consisting of 10 standard tests adapted for preschool children:

Wrist and Thumb Flexibility Test
Shoulder and Back Flexibility Test
Shoulder Flexibility (Back Scratch) Test
Standing Forward Bend Flexibility Test
Spinal Flexibility Test
Sit and Reach Test
Bridge Flexibility Test
Front Split Test
Right Split Test
Left Split Test

The tests were conducted under identical standardized conditions (same time of day, same equipment, same assessors). The results were evaluated on a 10-point scale (from 0.0 to 1.0 points) and converted into percentage increase indicators. Anthropometric measurements (height, weight, body mass index) were also recorded.

Data Analysis. The obtained data were processed using descriptive statistics (mean ± standard deviation), percentage change calculations, and inferential statistics (independent and

Table. Results of flexibility tests in 5-year-old girls before and after the experiment (mean ± standard deviation, percentage change, and statistical significance)

Tests	Group N=72	Pre-test ($\bar{x} \pm \sigma$)	Post-test ($\bar{x} \pm \sigma$)	t	p	Δ%
Wrist and Thumb Flexibility Test	CG	1.08 ± 0.90	0.94 ± 0.80	1.57	0.135	12.9
	EG	1.14 ± 0.80	0.72 ± 0.67	2.41	0.027	36.8
Shoulder and Back Flexibility Test	CG	55.89 ± 6.45	55.11 ± 6.14	0.05	> 0.05	1.39
	EG	55.78 ± 7.10	46.33 ± 5.97	4.35	< 0.01	16.93
Shoulder Flexibility - Back Scratch Test	CG	−0.64 ± 2.18	−0.56 ± 2.06	−1.23	0.236	12.5
	EG	−0.36 ± 2.07	+3.44 ± 1.23	−8.20	< 0.001	19.0
Standing Forward Bend Flexibility Test	CG	0.33 ± 0.77	0.44 ± 0.98	-0.62	0.542	33.3
	EG	0.39 ± 0.85	0.11 ± 0.32	1.43	0.172	71.4
Spinal Flexibility Test	CG	22.39 ± 5.70	21.83 ± 5.68	1.46	0.163	2.5
	EG	22.72 ± 5.69	19.72 ± 4.73	10.20	< 0.001	13.2
Sit-and-Reach Test	CG	2.22 ± 2.12	2.14 ± 2.07	1.37	0.187	3.75
	EG	2.03 ± 1.47	3.17 ± 1.25	−2.83	0.011	56.16
Bridge Flexibility Test	CG	24.72 ± 10.02	25.17 ± 9.64	-0.99	0.334	−9.0
	TG	24.94±10.27	24.22 ± 4.99	-0.20	0.843	2.2
Front Split Test	NG	19.83 ± 8.16	18.83 ± 8.02	4.12	0.0007	5.0
	TG	16.67 ± 7.28	1.83 ± 2.38	8.57	< 0.001	89.0
Right Split Test	NG	18.06 ± 7.63	17.50 ± 7.48	1.96	0.066	3.1
	TG	15.72 ± 6.83	1.44 ± 2.67	9.41	< 0.001	90.8
Left Split Test	NG	19.39 ± 8.33	18.72 ± 7.89	2.20	0.042	3.44
	TG	16.28 ± 7.54	1.78 ± 2.67	8.26	<0.001	89.08

Note: CG - control group; EG - experimental group; Δ% - percentage change. In the split and bridge tests, lower values indicate better flexibility.

paired samples t-tests). The statistical significance level was set at $p < 0.05$. All analyses were performed using SPSS 26.0 software. Where necessary, the effect size (Cohen's d) was calculated.

Results and discussion

A weekly pedagogical experiment demonstrated a statistically significant improvement in the flexibility of 5-6-year-old preschool girls following an integrated stretching and game-based approach, which was implemented using the "Stretching for Kids" digital platform. The experimental group (EG, n=36) showed a significant advantage compared to the control group (CG, n=36).

Flexibility development in 5-year-old girls. As shown in Table 1, the experimental group demonstrated considerably higher results than the control group in almost all tests.

Analysis: The experimental group demonstrated statistically significant improvements in 7 out of 10 tests ($p < 0.05$ to $p < 0.001$), with the greatest gains observed in the split tests (89.0-90.8%) and the "Sit-and-Reach" test (56.16%). In contrast, the control group showed only minimal and largely statistically insignificant changes ($p > 0.05$). These results indicate that the integrated stretching and gamified approach, implemented via a digital platform, is highly effective in enhancing both upper and lower body flexibility in 5-year-old girls and significantly surpasses the standard physical education program in conventional preschool institutions.

Flexibility Development in 6-Year-Old Girls. Table 2 presents the results for the 6-year-old participants. $p < 0.001$). The highest increases were observed in the splits tests (87.21-91.86%) and the wrist-thumb flexibility test (68.4%). In contrast, the control group exhibited only very minor changes (0-4.23%), most of which were statistically insignificant.

These results confirm that stretching exercises, game-based activities, and digital support are highly effective for this age group, leading to the stable development of both upper and lower body flexibility, along with a large effect

Table 2. Results of flexibility tests in 6-year-old girls before and after the experiment (mean ± standard deviation, percentage change, and statistical significance).

Tests	Group N=72	Pre-test ($\bar{x} \pm \sigma$)	Post-test ($\bar{x} \pm \sigma$)	t	p	Δ%
Wrist and Thumb Flexibility Test	NG	0.69 ± 1.13	0.67 ± 1.14	1.00	>0.05	4.0
	TG	0.53 ± 0.98	0.17 ± 0.38	2.25	<0.05	68.4
Shoulder and Back Flexibility Test	NG	51.83 ± 9.90	51.67 ± 9.87	1.00	0.331	0.32
	TG	51.61 ± 11.49	43.67 ± 7.86	2.45	0.025	15.39
Shoulder Flexibility - Back Scratch Test	NG	2.11 ± 1.60	1.89 ± 1.88	1.00	0.331	-10.53
	TG	1.17 ± 2.68	1.67 ± 2.20	-1.21	0.244	42.86
Standing Forward Bend Flexibility Test	NG	3.39 ± 5.91	2.94 ± 4.90	1.41	0.177	-13.1
	TG	3.39 ± 5.91	0.50 ± 1.89	2.54	0.021	87.7
Spinal Flexibility Test	NG	24.61 ± 4.30	24.61 ± 4.10	0.00	1.000	0.0
	TG	26.44 ± 4.25	22.78 ± 8.09	1.68	0.112	13.9
Sit-and-Reach Test	NG	1.83 ± 4.62	-1.83 ± 4.62	1.68	0.110	20.0
	TG	-2.50 ± 4.20	2.72 ± 2.47	-4.45	0.00035	28.0
Bridge Flexibility Test	NG	35.33 ± 9.32	35.33 ± 9.32	-	-	0.0
	TG	35.78 ± 15.44	26.17 ± 12.58	1.94	0.070	26.86
Front Split Test	NG	15.78 ± 7.11	15.22 ± 7.02	2.40	0.028	3.52
	TG	16.94 ± 6.99	2.17 ± 2.62	8.13	<0.001	87.21
Right Split Test	NG	15.00 ± 7.11	14.50 ± 7.23	2.47	≈0.025	3.33
	TG	16.39 ± 7.32	1.33 ± 1.91	7.78	<0.001	91.86
Left Split Test	NG	15.78 ± 7.52	15.11 ± 7.57	2.61	0.018	4.23
	TG	17.33 ± 7.37	1.67 ± 2.11	8.05	<0.001	90.38

size.

Overall, the study's outcome demonstrated a significantly greater increase in flexibility in both age groups compared to the standard preschool curriculum. The greatest improvements were recorded in lower extremity mobility (splits tests) and spinal flexibility (the "Sit-and-Reach" test). These findings clearly indicate that the developed model has high pedagogical effectiveness and practical significance within the physical education process for preschoolers.

The results of this study indicated that a 12-week holistic pedagogical model, which combined static and dynamic stretching exercises with a game-based approach and was implemented via the interactive "Stretching for Kids" digital platform, improved the flexibility of 5-6-year-old preschool girls to a statistically reliable and practically significant degree.

These improvements were markedly higher than the outcomes of the standard preschool program in the control group, with the most substantial gains observed in lower extremity mobility (split tests: 87-91.86%) and spinal flexibility (Sit-and-Reach test: 56.16% in 5-year-olds). The superior results in the experimental group are consistent with previous studies, which identify the preschool years (especially ages 5-6) as a sensitive "window of opportunity" for developing flexibility due to the high elasticity of the musculoskeletal system and neuromuscular adaptability (Donti et al., 2022).

The integration of play elements (animal poses, role-playing, and team exercises) increased the children's motivation and participation, transforming stretching from a tedious task into a fun and emotionally positive activity. These findings align with scientific evidence confirming that playful approaches significantly improve motor learning and engagement in young children compared to simple, structured exercises (Zosh et al., 2022; Veiga et al., 2025). The use of the "Stretching for Kids" digital platform significantly enhanced the effectiveness of the experiment by providing clear visual demonstrations, animated instructions, real-time feedback, and the opportunity for at-home practice.

These features addressed common challenges found in preschool educational institutions, such as educators' insufficient training in flexibility development and the difficulty of consistently maintaining the quality of sessions. Recent studies indicate that well-designed digital tools and mobile applications can yield equivalent or superior results compared to traditional physical education classes, provided they incorporate interactive and gamified elements (Zeng et al., 2025; Liang et al., 2025). In the current study, the platform's bilingual interface and child-friendly design (emojis, stars, rockets) contributed to a high level of engagement during the training sessions.

Gender characteristics were central to the development of the model. Girls naturally have

higher baseline flexibility than boys in "Sit-and-Reach" and similar tests, a fact confirmed across many age groups (Nuzzo, 2024; Yu et al., 2022). The program leveraged this advantage by combining gentle, controlled stretching with playful narratives tailored to girls' interests, resulting in particularly high scores on the splits and shoulder flexibility tests. This reaffirms the importance of gender-specific approaches in early childhood physical education.

Importantly, the improvements were achieved safely, with no injuries recorded. This demonstrates that short, age-appropriate stretching sessions lasting 25-30 minutes, held three times a week and enriched with gamified elements, are both effective and practical. This finding builds on previous research showing that structured stretching programs in physical education classes can maintain or improve hamstring and overall flexibility with minimal time commitment (Mayorga-Vega et al., 2016).

From a practical standpoint, the results obtained are directly relevant to preschool physical education in Uzbekistan and similar countries. The developed model addresses existing gaps in the systematic development of flexibility and offers a widely applicable solution through a state-registered digital platform (State Registration Certificate No. 56188). Educators can implement the program without additional resources, and parents have the opportunity to practice at home, thereby strengthening the partnership between the family and the preschool institution.

The limitations of the study include a relatively short intervention period and a focus solely on girls. Future research should examine the long-term retention of the achieved results, test the model on boys and in mixed-gender groups, and consider its integration with other motor skills such as balance, coordination, and strength. Furthermore, more multi-center studies across different regions would enhance the generalizability of the findings.

Conclusion

This study demonstrated that a weekly holistic pedagogical model, which combined static and dynamic stretching exercises with a game-based approach and was supported by the specially developed "Stretching for Kids" digital platform, was highly effective in optimizing flexibility in preschool-aged girls (5-6 years). The experimental group achieved statistically reliable and practically significant improvements in almost all flexibility tests, with the greatest gains recorded in the splits tests (87.0-91.86%) and the "Sit-and-Reach" test (up to 56.16%). In contrast, the control group, which followed a standard preschool physical education program, showed only minimal and largely statistically insignificant changes.

These results confirm that the preschool age (5-6 years) is a sensitive period for developing flexibility, and that integrating age-appropriate stretching exercises, play-based activities, and digital visualization significantly enhances training effectiveness and motivation. The "Stretching for Kids" platform proved to be a vital tool for providing clear visual instructions, increasing children's engagement, and ensuring continuity of practice between kindergarten and home.

The results obtained have significant theoretical and practical importance. Theoretically, they enrich our understanding of the mechanisms of flexibility development in early childhood and underscore the pedagogical value of combining traditional stretching methods with modern digital and game-based technologies. From a practical standpoint, the developed model and digital resource offer a ready-made, safe, and widely applicable solution for preschool educational institutions. The platform's official state registration (Certificate No. DGU 56188) further facilitates its widespread implementation.

In conclusion, this study provides strong experimental evidence that an integrated, game-based stretching approach supported by digital technology can significantly improve flexibility in preschool-aged girls. The findings support the modernization of physical education within the preschool system and make an important contribution to fostering a healthy, physically developed generation. Future research should examine the long-term retention of these results, expand the model to include boys and other age groups, and consider its integration with other motor skills such as balance, coordination, and strength.

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