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Original Article

The effects of game-based passive, static stretching, and trunk flexibility on the execution of forward roll in floor exercise: A factorial experimental design

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Abstract
Problem statement: This research aims to elucidate the intricate relationship between training methods (game-based passive and static stretching) and trunk flexibility, specifically in their influence on the proficiency of executing the forward roll in floor exercises. **Purpose:** This study aims to explore how training methods (game-based passive and static stretching) and trunk flexibility affect the forward roll skill in floor exercise. Despite the importance of these training modalities in enhancing physical performance, there remains a gap in understanding their combined impact on the forward roll skill. We hypothesize that the efficacy of training methods and trunk flexibility will significantly influence the execution the forward roll skill. **Approach:** The study employed an experimental approach with a 2 x 2 factorial design involving randomly selected students (N=40) aged 14.3±8.2 years old, who provided informed consent. Participants were divided into four groups and received either game-based passive or static stretching training over approximately six weeks, with a frequency of three times per week. Trunk flexibility and skill of forward roll data were assessed using the forward trunk flexion test, validity: r= 0.88 and reliability: r = 0.89, and forward rolling test, validity: r = 0.86 and reliability: r = 0.83. Data were analyzed using two-way ANOVA and the Tukey test. **Results:** Research findings revealed significant differences: (1) game-based passive stretching was more effective than game-based static stretching in enhancing the skill of forward roll (P<0.05), with an increase of 2.6 vs. 1.5, respectively; (2) individuals with high trunk flexibility benefited more from passive stretching than static stretching (P<0.05); (3) no significant difference was found in individuals with low trunk flexibility (P>0.05); (4) an interaction effect between training method and trunk flexibility was observed (P<0.05). **Conclusions:** In conclusion, game-based passive stretching is more beneficial for individuals with high trunk flexibility, while game-based static stretching may yield better results for those with low trunk flexibility. However, both modalities can be advantageous for individuals with low trunk flexibility. These findings offer insights for coaches and gymnastics instructors to tailor training programs effectively to enhance the skill of forward roll in floor exercise.
Keywords: Passive stretching, static stretching, game-based, skill of forward roll, trunk flexibility, artistic gymnastic, floor exercise

Introduction

Gymnastics is a competitive sports discipline comprising artistic gymnastics, rhythmic gymnastics, and aerobic gymnastics. Among them, artistic gymnastics has its own characteristics compared to other gymnastic disciplines as it consists of competitive events, such as floor exercise, vaulting horse, pommel horse, horizontal bar, parallel bars, uneven bars, balance beam, and rings. In artistic gymnastics, all athletes are required to skillfully perform compulsory movements or optional movements with perfect technique and aesthetic appeal (Atiković et al., 2020).

The achievement of artistic gymnastics in Indonesia still lags far behind compared to Asian countries such as Korea, Japan, and China (Sulistiyowati et al., 2022), Gymnasts from these countries have demonstrated their maximum potential in various gymnastics championship both in Asian Championships and the Olympics. However, there are still relatively few male and female Indonesian athletes who have been able to showcase their maximum potential. One clear constraint evident in the performance of Indonesian gymnasts is their insufficient mastery of technical skills. However, to achieve maximum performance in artistic gymnastics,

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athletes are required to skillfully execute compulsory movements as well as optional movements with perfect technique and aesthetic appeal, including overcoming psychological barriers (Dimyati, Ilham, et al., 2023; Dimyati, Setiawati, et al., 2023; Hedbávný et al., 2013; Ilham & Dimyati, 2021; Kaur & Koley, 2019; Potop et al., 2015; Swan et al., 2022).

One important technical skill in artistic gymnastics is the skill of forward roll, which is included in floor exercise movements (Parlina et al., 2021). It is the one of the basic movement patterns that must be mastered by an athlete, especially a gymnast (Handayani et al., 2023), since most sequences of floor exercise, such as handstands, cartwheels, and tiger springs, culminate with the forward roll movement. A gymnast lacking perfect technical proficiency in skill of forward roll, will never attain optimal performance.

Therefore, a knowledge and technology-oriented approach in training to enhance athletes' proficiency in performing the forward roll skill. This approach will lead to the achievement of gymnastics performance, both at the Southeast Asian, Asian, and international levels. Coaching should be continually directed towards performance improvement, tailored to the needs of athletes, including physical training and training methods to enhance their technical abilities (Dimyati, Ilham, et al., 2023; Mario et al., 2022; Ndayisenga et al., 2021; Pratama et al., 2024; Yendrizal et al., 2023). Various studies have been conducted to develop the technique skill of artistic gymnastics, specifically in the forward roll skill. For instance, an experimental study reported an improvement in forward roll skill ability in the experimental group compared to the control group through a teaching game approach ($P < 0.05$) (Handayani et al., 2023). Excessive focus on enhancing physical support throughout the physical preparation phases, coupled with inadequate attention to requisite recovery periods, resulted in overloading and consequently yielded subpar outcomes compared to those achieved during the Olympic Games (Alexandra, 2014). Recent research has also reported that dynamic stretching, although only slightly, tends to improve high jump performance compared to static stretching (Ferrara et al., 2019). In other words, this finding highlights the potential benefit of incorporating dynamic stretching technique into gymnastics training programs to enhance performance outcome. Gymnastics is commonly defined by its notable levels of strength, power and flexibility, all of which are essential for optimal performance in various gymnastics disciplines. However, there remains a need to further examined many factors in improving the physical and technical abilities of artistic gymnastics, particularly in floor exercise.

Artistic gymnastics discipline requires precise for forward roll movement which relies on a combination of both balance factors and trunk flexibility (Boligon et al., 2015; Sloanhoffer et al., 2018). The flexibility of the trunk area is a crucial factor in determining the success of athletes in various gymnastic disciplines (Oktay & Berisha, 2021; Vernetta et al., 2020). Therefore, a gymnast must prioritize developing excellent flexibility in their trunk area. To accomplish this objective, they should focus on specific stretching exercises and effective programmed methods designed to train and improve trunk flexibility.

Trunk flexibility can be improved through stretching exercises (Bompa & Buzzichelli, 2015; Chaeroni et al., 2022; de Souza et al., 2020; Erianti et al., 2022; Haryanto et al., 2021; Mikolajec et al., 2012). Among the commonly employed stretching techniques are static and passive stretching, both of which have been extensively studied for their effectiveness in improving flexibility (Andriichuk et al., 2021; Arazi et al., 2013; Arriaza et al., 2016). Static stretching exercises are one form of training used to improve flexibility. Numerous investigations have shown that static stretching has the potential to enhance compliance, consequently diminishing muscle-tendon unit stiffness (Magnusson & Renström, 2006). The duration and intensity of static stretching exercises seem to be crucial factors in these impairments, as prolonged and intense stretching sessions lead to a more significant reduction in subsequent power generation ability (Behm & Chaouachi, 2011). The method of performing static stretching exercises involves taking a certain posture, and stretching a specific group of muscles, typically preceded by a warm-up activity. For example, sitting with legs straight, then reaching both hands towards the toes, or starting from a prone position, pushing the body backward. This posture can be maintained statically for several seconds. Experts hold differing opinions on the ideal duration for holding a static stretch. However, most of them have agreed that 20 to 30 seconds is a commonly used and safe duration that is sufficient to improve joint flexibility. It is also important to note that sudden excessive stretching causing muscle pain should be avoided during static stretching exercises.

Passive stretching exercises can be performed individually without special training equipment (Andriichuk et al., 2021; Behm et al., 2021). These exercises allow individuals to work at their own capacity to achieve their training goals while paying attention to stretching discomfort. However, this impact is temporary and depends on the duration and intensity of the stretching protocols utilized (Magnusson & Renström, 2006). In addition, passive stretching denotes the capacity to execute movements with maximum amplitude under external influences such as assistance from a partner, one's body weight, or specialized equipment exerting direct physical pressure on specific motor segments (Andriichuk et al., 2021). To perform passive stretching exercises, participants must consciously relax a group of muscles while a partner statically stretches those muscles. Furthermore, an important benefit of passive stretching is that it enhances the elongation of the stretched muscles. Passive stretching involves a partner or friend assisting in maintaining a stretch for 10 - 30 seconds. The method achieves maximum flexibility with the assistance of a partner using their weight (Bompa & Buzzichelli, 2015).

This method also allows the use of external force, especially on elastic muscle groups. However, there remains a notable gap in research, with no studies comparing passive stretching methods with other techniques to evaluate their long-term effects on athletes' flexibility. In addition to the training methods mentioned above, physical components also influence a gymnast's performance in performing forward rolls. Movements in gymnastics exercises primarily involve large muscle groups, including the trunk, arm, chest, and abdomen muscles. The physical conditioning elements required are flexibility, strength, balance, and agility. This is in line with the statement that to optimize sport performance, athletes should fully consider four aspects of sports training: physical preparation, technical preparation, mental/psychological preparation, and preparation of tactics and strategies (Berhimpong et al., 2023; Bompa & Buzzichelli, 2015; Dimyati, Setiawati, et al., 2023; Ilham & Dimyati, 2021; Patrícia et al., 2019; Sulistiyowati et al., 2022; Weinberg & Gould, 2015). This also aligns with the relevant theoretical statement that gymnastics, a sport demanding elevated levels of anaerobic capacity and flexibility, mandates explosive strength and power alongside agility and balance skills across diverse apparatuses (Arazi et al., 2013).

Flexibility plays a crucial role in gymnastics performance, serving as a key indicator for executing movements such as the forward roll in floor exercise (Nugroho et al., 2021). It enables muscles and muscle groups to cooperate effectively, facilitating fluid movements and reducing the risk of injury. Flexibility is closely related to the range of motion abilities of joints such as the hips, trunk, spine, wrists, and ankles, which are considered in movement performances. Individuals with poor flexibility often exhibit stiff, rough, and sluggish movements. Flexibility is a primary asset that a gymnast must possess (Bobo-Arce & Méndez-Rial, 2013; Granacher & Borde, 2017; Oktariyana & Oktariyani, 2020). Good flexibility allows muscles and muscle groups to cooperate in performing movement activities (Bobo-Arce & Méndez-Rial, 2013). It also enables gymnasts to perform movements with artistic flair and execute high-difficulty movements effectively while minimizing the risk of injury (Behm & Chaouachi, 2011).

The researchers in the present study hypothesized that a possible approach could be to prioritize game-based elements in implementing both of these training methods. In addition to the aforementioned training methods, physical components such as flexibility also influence a gymnast's performance in executing a forward roll. Flexibility training helps to stretch muscles, protect against injuries, and allows for maximum range of motion in the joints. Based on previous research and considering the significant benefits of conducting this study, four questions are posed in this research: (1) Is there a difference in the results skill of forward roll between those trained with game-based passive and static stretching methods? (2) Is there a difference in the results of forward roll between those trained with game-based passive and static stretching methods among students with high trunk flexibility? (3) Is there a difference in the results skill of forward roll between those trained with game-based passive and static stretching methods among students with low trunk flexibility? (4) Is there an interaction between training methods and trunk flexibility on skill of forward roll in floor exercise? For this reason, it is necessary to investigate the effect of different training methods and trunk flexibility on the skill of forward roll in floor exercise. This research is essential for designing effective training programs for gymnasts at different levels of trunk flexibility.

Methods

Research design

This study employed an experimental research design with a 2x2 factorial design to investigate the direct effects of the treatments given and their control condition. These treatments consisted of different variable types (Montgomery, 2013). The research focused on the outcome of forward roll skill as the dependent variable, with the passive stretching play method and static stretching method serving as the independent variables. Meanwhile, the attribute variable of trunk flexibility was categorized into high and low trunk flexibility groups. For clarity, the term stretching training method (A) is used as the independent variable, while trunk flexibility and forward skill are attribute and dependent variables, respectively. Stretching training methods comprise the passive stretching method (A1) and static stretching method (A2). Meanwhile, trunk flexibility (B) is divided into two groups: those with high (B1) and low (B2) trunk flexibility. The classification of each variable in this study can be seen in Table 1. Thus, this study consists of four treatment groups: training methods using passive stretching for high and low trunk flexibility (A1B1 and A1B2), and training methods using static stretching for high and low trunk flexibility (A2B1 and A2B2).

Table 1. The two-way factorial ANOVA design

Trunk Flexibility (B)	Stretching Training Methods (A)	
	Passive Stretching (A1)	Static Stretching (A2)
High (B1)	A1B1	A2B1
Low (B2)	A1B2	A2B2
Total	A1	A2

Participants

From a population of 74 individuals, 40 gymnasts were randomly selected, with an average age of 16.4 ± 6.3 years. Their body weight was 46.4 ± 3.4 kg, height 157.3 ± 3.2 cm, and BMI 22.26 ± 1.4. They were randomly chosen to participate in all phases of the study. Commitment and signing of statements to participate in all research phases were obtained before intervention was conducted.

Data Collection Technique

In this study, data collection techniques were based on the involved variables. Data for the dependent variable (skill of forward roll) were collected through an assessment test of forward roll skill movement patterns, validity: r= 0.86 and reliability: r = 0.83. Meanwhile, data for the attribute variable (trunk flexibility) were obtained through measurements using a test for trunk flexibility, validity: r= 0.88 and reliability: r = 0.89.

Procedure

Research Permit

First, the researchers obtained the permission letter and ethical clearance from the Ethics Commission of Manado State University. Then, an agreement sheet was prepared and accepted by participants who agreed to participate in the entire research process.

Distribusi treatment grup

Based on the sampling chronology, the target population in this study was all students of SMP Negeri 2 Tondano, Minahasa Regency. However, due to school activity limitations, the accessible population consists of all male students in the first grade of junior high school (first level of secondary education) who could participate, resulting in 74 students. Then, to determine the number of samples to be intervened, a trunk flexibility test was conducted by selecting the top 27% and the bottom 27% of all measured population scores (Miller, 2008). Thus, N=40 was obtained. Based on the predetermined research design, the total N=40 was divided into four groups using a random system with an ordinal pairing technique. Therefore, each group consisted of 10 individuals. For more details, refer to Figure 1.

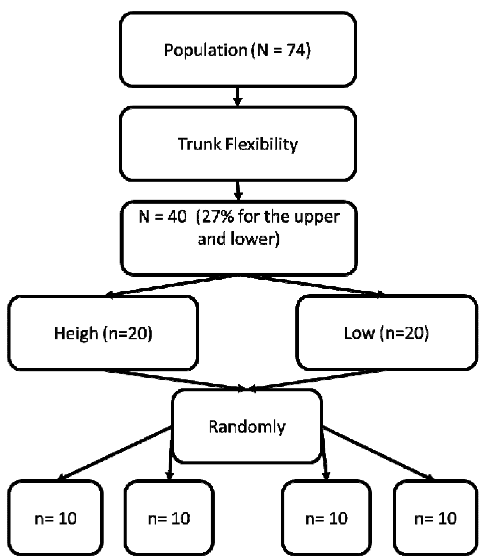


Figure 1. The procedure of treatment groups division

Intervention

The exercise program was carried out for six weeks with at least three exercises per week, each lasting 75 minutes. Each session consisted of warm-ups, game-based passive/active stretching exercises, and cool-downs. After the completion of the post-test, a training program was carried out to serve as hypothesis testing data. The detailed illustration can be seen in Table 2 below.

Table 2. The 2x2 Factorial Design

Training Methods (A) / Trunk Flexibility (B)	Passive game Stretching (A1)	Static game Stretching (A2)
High Trunk Flexibility (B1)	A1B1	A2B1
Low Trunk Flexibility (B2)	A1B2	A2B2
Total	A1	A2

Information:

A1B1 = Passive stretching game training method and high trunk flexibility. A2B1 = Static stretching game training method and high trunk flexibility. A1B2 = Passive stretching game training method and low trunk flexibility. A2B2 = Static stretching game training method and low trunk flexibility.
A1 = Passive stretching game method.
A2 = Static stretching game method.

Data Analysis Techniques

A descriptive analysis was conducted to obtain each characteristic of the resulting data. Normality and homogeneity tests were performed as a prerequisite for hypothesis testing. The Barlett test was utilized to test homogeneity, examining the relationship between the training model and the trunk flexibility of forward roll skill. Additionally, statistical hypothesis testing was carried out using a two-way 2 x 2 analysis of variance (ANOVA) technique at a confidence level of $\alpha = 0.05$. The Tukey Test further followed this analysis.

The statistical hypotheses to be tested in this study were as follows:

first H_0 : $\mu_{A1} = \mu_{A2}$
H_1 : $\mu_{A1} > \mu_{A2}$

Second H_0 : $\mu_{A1B1} = \mu_{A2B1}$
H_1 : $\mu_{A1B1} > \mu_{A2B1}$

Third H_0 : $\mu_{A1B2} = \mu_{A2B2}$
H_1 : $\mu_{A1B2} < \mu_{A2B2}$

Fourth H_0 : Int A x B = 0
H_1 : Int A x B # 0

Information:

H_0 = Zero hypothesis.
H_1 = Alternative Hypotheses.
μ_{A1} = Average results of skill of forward roll with training model treatment game-based passive stretching.
μ_{A2} = Average results of skill of forward roll with drills training model treatment game-based static stretching.
μ_{A1B1} = Average results of skill of forward roll, gymnasts group of abilities high trunk flexibility with game-based passive stretching treatment methods.
μ_{A2B1} = Average results of skill of forward roll, gymnast group of abilities high trunk flexibility with static stretching treatment methods .
μ_{A1B2} = Average results of skill of forward roll, gymnasts group of abilities trunk flexibility with game-based passive stretching treatment methods .
μ_{A2B2} = Average results of skill of forward roll, student group of abilities low trunk flexibility with game-based static stretching treatment methods .
A = Stretching training model.
B = Trunk flexibility.

Each data point was calculated using SPSS 25 (inferential statistical hypothesis) and visually presented using both SPSS 25 and the Origin Pro 2018 application.

Result

Data description

From the research findings of the forward roll skill, data from the final test of the treatment were obtained, reflecting the influence of the exercises performed. In this section, the researchers will report the descriptive data of all research variables, including the dependent variable of the forward roll skill (Y) and two other variables (X1 and X2), namely exercises with passive stretching and static stretching. For clarity, the descriptive research data can be seen in Table 3 and Figure 2 below.

Table 3. Summary of the calculation results of the values and standard deviations of the research data.

Trunk flexibility (B) \ Training Methods (A)	Exercise Passive stretching (A1)	Exercise Static stretching (A2)	Number of Rows
High Trunk flexibility (B1)	N = 10	n = 10	n = 20
	$\sum X$ = 303	$\sum X$ = 237	$\sum X$ = 540
	$\sum X^2$ = 10706	$\sum X^2$ = 5843	$\sum X^2$ = 16549
	SD = 3.65	SD = 5.01	SD = 8.66
	$\overline{X}$ = 30.30	$\overline{X}$ = 23.70	$\overline{X}$ = 27
Low Trunk flexibility (B2)	N = 10	n = 10	n = 20
	$\sum X$ = 225	$\sum X$ = 233	$\sum X$ = 258
	$\sum X^2$ = 5171	$\sum X^2$ = 5587	$\sum X^2$ = 10758
	SD = 3.47	SD = 4.19	SD = 7.66
	$\overline{X}$ = 22.5	$\overline{X}$ = 23.30	$\overline{X}$ = 22.90
Number of Columns	N = 20	n = 20	n = 40
	$\sum X$ = 74	$\sum X$ = 470	$\sum X$ = 544
	$\sum X^2$ = 15877	$\sum X^2$ = 11430	$\sum X^2$ = 27307
	SD = 5.29	SD = 4.50	SD = 9.79
	$\overline{X}$ = 26.4	$\overline{X}$ = 23.5	$\overline{X}$ = 24.95

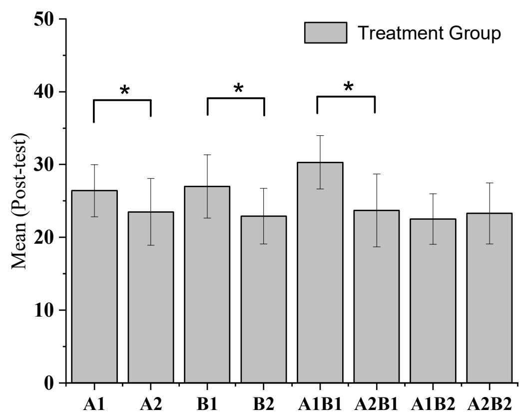


Figure 2. Average and standard deviation of forward roll skill in floor exercise of each treatment group (*p<0.05)

Test experimental prerequisites

Normality test

The scores of normality test for the forward roll skill in floor gymnastics was conducted using the Lilliefors test at a significance level of $\alpha = 0.05$. Summary of the normality test results for the samples can be seen in Table 4 below.

Table 4. Summary of the sample normality test results.

Group	N	L h	L_t	Conclusions
1	20	0.156	0.220	Normal
2	20	0.156	0.220	Normal
3	10	0.216	0.258	Normal
4	10	0.244	0.258	Normal
5	10	0.226	0.258	Normal
6	10	0.185	0.258	Normal

Information:

Group 1 = Group of game-based passives stretching method training as a whole.
Group 2 = Group of game-based static stretching method training as a whole.
Group 3 = Group of high trunk flexibility with game-based passive stretching method training.
Group 4 = Group of low trunk flexibility with gam-based passive stretching play method training.
Group 5 = Group of high trunk flexibility with game-based static stretching play method training.
Group 6 = Group of low trunk flexibility with game-based static stretching play method training.
L h = Lilliefors observation value.
Lt = Lilliefors Table value.

The calculation results, as depicted in Table 4, show that Lh for the entire sample group is smaller than Lt. Thus, it can be concluded that the sample drawn from the population was considered as a normal distribution.

Homogeneity test

The homogeneity test was conducted using Bartlett's test at a significance level of α = 0.05. A summary of the homogeneity test results is presented in Table 5.

Table 5. Summary of the homogeneity test results.

Group	Varian	Pooled variance	X2h	X2t	Conclusions
1	13.322	16.2545	1.51	7,81	
2	12.040				homogeneity
3	22.100				
4	17.556				

Information:

Group 1 = High flexibility group with passive stretching exercise method.
Group 2 = Low flexibility group with game -based passive stretching exercise method.
Group 3 = High trunk flexibility group with game-based static stretching exercise method.
Group 4 = Low flexibility group with static stretching exercise method.
X^2_h = Calculated Chi-square value.
X^2_t = Tabulated Chi-square value

The calculation results as depicted in Table 14 above, yielded X2h = 1.51, which is smaller than X2t = 7.81. Hence, Ho: $\sigma^2 1 = \sigma^2 2 = \sigma^2 3 = \sigma^2 4$ is accepted at a significant level of α = 0.05. Consequently, it can be concluded that all four populations have the same variance (homogeneity).

Results of testing research hypotheses

A two-way analysis of variance (ANOVA) technique and Tukey's test were employed to test the hypothesis. The summary is depicted in Table 6.

Table 6. Summary of the ANOVA calculation results for skill of forward roll scores in floor gymnastics at a significance level of α = 0.05.

Source of Variation	dk	JK	KT	Fo	Ft
Mean	1	24900,1			
Treatment					
A	1	84.1	84,1	4.94 *	4.11
B	1	168.1	168,1	9.88 *	4.11
AB	1	136.9	136,9	8.04 *	4.11
Error (E)	36	612.8	17.02		
Total	40	25902.0			

Information:

* = significant at a significance level of α = 0.05.
dk = degrees of freedom.
JK = sum of squares.
KT = mean sum of squares.
Fo = observed F value.
Ft = critical F value.

1. ***The difference in skill of forward roll outcomes in floor gymnastics between the passive stretching exercise method and the static stretching exercise method overall.***

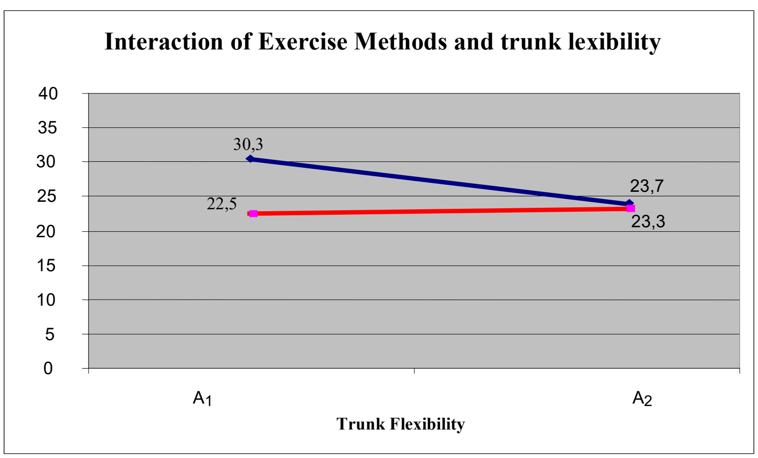
Based on the analysis of variance (ANOVA) at a significance level of α = 0.05, it was found that Fh = 4.94 and Ft = 4.11 (Table 6). Therefore, Fo> Ft, indicating that Ho is rejected. Thus, it can be concluded that overall, there is a significant difference between the passive and static stretching exercise methods regarding the skill of forward roll in floor exercise. In other words, the skill of forward roll in floor exercise using the passive stretching exercise method ($\overline{X}$ = 26.40; SD = 5.29) is better than those using the static stretching exercise method ($\overline{X}$ = 23.50; SD = 4.50). This result also suggests that the passive stretching method is more effective for improving forward roll performance.

2. ***Interaction between stretching exercise methods (game-based passive and static) and trunk flexibility on the skill of forward roll performance in floor exercise***

Based on the results of the two-way analysis of variance, the interaction between stretching exercise methods and trunk flexibility on the outcome of forward roll skill performance in floor exercise is evident in the ANOVA calculation table (Table 6). The calculated value of the interaction F ratio (FAB) is 8.04, while the critical F value is 4.11. From these results, it is apparent that the calculated F value exceeds the critical F value, thus rejecting the null hypothesis (H0) and supporting the alternative hypothesis (H1). Therefore, it can be concluded that there is a significant interaction between stretching exercise methods and trunk flexibility on the outcome of forward roll performance in floor exercise.

According to the research data, the average score of forward roll performance in floor exercise for the high trunk flexibility group trained with game-based passive stretching exercise method are 30.30, while for the low trunk flexibility group, the average score is 22.50. On the other hand, the average scores of forward roll performance in floor exercise for the high trunk flexibility group trained with the static stretching exercise method is 23.70, while the average score for the low trunk flexibility group is 23.30.

Thus, the fourth research hypothesis has been confirmed, which posits the presence of an interaction between stretching exercise methods and trunk flexibility on forward roll performance. The interaction between stretching exercise methods and trunk flexibility on the skill of forward roll performance in floor exercise can be observed in **Figure 3.**



High Low

Figure 3. The Interaction of Exercise Methods with Trunk Flexibility (Data Analysis via 2x2 ANOVA)

<u>Information:</u>
A_1 = Passive stretching exercise method
A_2 = Static stretching exercise method

3. ***The difference skill of forward roll performance in floor exercise between passive and static stretching exercise methods for the high Trunk flexibility group.***

The passive and static stretching exercise methods yield significant differences in skills of forward roll performance in floor exercise for the group with high trunk flexibility. It is evidenced by the post-hoc test results using the Tukey test (Table 7).

Table 7. Comparison between the passive and static stretching exercise methods in the group with high trunk flexibility.

No	The compared groups	Q_{count}	Q_{table} ($\alpha = 0.05$)	Information
1	P_1 and P_2	5,06	3,79	Significant

Information:
P1 = Group with trunk flexibility undergoing passive stretching exercise method.
P2 = Group with trunk flexibility undergoing static stretching exercise method.

The high trunk flexibility group using the passive stretching training method (P1) compared to the trunk flexibility group using static stretching training method (P2), obtained Qh = 5.06 and Qt = 3.79. Thus, Qh is greater than Qt, so Ho is rejected. In conclusion, for students who have high trunk flexibility, the results of the forward roll skill performance in floor exercise with the passive stretching training method ($\bar{X}$ = 30.30, and SD = 3.65) are better than static stretching training method ($\bar{X}$ = 23.70 and SD = 5.01).

4. ***The difference of skill of forward roll performance in floor exercise between passive and static stretching training methods for the low trunk flexibility group.***

The passive and static stretching training methods yield differences in the skill of forward roll performance in floor exercise for the trunk flexibility group. However, these differences are not significant, as it is evidenced by the post-hoc test results using the Tukey test (Refer to Table 8).

Table 8. Comparison between the passive and static stretching training methods for the low trunk flexibility group.

No	The compared groups	Q_{count}	Q_{table}	Information
2	P_4 and P_3	0,61	3,79	Not significant

Information:
P4 = Trunk flexibility group with static stretching training method.
P3 = trunk flexibility group with passive stretching training method.

For the low trunk flexibility group, the result obtained when comparing the group trained with the static stretching training method (P4) to the group trained with the passive stretching training method (P3) yields Qh = 0.61 < Qt = 3.79. These findings depict information that Ho is accepted, and H1 is rejected. Thus, it can be said that for the trunk flexibility group, the results skill of forward roll performance in floor exercise trained with static stretching training method ($\bar{X}$= 23.30; SD = 4.19) and passive stretching training method ($\bar{X}$= 22.50; SD = 3.47) do not show significant differences at the α level of 0.05.

Discussion

After conducting data analysis using analysis of variance (ANOVA) approach followed by the Tukey's test, the discussion of research findings will focus on four hypotheses that have been tested for their validity. Overall, the outcomes of forward roll performance in floor exercise through the application of the passive stretching exercise method (A1) are better than the static stretching exercise method (A2). These results confirm previous research findings that passive stretching for 15-30 seconds is more effective than dynamic or static stretching in improving flexibility (range of motion) (D'anna & Paloma, 2015). Recent research has also reported that if someone maintains a stretch for more than 4 minutes, their range of motion is likely to be a more significant increase compared to maintaining the stretch for a shorter period (Behm et al., 2021). In its implementation, the passive stretching training method emphasizes exercises assisted by a friend or partner with the game approach. The passive stretching training method utilizes the weight of the partner as resistance during the exercise. With the assistance of the partner's body weight as resistance, the performer can achieve maximum stretching. Student assisted by a friend during stretching exercises are easily supervised or controlled by the assisting friend in terms of both timing and the student's ability limits. Because the execution is done slowly and carefully according to the student's ability. With the help of a friend, students will be motivated to perform better than their peers. Thus, stretching training with the passive training method will stimulate the emergence of motivation in practicing to achieve higher levels of flexibility, which will result in good skill of forward roll performance in floor exercise.

In its implementation, the static stretching training method emphasizes independent exercises independent exercises (Özer & Soslu, 2019). The student performs the static stretching exercise individually after receiving instructions from the teacher or coach, preceded by the game approach. Thus, the student conducts the stretching exercise independently according to their ability limits, while the teacher or coach only observes. Students who engage in static stretching exercises sometimes only do so according to their own desires, resulting in the exercise sometimes not reaching the maximum stretching limit, and the designated time for execution is sometimes disregarded. It will hinder the development of their flexibility, consequently limiting the improvement of forward roll performance in floor exercise.

The motion analysis results above are reinforced by the calculation results of the analysis of variance regarding the difference in effectiveness between the two training methods overall; the observed F value between columns (FA) = 4.94, which is greater than the critical F value, which is 4.11 (Fo = 4.94 > Ft = 4.11). Based on the comparison of the results of the forward roll performance skill in floor exercise using two different training methods, passive stretching (mean = 26.40, SD = 5.29) and static stretching (mean = 23.50, SD = 4.50), the researchers concluded that the passive stretching training method is more effective in improving the skill of forward roll in floor exercise. Therefore, based on the research findings, it can be recommended that the passive stretching training method is more suitable for enhancing skill of forward roll performance in floor exercise.

Additionally, the present research also reports an interaction between the training method and trunk flexibility concerning the results skill of forward roll performance in floor exercise. Prior studies have consistently affirmed that artistic gymnastics exercises have a positive effect on flexibility components and vice versa (Gündoğan et al., 2020). The 2x2 analysis of variance results on the interaction between the training method and the trunk flexibility concerning the skill of forward roll performance in floor exercise show that the observed F value = 8.04 > the critical F value at 0.05 significance level = 4.11. This interaction illustrates that the passive stretching training method is more suitable for students with high trunk flexibility compared to the static stretching training method: A1B1 > A2B1. Conversely, the static and passive stretching training methods can both be applied to students with low trunk flexibility. This is reinforced by the post-hoc test results differentiating between the passive stretching training method with high trunk flexibility and the static stretching training method with high trunk flexibility; A1B1: A2B1 (P: P2), the calculated Q value 5.06> the tabulated Q value 3.79. In other words, the effectiveness of the passive stretching training method with high trunk flexibility ($\bar{X}$ = 30.30 and SD = 3.65) is significantly better than the static stretching training method ($\bar{X}$ = 23.70 and SD = 5.01). The static stretching training method has low trunk flexibility, and the passive stretching training method has low trunk flexibility; A2B2: A1B2 (P4: P3), the calculated Q value is 0.61 > the tabulated Q value 3.79. In other words, the static stretching training method ($\bar{X}$ = 23.30 and SD = 4.19) and the passive stretching training method ($\bar{X}$ = 22.50 and SD = 3.47) contribute equally to the effectiveness of the results in the skill of forward roll performance in the floor exercise.

Considering the findings above, it is advisable for students with high flexibility who wish to improve their skill of forward roll performance in floor exercise to train using passive stretching methods. Conversely, those with low trunk flexibility can benefit from a combination of passive and static stretching techniques.

Meanwhile, for students with high trunk flexibility, the forward roll performance in floor exercise is better achieved through the application of passive stretching methods (A1) compared to static stretching methods (A2). Passive play stretching methods emphasize exercises assisted by a friend or partner, incorporating an element of play. Training methods performed in pairs or with the assistance of a friend facilitate execution and evoke motivation from the practitioner. In other words, students who practice passive play stretching methods will greatly benefit in reaching their maximum stretching limits as they are assisted by a friend who aids in pushing and holding stretches until the predetermined time limit.

The researchers also suggest that students with high trunk flexibility facilitate the development of their skills enhancement abilities, as they are more inclined to engage in deeper stretching. Stretching exercises assisted by a friend will enhance motivation among practitioners, thus fostering a sense of competition among peers. Consequently, this will also ignite enthusiasm for improving forward roll performance in floor exercises.

On the other hand, the static stretching method emphasizes independent exercises with a playful element. These exercises are performed individually based on one's own abilities. In other words, students practicing stretching with the static play method are not influenced by external factors. For students with high trunk flexibility, such exercises are considered routine and lack significant challenges, as they find them exceptionally easy and straightforward. Consequently, these exercises do not evoke high motivation, and there is minimal competitive element in improving trunk flexibility. Therefore, the results achieved may fail to meet expectations. In other words, practicing with the static play stretching method for students with trunk flexibility tends to lack motivation and competitiveness. Nevertheless, the response to static stretching depends on the stretching mode and the participants' training experience (Donti et al., 2020).

The analysis results are further supported by the results of an advanced group test on students with high trunk flexibility trained using the passive stretching method (P1) compared to those trained using the static stretching method (P2). The results are as follows: $Q_{count} = 5.06 > Q_{table} = 3.79$. In other words, for students with high trunk flexibility, the effectiveness of the passive stretching method ($\overline{X}$= 30.30 and SD = 3.65) is significantly better than the static play stretching method ($\overline{X}$ = 23.7 and SD = 5.01). Therefore, based on the discussion of the research results, it can be recommended that for students with high trunk flexibility, the passive play stretching method is more suitable for enhancing skill of forward roll performance in floor exercise.

For students with low trunk flexibility, the effectiveness of improving the skill of forward roll performance in floor exercise is greater through the application of the static stretching method (A2) compared to the passive play stretching method (A1). Both methods aim to enhance forward roll performance in floor exercises, but differ in their execution. The static stretching emphasizes independent exercises (Bouguezzi et al., 2023; Donti et al., 2020) and is performed without the assistance of a friend or partner. It means that the stretching is conducted based on the individual's own desires and abilities. In other words, students practice according to their own rhythm and capabilities without time constraints or external influences. For students with low trunk flexibility, exercises like this are highly enjoyable because they perceive the movements as not overly challenging, allowing them to perform based solely on their preferences.

Hence, the expected outcomes are more likely to be achieved. In other words, practicing with the static play stretching method for students with low trunk flexibility stimulates the emergence of enthusiasm to achieve automaticity in forward roll performance in floor exercise. Conversely, practicing passive stretching for students with low trunk flexibility does not stimulate the same enthusiasm and motivation in striving for automaticity in forward roll performance in floor exercises.

The results of an advanced group test on students with low trunk flexibility further support the data analysis findings. The test compared those trained using the static play stretching method (P4) compared to those trained using the passive play stretching method (P3). The results are as follows: $Q_{count} = 0.61 < Q_{table} = 3.79$. In other words, for students with low trunk flexibility, both the static stretching method (mean = 23.3 and SD = 4.19) and the passive play stretching method ($\overline{X}$ = 22.5 and SD = 3.47) do not significantly contribute to the improvement skill of forward roll performance in floor exercise. In simpler terms, both stretching methods are suitable for enhancing skill of forward roll performance in floor exercises for students with low trunk flexibility.

This research was conducted with students as research respondents, and it is not without weaknesses and limitations, despite efforts to maximize control and supervision. This study was limited to involving students as research respondents, so it can only be generalized to the same age group and characteristics. Additionally, although control measures such as attendance and scheduled training materials were implemented, other activities outside the training schedule might still influence the research results. In both passive and static stretching methods, the control during implementation was limited to one instructor, two students, and three teachers, which may have affected the quality of training. However, the researcher minimized this issue by providing guidance and instructions before and after training sessions. Thirdly, this study only involved male samples, so it cannot be generalized to female samples. As described regarding the weaknesses and limitations of the study above, future researchers should take these into serious consideration and anticipate them to minimize these limitations for more accurate research results.

Conclusion

This study investigated the effectiveness of passive and static stretching methods on forward roll performance in students with varying trunk flexibility levels. The study on the skill of forward roll for students revealed some interesting conclusions. Firstly, the students trained with the passive stretching exercise method performed better than those trained with the static stretching exercise method. Secondly, for students with high trunk flexibility, the passive stretching exercise method produced better results than the static stretching exercise method. Thirdly, the static stretching exercise method produced better results for students with low trunk flexibility than the passive stretching exercise method. Finally, there was an interaction between stretching exercise methods and trunk flexibility towards the skill of forward roll in floor exercise.

The research team has put forth some valuable recommendations based on their findings to enhance student's ability to perform forward roles. First, it is crucial to provide stretching exercises that cater to individual internal factors, such as flexibility. Physical education teachers and coaches must assess the flexibility level of students beforehand to ensure that the stretching exercises provided are effective. In addition, for students with high trunk flexibility, it is advisable to use the passive stretching exercise method to train them in floor exercise. For students with low trunk flexibility, opting for the static stretching exercise method is recommended to train them in the forward roll skill in floor exercise. Lastly, it is suggested that further research be conducted by researchers interested in this issue, involving other significant variables that impact the forward roll skill, such as concentration, balance, and coordination. Such research will contribute to developing research in floor exercise and enrich knowledge in sports science.

Conflicts of interest - If the authors have any conflicts of interest to declare.

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