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Static vs dynamic stretching: which is better for flexibility in terms of gender of badminton athletes?

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Abstract

Background and Study Aim: Flexibility is a crucial component of physical conditioning for badminton players. In this context, this study aims to investigate the impact of static and dynamic stretching on the flexibility of badminton athletes. The research objectives include analyzing the effectiveness of each stretching technique, comparing flexibility between male and female players, and examining the interaction between stretching methods and gender on athletes' flexibility.

Material and Methods: This type of research is an experiment using a 2x2 factorial design. The participants were 20 badminton athletes aged 14-16 years. The sample obtained 10 male athletes and 10 female athletes. The flexibility instrument uses the sit and reach test. The data analysis technique used is ANOVA two way.

Results: Static stretching demonstrated greater effectiveness than dynamic stretching on flexibility (p-value 0.033 < 0.05). A notable difference was observed between male and female athletes regarding flexibility, with females exhibiting better flexibility (p-value 0.004 < 0.05). The study identified a significant interaction between stretching techniques (static and dynamic) and gender (male and female) on flexibility (p-value 0.000 < 0.05).

Conclusions: The research findings highlight the importance of gender-specific training programs that consider individual muscle capabilities and characteristics. By tailoring training regimens to each gender, badminton athletes can enhance their performance and reduce the risk of injuries. Based on these findings, it is recommended that badminton coaches and practitioners take into account the observed differences in the effectiveness of static and dynamic stretching based on gender.

Keywords: stretching static, stretching dynamic, flexibility, gender

Introduction

Badminton is a sport that belongs to the group of game sports. Badminton games can be played on or off the court, with the court being demarcated by lines of a certain length and width [1]. The badminton game uses a racket as a batting tool and a shuttlecock as the object being hit, the playing field is rectangular and is limited by a net to separate the playing area itself and the opponent's playing area [2]. Badminton sport is popular because almost every area is found badminton courts in both indoor and outdoor forms. The physical condition factor of athletes is very important in supporting the implementation of technical and tactical training. All sports, including badminton, definitely require good physical condition. Good physical condition can optimize in training and in a match. Physical condition is a capacity that must be possessed by an athlete in improving and developing maximum sports achievement. Some components in badminton physical condition are muscular power, explosive power, speed, coordination, endurance, reaction, strength, accuracy, flexibility, agility, and balance [3, 4, 5].

One of the physical condition elements needed for badminton players is flexibility [6, 7]. Flexibility is the ability of a joint to move with full Range of Motion (ROM), easily, without resistance and pain. An individual's ability to move smoothly depends on their flexibility, an attribute that enhances safety and optimizes physical activity. Flexibility is the ability of a joint, its surrounding muscles and ligaments to move freely and comfortably within the maximum expected range of motion. Flexibility is the ability of a joint to move within its joint range of motion [8,9]. Badminton players need a high level of flexibility to handle movements that are difficult to reach. Flexibility can affect the results of smash shots, where the flexibility of the backward took when doing smash will increase the strength of the blow. The better the backward bending of an athlete, the better the basic techniques that the athlete has, especially the basic smash technique. Research results showed that there is a significant relationship between flexibility and badminton smash ability [10]. Research results shows that there is a significant relationship between wrist flexibility and badminton service ability [11].

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Based on the results of observations in February 2023, it shows that the players' flexibility is still low. Like players when doing smash and service techniques, the flexibility of the wrist is too stiff, so that when hitting the shuttlecock the results are not good. Flexibility is one of the variables that support the results of smash ability. Flexibility can help swing the waist when hitting a smash, so that the shuttlecock hit is precise, strong and sharp at the target that the athlete has determined. Therefore flexibility also has an important role in smash ability.

It should be noted that choosing an exercise method to help smooth the training process is one of the very strategic efforts that can be made by a coach to deliver the training material that has been prepared. This is so that the training process is more interesting and fun, so that the training objectives can be achieved. The results of the methods provided by coaches that are less varied result in athletes not being able to improve mastery and understanding of the concept of motion optimally. This flexibility is needed by every athlete to make it easy to learn various movements, improve skills, reduce the risk of injury, and optimize strength, speed, and coordination. Determination can be developed through stretching exercises [stretching], whose model consists of dynamic stretch, static stretch, passive stretch, and Proprioceptive Neuromuscular Facilitation (PNF) [12,13].

The method that will be applied is the static stretching exercise method and the dynamic warm-up exercise method. Through stretching movements (stretching) can increase the range of motion (ROM) of the joints [14]. Stretching can improve flexibility, stamina, muscle strength, reduce joint muscle pain, have a greater ability to move maximum force through a wide range of motion, prevent some lower back problems, improve appearance and self-image and improve body alignment and posture [15]. Revealed that static and dynamic stretching are two commonly recommended stretching techniques to improve flexibility [16]. The right series of stretching exercises for flexibility should follow the general principles of training, namely: readiness, specificity, regularity, frequency, adjustment, overload, and size.

Static stretching is a type of stretching exercise in which muscle lengthening is performed with low force and long duration (usually 30 seconds). Static stretching has a relaxing effect, a lengthening effect on the muscle, increases range of motion, reduces muscle stiffness and also reduces the risk of acute muscle injury [17]. Static stretching is a movement that is performed slowly on the muscles until tension occurs and pain is reached. Stretching with this technique the body position is maintained without moving. Static stretching is a stretching exercise performed by maintaining the position of the stretched muscle for a long time, this stretch is done slowly and smoothly. When the muscle is stretched, the muscle spindle will also be stretched. Muscle spindles will report changes in length and how fast changes in muscle length occur, muscle spindles will also provide signals to the spinal cord to forward information to the central nervous system [18]. One of the advantages of static stretching is that it facilitates the Golgi Tendon Organ (GTO). Static stretching performed on the muscle tendon unit has been known to activate the GTO. Static stretching has been shown to be very effective in increasing hamstring length [19].

Dynamic stretching exercise is a stretching exercise by moving the body or limbs rhythmically without maintaining the farthest stretch position [20]. Dynamic stretching is a traditional training method to train flexibility, which is stretching done by moving the body or limbs rhythmically with rotating or bouncing movements of the limbs in such a way that the muscles feel stretched. The advantage of dynamic stretching exercises is that they progressively increase joint motion space, while the disadvantage of dynamic stretching exercises is that they can cause pain and injury to the muscles [21]. Exercises performed with regular frequency such as dynamic stretching exercises performed regularly for six days are physical activities that use the long term energy system [22]. Exercise that uses a long term energy system and is carried out continuously will cause adaptation to the mitochondria, so that energy metabolism is better. Aerobic metabolism increases the effectiveness of the level of muscle work making the oxygen supply sufficient to produce more energy and increase the peripheral response which causes vasodilation of the blood vessel walls and causes blood flow to be smooth, so that the heart workload decreases and so the pulse rate decreases. The decrease in pulse rate is caused by the frequency of exercise, namely dynamic stretching exercises which are carried out regularly for six days, and the results are known to be quite significant. Exercise frequency is closely related to exercise intensity and exercise duration. In doing exercise, the frequency of exercise should be carried out at least three times a week, both for health sports and for sports achievements. In this context, this study aims to investigate the impact of static and dynamic stretching on the flexibility of badminton athletes. The research objectives include analyzing the effectiveness of each stretching technique, comparing flexibility between male and female players, and examining the interaction between stretching methods and gender on athletes' flexibility.

Materials and Methods

Participants

The participants in this study were PB. MDP Sleman badminton athletes totaling 58 athletes. The sampling technique used is purposive sampling. The

criteria are still actively training, male and female, aged 14-16 years, not in pain, willing to follow the rules in the treatment applied. Based on these criteria, there were 20 athletes who met. The sample obtained 10 male athletes and 10 female athletes. Then from each of these data is divided into two groups by means of ordinal pairing and obtained 5 male athletes each were given static stretching exercises and 5 people were given dynamic stretching exercises, the same was done for groups of female athletes.

Research Design

This type of research is an experiment using a 2x2 factorial design (Table 1). Factorial design is experimental designs with more than one independent variable (manipulated) are known as factorial experimental designs. The term factor refers to each independent variable that is manipulated. The following is the research design for this experimental research.

Flexibility is assessed using a sit-and-reach test. This is done at the gym using standard boxes. Participants sit on the floor with their feet extended to most of their knees with the soles of their bare feet placed in a prone box. Participants are asked to reach the chest measurement line as far as possible and hold this position for 1-3 seconds. Participants were tested three times with the best result recorded in centimetres [23]. Static and dynamic stretching exercises were performed for 18 meetings.

Statistical Analysis

Data analysis can also be defined as an activity carried out to convert data from research into new information that can be used in making conclusions. The data analysis technique used in this study using Statistical Package for the Social Sciences (SPSS) software, specifically version 21. SPSS is to use two-way ANOVA, p-value < 0.05.

Results

The results of the pretest dan posttest flexibility between male and female athletes after being given static and dynamic stretching are presented in Table 2.

Based on Table 3, it can be observed that the flexibility of all four groups had an average pretest level and increased during the posttest.

Normality Test

The data normality test in this study used the Shapiro-Wilk method. The results of the data normality test carried out on each analysis group were carried out with the SPSS version 21.0 for windows software programme. The results of the normality test are presented in Table 4.

Based on the statistical analysis of the normality test using the Shapiro-Wilk test in Table 4, it shows that the pretest-posttest flexibility data for male and female athletes had p-values greater than or equal to 0.05, indicating that the data is normally distributed.

Homogeneity Test

A homogeneity test is useful to check the homogeneity of a sample. A homogeneous or heterogeneous sample drawn from a population. Univariate test with Levenes test. A test is declared unimodal if the univariate rule $p > 005$. Similar test results are shown in Table 5.

Table 1. 2 x 2 Factorial Research Design

Gender (B) \ Stretching Exercise (A)	Static (A1)	Dynamic (A2)
Male (B1)	A1. B1	A2. B1
Female (B2)	A1. B2	A2. B2

Description: A1B1 - Athletes trained using static stretching exercises were male. A2B1 - Athletes trained using dynamic stretching exercises were female. A1B2 - Athletes trained using static stretching exercises were male. A2B2 - Athletes trained using dynamic stretching exercises were female.

Table 2. Pretest and posttest of flexibility atlet male.

No	Male					
	Stretching Static (A1B1)			Stretching Dynamic (A2B1)		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
1	12.2	13.3	1.1	12.0	13.2	1.2
2	11.3	12.2	0.9	11.6	14.0	2.4
3	11.2	12.4	1.2	11.1	13.5	2.4
4	10.8	11.3	0.5	10.9	11.6	0.7
5	10.6	11.5	0.9	10.3	11.7	1.4
Mean	11.22 cm	12.14 cm	0.92 cm	11.18 cm	12.8 cm	1.62 cm

Table 3. Pretest and posttest of flexibility atlet female.

No	Female					
	Stretching Static (A1B2)			Stretching Dynamic (A2B2)		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
1	12.1	14.6	2.5	11.8	12.3	0.5
2	11.7	14.3	2.6	11.7	12.4	0.7
3	11.3	14.5	3.2	11.2	12.6	1.4
4	11.0	14.1	3.1	11.1	12.7	1.6
5	10.7	13.9	3.2	10.7	12.3	1.6
Mean	11.36 cm	14.28 cm	2.92 cm	11.30 cm	12.46 cm	1.16 cm

Table 4. Normality test results.

Group		Shapiro-Wilk		
		Statistic	df	Sig.
Male	Pretest Static	0.918	5	0.515
	Posttest Static	0.945	5	0.698
	Pretest Dynamic	0.988	5	0.971
	Posttest Dynamic	0.869	5	0.263
Female	Pretest Static	0.981	5	0.941
	Posttest Static	0.962	5	0.823
	Pretest Dynamic	0.936	5	0.635
	Posttest Dynamic	0.867	5	0.254

Table 5. Homogeneity test results.

Group	Levene Statistic	df1	df2	Sig.
Pretest-Posttest Static	5.044	3	16	0.112
Pretest-Posttest Dynamic	4.275	3	16	0.601

Table 6. Hypothesis test results.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Stretching	1.404	1	1.404	5.433	0.033
Gender	2.965	1	2.965	11.468	0.004
Stretching * Gender	7.565	1	7.565	29.263	0.000

Based on the statistical analysis of homogeneity tests using Wilk's Levene Test in Table 5, the calculation results for pretest-posttest static p-values were greater than or equal to 0.05 (p-value 0.112 and p-value 0.601). This indicates that the data groups have a homogeneous variant, suggesting that the population has a similar variant or is homogenous.

Hypothesis Test Results

Research hypothesis testing is carried out based on the results of data analysis and interpretation of the analysis. two-way ANOVA using the SPSS software, specifically version 21. The results of hypothesis testing are shown in Table 6.

Based on Table 6, in the static and dynamic stretching data, the F-value and p-value were found to be significant (F-value 5.433 and p-value 0.033 < 0.05). This confirms the hypothesis that there is a significant difference in the effect between static stretching and dynamic stretching on flexibility. The average static stretching group and dynamic stretching group had average differences of 0.53 cm. These results indicate that static stretching is more effective than dynamic stretching in improving flexibility.

Based on Table 6, the gender data (male and female) showed a significant difference (F-value 11.468 and p-value 0.004 < 0.05), confirming the hypothesis of a significant influence of gender on flexibility. The average flexibility for males was 1.27

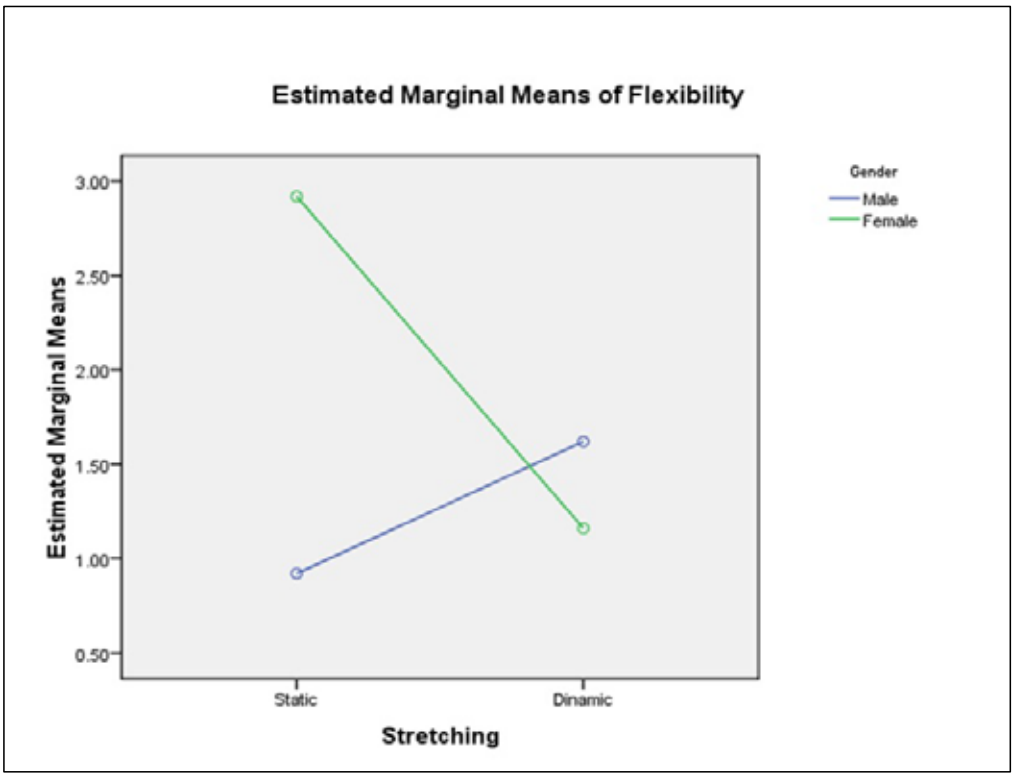

Figure 1. Interaction between stretching (static and dynamic) and gender (male and female) on flexibility.

Table 7. Tukey Test Result.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A1B1	A2B1	-0.7000	0.32156	0.172	-1.6200	0.2200
	A1B2	-2.0000*	0.32156	0.000	-2.9200	-1.0800
	A2B2	-0.2400	0.32156	0.877	-1.1600	0.6800
A2B1	A1B1	0.7000	0.32156	0.172	-0.2200	1.6200
	A1B2	-1.3000*	0.32156	0.005	-2.2200	-.3800
	A2B2	0.4600	0.32156	0.500	-0.4600	1.3800
A1B2	A1B1	2.0000*	0.32156	0.000	1.0800	2.9200
	A2B1	1.3000*	0.32156	0.005	0.3800	2.2200
	A2B2	1.7600*	0.32156	0.000	0.8400	2.6800
A2B2	A1B1	0.2400	0.32156	0.877	-0.6800	1.1600
	A2B1	-0.4600	0.32156	0.500	-1.3800	0.4600
	A1B2	-1.7600*	0.32156	0.000	-2.6800	-0.8400

Note: the results of the Tukey test calculation on the asterisk sign (*) show that the interaction pairs or pairs that are significantly different (significant) are: A1B1-A1B2, A2B1-A1B2, A1B2-A2B2, while the other pairs declared to have no difference in effect are: A1B1-A2B1, A1B1-A2B2, and A2B1-A2B2.

cm, while for females, it was 2.04 cm, with an average difference of 0.77 cm. These findings indicate that females have better flexibility than males. Additionally, based on Table 6, the interaction data between stretching (static and dynamic) and gender (male and female) also showed a significant result (F-value 29.263 and p-value 0.000 < 0.05). This supports the research hypothesis of a significant interaction between stretching methods and gender on flexibility. The graphical representation of the interaction test results between stretching (static and dynamic) and gender (male and female) on flexibility is presented in Figure 1.

After it is tested that there is an interaction between stretching (static and dynamic) and gender (male and female) on flexibility, it is necessary to conduct further tests using the Tukey test. Further test results can be seen in Table 7 below:

Table 8. Tukey HSD Test Result.

Group	N	Subset	
		1	2
A1B1	5	0.92	
A2B2	5	1.16	
A2B1	5	1.62	
A1B2	5		2.92
Sig.		.172	1.00

The results of the Tukey HSD analysis to determine which training group improved flexibility better are in Table 8 as follows.

Based on the Tukey HSD test results in Table 8, the A1B2 group (female athletes trained using static stretching) is in a different subset column. Based on this it can be concluded that the A1B2 group is better than the A1B1, A2B2, and A2B2 groups.

Discussion

The results of the first analysis showed that static stretching was better than the dynamic stretching group on flexibility. This is in accordance with the results of research on the comparison of the effectiveness of static stretching with dynamic stretching on increasing hamstring muscle flexibility with a total of 74 subjects who meet the criteria. The results showed that static stretching was more influential than dynamic stretching in increasing the flexibility of the hamstring muscles [24]. Static and dynamic stretching can basically both help improve flexibility. However, static stretching is considered more suitable for increasing flexibility, while dynamic stretching is more suitable for increasing muscle power than for increasing flexibility and joint range of motion. A total of 20 female students in their final year from various departments at Universitas Pendidikan Sultan Idris (UPSI) were involved in this study. Subjects were selected based on body mass index and never actively exercising. The wills were divided into two groups. Group A (n=10) will perform five types of static stretching exercises while the second group B (n=10) will perform five types of dynamic stretching exercises. They will do a 5-minute warm-up exercise of jogging before starting the stretching. The stretching exercises will be performed in three alternate days for four weeks. The results indicated that static stretching exercise is more effective in increasing the flexibility of the hamstring compared to dynamic stretching exercise and also has results on it in reducing the risk of injury [25].

Static stretching is performed by pulling the muscle to its maximum range and maintaining this position for a specified duration. One of the advantages of static stretching is that it facilitates the GTO. Static stretching performed on the tendon muscle unit has been known to activate the GTO. Static stretching has been shown to be very effective in increasing hamstring length [26]. Static stretching is a stretching exercise that is done by maintaining a stretched position for a long time, the movements are slow and smooth. When the muscle is stretched, the muscle spindle is also stretched. Muscle spindles will report changes in length and how fast the change in length occurs and provide signals to the spinal cord to forward information to the central nervous system. The muscle spindle will trigger the stretch reflex, also known as the myostatic reflex, to try to resist the changes in muscle length that occur by contracting the stretched muscle [27]. One of the reasons for maintaining a stretch for a long period of time is that when the muscle is maintained in the stretched position, the muscle spindle will get used to the new muscle length and will reduce the signal. Gradually the stretch receptors will be trained to provide greater length to the muscle. When the muscle is stretched slowly and gently, the Golgi tendon organ will be optimally stimulated, so that stretching will occur in muscle fibres and fascia where the number of sarcomeres increases and fascia is stretched. Stretch reflex has two components, namely the static component and the dynamic component. The static component is found throughout when the muscle is stretched. The dynamic component is found only at the end when the muscle is stretched and the response causes an immediate change in muscle length. The underlying reason that the stretch reflex has two components is because there are two intrafusal muscle fibres: nuclear chain fibres responsible for the static component and nuclear bag fibres responsible for the dynamic component. The muscle response to stretching basically occurs in the elastic components (actin and myosin) and the tension in the muscle increases sharply, the sarcomere lengthens and if this is done continuously the muscle will adapt.

Static stretching has a relaxing effect, lengthening effect on muscles, increasing ROM, reducing muscle stiffness and also reducing the risk of acute muscle injury [14]. In this method, there is no stretch reflect as in the dynamic stretching method. The movement of the joint to expand its space can be done maximally and continuously according to its ability, then maintained for some time and repeated several times according to the instructions of the trainer. When the muscle is passively stretched the initial elongation occurs in the sarcomere component and the tension increases drastically. When the strain is removed, the sarcomere will return to its initial length before being stretched. This tendency of the muscle to return is called elasticity. Meanwhile, when the muscle is actively stretched, the first effect will occur on elastin (actin and myosin), muscle tension increases sharply, sarcomeres lengthen and if done

continuously the muscle will adapt and will last for some time Flexibility itself has a relationship with the breadth of joint motion or range of motion. When flexibility increases, joint range of motion will increase.

The results of the second analysis found that female athletes have better flexibility than male athletes. Gender is one of the factors that affect flexibility and a person's ability to move joints. Most women will be more flexible than men [28], because it is due to differences in bone and joint structure. Females will have a lower torso body than males after adolescence. This is because females have a lower centre of gravity and shorter legs than males. Sex difference is one of the factors that affect flexibility. Girls will tend to be more flexible than boys in childhood when entering adulthood there will be little difference. Women are more flexible than men due to anatomical and hormonal influences. Women have wider hips than men or maybe because women do activities or sports related to good physical fitness, such as dancing, gymnastics, or swimming.

Another difference is due to the different anatomical structure of soft tissues between the two, namely muscles, tendons, ligaments and fascia in men are larger and thicker, which reduces the flexibility of these tissues, and the hormone estrogen in women also has an effect on increasing the elasticity of these soft tissues. Grimston tried to analyse ankle flexibility based on age and gender, and more specifically, the study concluded that age and gender are some of the factors that affect a person's flexibility. Where women have better ankle flexibility than men, and the growth factor of age makes a person's flexibility ability decrease (both male and female) [29]. Further findings showed for the flexibility test, women achieved a greater distance than men for the sit and reach test (p-value <0.001) [30].

Other literature also reveals several causes that can be used as a reference or basis related to women having better flexibility than men. The literature review that women's flexibility is better than men's is due to several things, such as: the factor of decreasing blood volume when the muscle is extending is better in women than in men, in other words it can be said that the mechanism of blood flow in the arteries in women is better than men [31], the influence of the hormone estrogen which makes differences in muscle composition in men and women, where the composition of female muscles is less than the composition of muscles in men, causing flexibility in women better than men [32], and another factor is the fasciculation of tendon muscles that is better in women than in men, thus making women more ideal in performing extension movements [33].

Based on the results that have been stated that there is a significant interaction between stretching (static and dynamic) and gender (male and female) on flexibility. The results showed that the static stretching group was a more effective method used for female athletes and the dynamic stretching group was more effective for male athletes. Some of the theories above are actually enough to explain that women's flexibility will indeed be superior to men, but what needs to be realised in this case is that the training factor in sports can be one of the things that affects flexibility itself. Back to the nature of sport, which is a systematic movement or sports activity for a long time, improved progressively and individually which leads to the characteristics of human psychological and physiological functions to achieve specified goals [34], It is not impossible for a male athlete to achieve the same flexibility as a female, if the male athlete is trained harder than the female athlete. Although we should be aware that men will have a heavier training dose in creating flexibility if they want to match women, given the physiological factors that favour women over men.

Conclusions

Based on the results of the research and data analysis, the following conclusions are drawn:

- There is a significant difference in influence between static stretching and dynamic stretching on flexibility (p-value 0.033 < 0.05). Static stretching is more effective than dynamic stretching in improving flexibility.
- There is a significant difference in effect between male and female gender on flexibility (p-value 0.004 < 0.05). Females exhibit better flexibility compared to males.
- There is a significant interaction between stretching (static and dynamic) and gender (male and female) on flexibility (p-value 0.000 < 0.05). The static stretching group is more effective for female athletes, while the dynamic stretching group is more effective for male athletes. Incorporating both static and dynamic stretching methods in training can effectively enhance flexibility.

Badminton coaches and practitioners are encouraged to consider gender-specific characteristics and muscle capabilities when designing training programs, especially focusing on flexibility, to improve athlete performance and reduce the risk of injury in badminton athletes.

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Conflict of interest

We are not aware of any conflict of interest related to this publication. Also no financial aspects were included in this study which might have affected the results. On behalf of the corresponding author I approve the manuscript for reading and submission by all named authors.

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