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ORIGINAL ARTICLE

Acute effect of five different stretching strategies on speed and agility parameters in recreationally active women

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ABSTRACT

BACKGROUND
Stretching includes movements that provide joint range of motion, increase the flexibility of muscles, joints, ligaments, and the speed of musculoskeletal communication, which are applied to increase performance in the main part of the training. Anaerobic properties are among the most important determinants of performance in athletes. Therefore, the objective of this study was to investigate the effects of five different stretching exercises on anaerobic performance (speed and agility parameters) in recreationally active women.

METHODS
A study of within-subject experimental design was conducted involving 30 recreationally active females aged 23.76 ± 1.50 years. Five different protocols (NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static + dynamic stretching; DSS: dynamic + static stretching) were used to measure performance parameters after stretching exercises. After each stretching exercise, the 10 and 20 m sprint, Illinois agility test, and reactive agility test were used to determine anaerobic performance. Repeated measures analysis of variance (ANOVA) was employed for the analysis.

RESULTS
A notable difference was observed in the 10 m and 20 m performance of recreationally active women after five different stretching protocols ($p<0.05$). When looking at the agility test values, it was found that a significant difference existed ($p<0.05$). DS showed the best performance in all tests.

CONCLUSION
According to these results, in recreationally active women, only SS should be avoided before high or explosive exercises, or the warm-up period should include only DS, or if a combined application is to be made, DS should be applied after SS.

Keywords: Recreationally active women, stretching, dynamic stretching, speed, agility, warm-up

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INTRODUCTION

A warm-up protocol is very important in order to exhibit the highest sports performance in training or competition.[1] The negative or positive effects on performance of the stretching exercises performed in the warm-up section have become an important issue for coaches and athletes.[2] Many athletes incorporate stretching exercises into their warm-up routine before physical activity to prevent injuries and improve their performance through increased flexibility.[3] Various stretching exercises are performed by professionals, amateurs, and recreational exercisers as part of the warm-up section[1] to achieve high performance in the main part of the exercise.[4] The purpose of stretching exercises is to enhance the person's ability to adapt to the muscles by achieving sufficient joint range of motion while performing sports activities and reducing the risk of injury by reducing muscle stiffness.[5] Stretching methods have different physiological and neurological effects. The most discussed stretching types in the literature are static, dynamic, ballistic, and proprioceptive neuromuscular facilitation (PNF) stretching.[2,5-8]

While static stretching (SS) has been shown to serve as an effective approach to enhance joint range of motion,[9] it has been reported that dynamic stretching (DS) exercises increase body temperature, control muscle stiffness, and increase coordination skills and proprioceptive sensitivity.[10] Ballistic stretching (BS) contains rapid and active movements throughout the entire joint range of motion.[11] The basic mechanism of action in PNF techniques is the transmission of the stimulus to the reflexes in the body and its location. Proprioceptive neuromuscular facilitation shows potential benefits if performed correctly and consistently.[12]

Studies revealing the negative effect of static stretching exercise on performance have directed coaches, athletes, and sports scientists to different stretching exercise protocols.[13-18] When the literature is investigated, it is not clear which type of flexibility should be used, but the debate on this issue continues.[13,14,19-22] In the studies by Blazevich et al.[20] it is reported that short-term SS or DS does not affect the performance of fast running, jumping, or changing direction when included as a component of a physical preparation regimen. Some studies report that SS may negatively affect subsequent performance.[17, 23] Iwata et al.[21] report in their study results that the dynamic method has more positive effects on vertical jump performance than the static method. Chatzopoulos et al.[22] reported that DS statistically improved acute agility performance compared to SS. In another study, Gürses and Akgül [11] applied four different stretching protocols, comprising NS, SS, DS, and combined stretching (CS), to athletes. As a result of the study, the investigators state that the stretching activities applied do not have an acute effect on short-term high-intensity performances. As can be seen, although each type of stretching has different characteristics, there is no consensus on which one should be used before or after training or competition.

The biology and physiology of women, including factors such as heart size, oxygen capacity, and muscle ratio, differ from those of men in several key ways.[23-25] In addition. women's physiological responses to exercises have always been a topic of focus and curiosity in research conducted in the field of sports sciences.[26,27] However, when looking at the literature, it is generally seen that various stretching exercise types have been examined in studies conducted on male athletes of different ages and performing different sports branches.[4,16,28] A study by Cigerci et al.[18] involving 30 men showed that DS variations should be prioritized before activities that demand speed and strength. Cigerci's study includes only male participants, therefore it does not provide any information about women. A different study with ten recreationally active individuals (5 men and 5 women) investigated how various warm-up protocols influence peak power in the Wingate Anaerobic Test (WAnT). In this study, it is stated that different stretching exercises do not cause any difference in the performance of the participants, but although there are female participants in the study, it is seen that women's values are not examined separately.[29]

A cross-over, repeated-measures study involving 26 female gymnasts showed that DS offers significant advantages for enhancing explosive performance skills, such as the 20 m sprint and agility performance.[30]

When the above information is taken into consideration, it is seen how effective warm-up protocols are for the initial periods of training in professional or non-professional individuals. The existing literature includes only a few studies that investigate the impact of various warm-up protocols on sports performance in female athletes.[26,27,30] The difference between our study and the other studies is that there is no other study

on recreationally active women. Therefore. the aim of our study was to investigate the effects of five different stretching exercises on speed and agility parameters of recreationally active women.

METHODS

Research design

A within-subject experimental study was conducted in the Kastamonu University gymnasium, where a specific type of stretching exercise was performed, measurements were taken, followed by a day of rest. This study was completed over a total of 10 days (in January 2024).

Research subjects

The minimum number of participants required for the study was determined by G-Power analysis version 3.1.9.6 (Düsseldorf, Germany) and the minimum power of 80% was calculated for a bias level of 0.05, resulting in a total number of participants (sample) of 30. Therefore, the number of participants in this study is considered to be quite sufficient for repeated tests. Thirty recreationally active female volunteers who exercise at least two days a week participated in the study. The inclusion criteria were as follows: no injuries within the past 6 months, and age range of 21-28 years. Subjects had to be free of orthopedic health problems and must have regularly participated in the tests (10-20 meter sprint, Illinois agility, and reactive agility tests). The exclusion criteria were: any health problems (such as fever or hypertension) or injuries during the study, irregular participation in the tests**,** and failure to perform maximally, as the tests were anaerobic-based. For performance evaluation, the Karvonen formula was used: X = [220-Age-Resting Pulse] x Exercise intensity (85%) + Resting Pulse, where performance is considered anaerobic if it exceeds X.[31] All measurements were performed at 10:30 am.

Anthropometric profile

While the participants were in an anatomical posture, their height and body weight values were measured with the help of a stadiometer (Holtain, UK). Additionally, body mass index (BMI) was calculated with the formula kg/(height)^2.

Measurements

To obtain the results of the tests applied after the stretching exercises, the 10 m sprint, 20 m sprint, Illinois agility, and reactive agility tests were applied.

Sprint test: the sprint was initiated from a standing start position. Subjects began the test positioned 1 meter behind the starting line. The time of the 10 m and 20 m sprints was recorded using the Newtest 2000 sprint timing system (Newtest Oy, Oulu, Finland). Two pairs of photocells were positioned at distances of 10 meters and 20 meters. The first pair was positioned at the starting line (0 m), while the second pair was set up at the finish line (10 m and 20 m). Each participant began running from an upright position 50 cm before the first pair of photocells, aiming to sprint through the finish line (the second pair) without slowing down. The best of the two attempts was accepted as the test score.[1]

Illinois agility test: the Illinois agility test is a commonly utilized field assessment that evaluates a person's capacity to quickly change direction while running. This test is performed in an area of 5 m width and 10m length. The midline of the 10 m length is divided into 3 by cones placed at equal intervals (approximately 3.3 m). Before starting this test, the subjects lie face down and place their hands on the ground at shoulder level. They remain in this position, ready and waiting. This test consists of approximately 40 meters of straight running and 20 meters of slalom running between cones. This test consists of 5 spins of approximately 180° each, in addition to a full rotation, and includes 6 additional spins (Figure 1). Subjects started from the starting point on command and ran to the finish point in the shortest time by zigzagging through the center cones following the arrows. The best of the two attempts was accepted as the test score.[14]

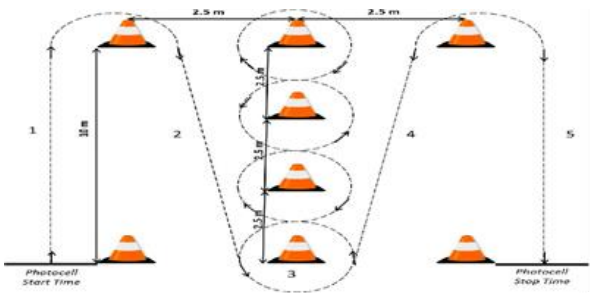

Figure 1. Illinois agility test

Reactive agility test: this agility test evaluates a player's speed, agility, and quick reaction to recognize stimuli. It consists of running skills involving a 45° change in direction and a total distance of 5 meters. Subjects start the test from the starting point with the exit command and after a 2-meter run, they exit the gate on the right or left according to the flashing light command (Figure 2). The test is performed twice and the better one is recorded in seconds.[32]

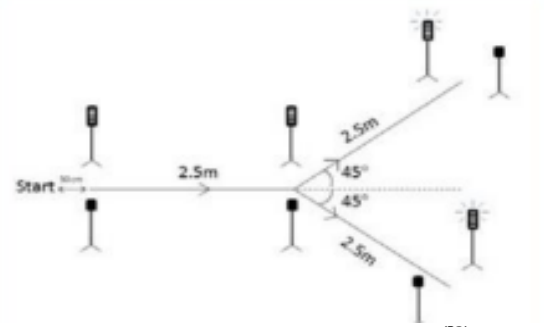

Figure 2. Reactive agility test [32]

Table 1. Stretching exercise protocols[19]

NS	SS	DS	SDS	DSS
	Latissimus dorsi muscle group	High glute pull	Latissimus dorsi muscle group + High glute pull	High glute pull + Latissimus dorsi muscle group
	Pectoralis major (chest) muscle group	Walking lunge	Pectoralis major (chest) muscle group + Walking lunge	Walking lunge+ Pectoralis major (chest) muscle group
	Trapezius (neck) muscle group	Light high knees	Trapezius (neck) muscle group + Light high knees	Light high knees + Trapezius (neck) muscle group
	Abdominis (abdominal) muscle group	High knee pull	Abdominis (abdominal) muscle group + High knee pull	High knee pull + Abdominis (abdominal) muscle group
	Gluteus maximus (hip) muscle group	Straight leg kick	Gluteus maximus (hip) muscle group + Straight leg kick	Straight leg kick + Gluteus maximus (hip) muscle group
	Quadriceps (front leg) muscle group	Carioca	Quadriceps (front leg) muscle group + Carioca	Carioca + Quadriceps (front leg) muscle group
	Hamstring (back leg) muscle group	Skipping A	Hamstring (back leg) muscle group + Skipping A	Skipping A + Hamstring (back leg) muscle group
	Calf muscle group	Skipping B	Calf muscle group + Skipping B	Skipping B + Calf muscle group

NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

RESULTS

The mean age, height, weight, and BMI of the 30 subjects participating in the study were 23.76 ± 1.50 years; 1.66 ± 0.03 m; 58.47 ± 5.36 kg; and 21.12 ± 3.75 kg/m^2, respectively.

When Table 2 is examined, a significant difference is detected in the 10 m performance of recreationally active females in our study after five different stretching protocols ($p<0.014$). Accordingly, it is seen that there is a difference between NS and DS, SS and DS, DS and SDS, and DS and DSS, respectively, with DS performing better. When looking at the 20 m results, it is seen that there is a significant difference in the stretching exercises between NS and DS, SS and DS, DS and SDS, and DS and DSS ($p<0.003$), with DS performing better than the other stretching protocols. When looking at the Illinois agility test values, it is evident that there is a significant difference between NS and DS, NS and SDS, NS and DSS, SS and DS, DS and SDS, and DS and DSS ($p<0.000$). Additionally, when the reactive agility test values are examined, it is found that there is a significant difference between NS and DS, NS and SDS, NS and DSS, SS and DS, SS and SDS, and SS and DSS ($p<0.000$).

The Bonferroni multiple comparison test for the 10 m test (Table 3), the 20 m test (Table 4), and the Illinois agility test (Table 5), revealed that the DS protocol resulted in faster 10 m, 20 m, and Illinois agility test results compared to NS, SS, SDS, and DSS ($p=0.000$). Furthermore, there was no statistically significant difference of DS with SDS and DSS in reactive agility test (Table 6, $p>0.005$). According to these results, DS showed the best performance in both agility tests.

Table 2. Comparison of speed and agility test after no stretching (NS), static stretching (SS), dynamic stretching (DS), SDS, and DSS (n=30)

Variables	Protocols					p value
	NS	SS	DS	SDS	DSS	
10 m (s)	2.36 ± 0.12	2.37 ± 0.15	2.25 ± 0.14	2.33 ± 0.17	2.36 ± 0.16	0.014*
20 m (s)	3.93 ± 0.22	3.90 ± 0.23	3.76 ± 0.30	3.85 ± 0.30	3.87 ± 0.29	0.003*
Illinois agility (s)	19.88 ± 1.30	19.83 ± 1.29	19.55 ± 1.15	19.65 ± 1.16	19.67 ± 1.17	0.000*
Reactive agility (s)	1.70 ± 0.09	1.67 ± 0.07	1.58 ± 0.08	1.60 ± 0.08	1.61 ± 0.07	0.000*

*p<0.05; Data presented as mean ± SD; NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

Table 3. Bonferroni multiple comparison test results for 10 m

Groups (I)	Groups (J)	Mean Difference (I-J)	p value
NS	SS	-0.006	1.000
	DS	0.117	0.000*
	SDS	0.034	0.625
	DSS	0.007	1.000
SS	NS	0.006	1.000
	DS	0.123	0.000*
	SDS	0.041	0.227
	DSS	0.014	1.000
DS	NS	-0.117	0.000*
	SS	-0.123	0.000*
	SDS	-0.082	0.000*
	DSS	-0.109	0.000*
SDS	NS	-0.034	0.625
	SS	-0.041	0.227
	DS	0.082	0.000*
	DSS	-0.027	0.006*
DSS	NS	-0.007	1.000
	SS	-0.014	1.000
	DS	.0109	0.000*
	SDS	0.027	0.006*

***p<0.05; NS:** no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

DISCUSSION

Speed and agility are the most important psychomotor features in athletes. The physiology of women differs from men in many points. Women's physiological responses to exercises have always been a topic of focus and curiosity in research conducted in the field of sports sciences.[26,27,30] In this context, the objective of our study was to investigate the immediate effects of various stretching exercises on speed and agility, which are anaerobic motoric characteristics in recreationally active females. One of the results we found in our study is that SS applied to recreationally active females did not have an acute significant effect on speed and agility. On the contrary, it was found that DS was statistically significantly more effective on the speed and agility characteristics compared to all other stretching protocols in the study. On the other hand, we can say that the combined protocol of dynamic stretching after static stretching achieved the best results after DS. In the literature, the negative effects or benefits of stretching practices performed before exercise are discussed.[5,33,34] Although there are very few studies investigating the acute effects of various stretching exercise strategies on the performance of female athletes, it seems that there is no consensus on these. Wallmann et al.[35] stated that in their study where they examined the effects of different stretching techniques on the agility characteristics of female football players, they did not find any difference. Similarly, a study on female collegiate soccer players showed that various types of stretching performed in the warm-

up section did not affect effect on subsequent athletic ability test performance.[36] Dallas et al.[30] in their study examining the effects of different stretching techniques on the sprint performance and agility characteristics of female gymnasts, stated that dynamic stretching provides significant benefits for improving explosive performance skills. Zmijewski et al.[37] in their study examining the effects of static and dynamic stretching warm-up protocols on repetitive sprint performance in female handball players, also found that dynamic stretching led to a greater increase in repetitive sprint performance compared to both no stretching and static stretching protocols.

Table 4. Bonferroni multiple comparison test results for 20 m

Groups (I)	Groups (J)	Mean Difference (I-J)	p value
NS	SS	0.024	0.703
	DS	0.168*	0.003*
	SDS	0.078	0.640
	DSS	0.056	1.000
SS	NS	-0.024	0.703
	DS	0.144*	0.006*
	SDS	0.054	1.000
	DSS	0.032	1.000
DS	NS	-0.168*	0.003*
	SS	-0.144*	0.006*
	SDS	-0.090*	0.000*
	DSS	-0.112*	0.000*
SDS	NS	-0.078	0.640
	SS	-0.054	1.000
	DS	0.090*	0.000*
	DSS	-0.022	0.175
DSS	NS	-0.056	1.000
	SS	-0.032	1.000
	DS	0.012*	0.000*
	SDS	0.022	0.175

*p<0.05; NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

Table 5. Bonferroni multiple comparison test results for Illinois agility test

Groups (I)	Groups (J)	Mean Difference (I-J)	p value
NS	SS	0.044	0.234
	DS	0.328*	0.000*
	SDS	0.228*	0.014*
	DSS	0.212*	0.040*
SS	NS	-0.044	0.234
	DS	0.283*	0.000*
	SDS	0.184	0.061
	DSS	0.168	0.161
DS	NS	-0.328*	0.000*
	SS	-0.283*	0.000*
	SDS	-0.100*	0.000*
	DSS	-0.115*	0.004*
SDS	NS	-0.228*	0.014*
	SS	-0.184	0.061
	DS	0.100*	0.000*
	DSS	-0.016	1.000
DSS	NS	-0.212*	0.040*
	SS	-0.168	0.161
	DS	0.115*	0.004*
	SDS	0.016	1.000

*p<0.05; NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

Table 6. Bonferroni multiple comparison test results for reactive agility test

Groups (I)	Groups (J)	Mean Difference (I-J)	p value
NS	SS	0.028	0.254
	DS	0.117	0.000*
	SDS	0.097	0.000*
	DSS	0.084	0.000*
SS	NS	-0.028	0.254
	DS	0.089	0.000*
	SDS	0.069	0.000*
	DSS	0.056	0.005*
DS	NS	-0.117	0.000*
	SS	-0.089	0.000*
	SDS	-0.020	0.434
	DSS	-0.033	0.095
SDS	NS	-0.097	0.000*
	SS	-0.069	0.000*
	DS	0.020	0.434
	DSS	-0.013	1.000*
DSS	NS	-0.084	0.000*
	SS	-0.056	0.005*
	DS	0.033	0.095
	SDS	0.013	1.000*

*****p<0.05; NS: no stretching; SS: static stretching; DS: dynamic stretching; SDS: static stretching + dynamic stretching; DSS: dynamic stretching + static stretching

On the other hand, Chatzopoulos et al.[22] in their study on female university athletes, stated that DS achieved better results in agility and movement time characteristics than SS. Kruse et al.[38] in their study examining the effects of different stretching protocols on the vertical jumps of female volleyball players, recommended DS during the warm-up period for higher performance.

We see that studies conducted on men on this subject report similar results to those of women. Ciğerci et al.[18] stated that the static stretching protocol they applied did not reveal a negative effect on speed and agility.

On the other hand, Galazoulas[1] in his study comparing the acute effects of static and dynamic stretching exercises on the countermovement jump and sprint characteristics of basketball players, reported that SS caused a decrease in performance.

In addition, different results are reported in combined stretching where SS and DS are applied together. In one of these studies, Amiri-Khorasani et al.[39] state that this combination improves speed performance. On the other hand, another study stated that SS applied after DS led to increased speed performance.[40]

It is reported in the literature that SS provides joint range of motion, thus reducing the risk of injury.[41] However, some sources state that SS causes loss of strength by negatively affecting the length-tension relationship during the storage of elastic energy in the eccentric phase of muscle contraction and by causing neuromuscular inhibition.[9] It is stated that DS provides a similar increase in flexibility as SS.[42] In addition, DS increases muscle power production and stretching speed by lengthening muscle fibers. Furthermore, by lengthening muscle fibers, it provides an increase in muscle power production and stretching speed, which is important for anaerobic properties.[43] Muscle temperature increases with DS applied in the warm-up section, reducing muscle stiffness. Thus blood and muscle lactate levels decrease, while glycolysis and glycogenolysis in the muscles increase. Additionally, this increases high-energy phosphate degradation. As a result, it is stated that the anaerobic properties of the muscles increase.[10] It is also reported that DS increases exercise results by increasing body and muscle temperature, increasing heart rate, motor unit stimulation, and kinesthetic sensation.[44] Since static stretching is a passive exercise and there is no increase in muscle temperature, the conditions mentioned for DS will not occur.

One of the limitations of our study is that it was applied to female individuals aged between 21 and 28 who participated in recreational activities at least two days weekly. Therefore, this study is limited to female individuals who do not have an active exercise plan. The same study can also be

applied to recreationally active individuals of different age groups, male and female, or to female individuals with a specific exercise plan. Another limitation is the lack of control regarding menstrual cycle fluctuations. Future studies should be carried out by ensuring menstrual cycle control. Individuals were given information about nutrition, but each individual's daily activity and nutrition routine was not followed. The same study should be applied by following a regular nutrition program.

CONCLUSIONS

As the most striking result of our study, DS exercises used by recreationally active females in the warm-up period are statistically more effective than other stretching protocols. According to these results, only SS should be avoided before high or explosive exercises, or the warm-up period should include only DS, or if a combined application is to be made, DS should be applied after SS.

Conflict of Interest

The authors declare no conflict of interest.

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Author Contributions

HG contributed to the design, implementation, and analysis. AEC contributed to the design and revision.MA contributed to the implementation, analysis, and revision stages of the study. All authors have read and approved the final manuscript.

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Data Availability Statement

Requests for the original data presented in this study can be directed to the corresponding author.

Declaration of Use of AI in Scientific Writing

The authors declare that they did not use artificial intelligence (AI) in the writing of this manuscript.

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