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ACUTE EFFECTS OF FIVE DIFFERENT STRETCHING EXERCISES ON AGILITY AND SPEED

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Abstract The aim of the research was to evaluate the acute effect of five different stretching techniques used as a part of agility and speed training. The sample groups consisted of 108 PF UJEP students who study in the field of physical education and sports. Participants performed five different warm-up stretching models in five different weeks, each Monday at the same time and place. The agility test and sprint were applied immediately after each stretching exercise. Both tests were performed without stretching (NS), after static stretching (SS), dynamic stretching (DS), static + dynamic stretching (SDS), and dynamic + static stretching (DSS) following 5 minutes of jogging. The ANOVA Chi Square statistical method and Wilcoxon Matched Pairs Tests were used to evaluate the data. The differences between the protocols were as follows NS with DS, NS with DSS, NS with SDS, SS with DS, SS with DSS, SS with SDS, DSS with SDS in 10 m ($p < 0.05$). There is a statistical difference between NS with SS, NS with DS, NS with DSS, NS with SDS in Illinois agility test ($p < 0.05$). Types of dynamic stretching have a positive effect on strength and speed sports performance. To increase agility, it is recommended to warm up in combination with a model of dynamic stretching after static stretching.

Key words: agility, stretching, warm-up, speed

Introduction

Warm-up is an integral part of the training and teaching unit when there is an increase of requirement for sports performance. Warm-up is important to increase body temperature and stretching is primarily intended to increase range of motion at a joint or group of joints. Stretching further compensates for one-sided loading, reduces muscle tension, facilitates regeneration after loading and creates a feeling of body relaxation.

There are various types of stretching such as static stretching, dynamic stretching, ballistic (swing stretching), proprioceptive neuromuscular facilitation (PNF) stretching and many of its subtypes. In our research, we deal with static and dynamic stretching, including their combinations. Static stretching is slow stretching of the muscles in the final position up to 60 seconds (Peck et al., 2014; Torres et al., 2008; Young & Behm, 2002). It is necessary to respect gradual stretching with prolonged exhalation and avoid drastic stretching, which is very painful and unwholesome. Mild stretching, when, after taking up the starting position, the muscle is slowly stretched to the appropriate position with a feeling of a slight stretch, is followed by a phase after two to three seconds of releasing the developing stretch, i.e., the second phase continuing the tensile action on the muscle. Dynamic stretching is performed in such a way that the driving force of the movement is the kinetic energy of the body. The movement is carried out in a controlled and conscious manner without maintaining the final position, but there is no swing [4]. The positives of dynamic stretching are that the neural pathways responding to the stretching stress are activated more strongly than with static stretching, the rapid strength in the muscles is better preserved than with static stretching, coordination within the muscle is improved, and the capillaries remain fully open during exercise, while the muscles can be continuously perfused (Kabešová, 2017; Slomka & Regelin, 2008).

Research deals with the question of the influence of warm-up on the performance itself. The issue of the application of stretching as a part of the warm-up before performance is currently a highly discussed topic. A number of studies suggest that dynamic forms of stretching should be preferred over activities that require speed and strength (Aguilar et al., 2012).

Dynamic stretching causes faster contractions of activated muscles and is therefore a prerequisite for faster movements. Muscles produce more force after dynamic stretching due to increased activation of motor units (Behm & Caouachi, 2011). In contrast, a reduced ability to produce force was demonstrated after static stretching, which was due to reduced motor unit activation, or reduced inelasticity of muscle tendon units (Hayes & Walker, 2007). A decrease in the effect on performance occurred after the application of static stretching during the warm-up for running sprint and power endurance performances (Nelson et al., 2005; Nelson & Kokkonene, 2021), for standing long jump and other activities with static force production (Behm & Chaouachi, 2011; Nelson & Bandy, 2005; Nelson & Kokkonene, 2021). It is recommended using a sport-specific warm-up phase method that combines dynamic stretching after static stretching to increase the athlete's speed and agility (Aguilar et al., 2012).

The acute effect of static stretching has a negative effect on agility and sprint performance. This study suggests that dynamic and static + dynamic stretching could be used to achieve better acceleration, speed, and agility performances during warm-up training in young tennis players (Kilit et al., 2017).

Static stretching (SS) shows a decline in many domains, including strength, anaerobic power, and sprint time. Dynamic stretching (DS) shows an increase in anaerobic power and a decrease in sprint time. Research on the effects of stretching on agility performance is limited (Aguilar et al., 2012).

The aim of the study

The aim of the research was to evaluate the acute effect of five different stretching techniques used as a part of agility and speed training. It is assumed that after warming up with dynamic stretching and combinations with dynamic stretching, there will be a relevant improvement in the level of selected tests of agility and speed.

Materials and methods

Participants

The study was attended by 108 healthy and physically active students at the University of Jan Evangelista Purkyně in Ústí nad Labem studying in the field of physical education and sports. The average age of men (n = 72), which was 21.15 + 1.69 years, mean height was 1.80 + 6.25 m and body weight average was 77.52 + 10.05 kg and for women (n = 36) the average age is 21.11 + 2.45 years, mean height 1.68 + 6.28 m and body weight average 61.38 + 5.61 kg.

The criterion for inclusion of the participant in the research was the absence of health problems at the time of the research and regular participation in the research. The students participated voluntarily and confirmed their participation in the study by filling in the informed consent form. Each participant was informed about the procedure and participant´s consent was obtained. If students did not meet the given criteria, they were excluded from the study. All tests were carried out at the same time of day (9 o´clock a.m.) and the implementation took place in five weeks, every Monday from April 2023.

Research design

Participants were informed about the individual steps of the research and were provided with information about the implementation of the test. All actions were carried out under the guidance of the examiner. Testing took place under standard conditions (time, temperature, place) within 5 weeks from April 2023 and the first initial anthropometric assessment.

Participants were informed not to exercise or consume alcohol or caffeine 24 hours before the tests. The stretching warm-up model was performed under the supervision of an expert after a 5-minute warm-up (aerobic jogging of minimum intensity). After each applied model of stretching exercises, the Illinois agility test (s) and a 4 x 10 m (s) shuttle run followed.

The height of the participants was measured using a stadiometer (cm) and body weight was determined using a Tanita scale (kg).

Performance test

Sprint test 4 x 10 m (s) and Illinois agility test (s) were used to determine performance parameters. Information from a controlled interview was used to collect data.

In Figure 1, the Illinois agility test starts at point A, proceeds to point B, and from there zigzags around funnels spaced 3.3 m apart to point C and the test finished at point D (Miller et al., 2006). Test is set up with four cones forming the agility area (10 meters long x 5 meters wide). Cone at point A, marking the start. Cone at B & C to mark the turning spots. Cone at point D to mark the finish. Start lying face down with the hands at shoulder level. On the "go" command, participant begins and time starts when they cross the photocells. Participants should get up and run the course along the set path (left to right or right to left). At the turn spots B and C, they must ensure they touch the cones with their hand. The trial is considered complete when they cross the finish line and no cones have been knocked over.

Sprint test: at the whistle, the participant runs from a semi-high start position from one cone, then the second cone is run around, and the participant returns diagonally to the first cone (so that the track forms a figure eight). After running around, he/she continues to the second cone again, touches it and returns to the start, where he/she must touch the cone again. Each participant first runs the entire course on trial to avoid mistakes. Each proband first runs the entire course on trial to avoid mistakes. Two attempts are made, between which there must be a break of at least 5 min. A better result is noted. Time is measured with an accuracy of 0.1 s. Running path (figure 2) (Pětivlas & Mrázková, 2012).

Stretching exercise protocol

Five types of stretching exercises were used in the following order: non-stretching phase NS, SS (static stretching), DS (dynamic stretching), SDS (static and dynamic stretching) and DSS (dynamic and static stretching).

The non-stretching phase consists of 5 minutes of moderate-intensity aerobic jogging, after which the participants are tested without any other exercise application.

In the SS phase, after a warm-up, i.e., 5 minutes of aerobic jogging, and a cooldown, static stretching followed with eight static exercises targeting the upper and lower limbs and the trunk. The procedure for SS was to take the starting position of the exercise and then stretch with holding time in the extreme position for 30 seconds. The exercise focused on latissimus dorsi (back), pectoralis major (chest), trapezius (neck), rectus abdominis (abdomen), gluteus maximus (hip), quadriceps (front of the leg), hamstring (back of the leg), gastrocnemius (calf) muscle groups.

For DS, the same exercises as in research (Cigerci et al., 2023) were applied: high glute pull, walking lung, light high knees, high knee pull, straight leg kick, carioca, skip A (jumping), skip B (jumping).

In the combination of SS and DS stretching, 8 static exercises with holding time in the extreme position for 30 s were applied, followed by 8 dynamic exercises with 15 s intervals between repetitions. In the combination of DS and SS stretching, the application was reversed. First 8 dynamic stretches were performed with 15 s intervals between repetitions, and then eight static stretches were performed once for 30 seconds at the point of maximal range of motion (Aydin et al., 2019).

Statistical analysis of data

Data were analyzed by analysis of variance (ANOVA) using Statistica software. According to the Shapiro-Wilk normality test, we dealt with non-parametric data and the Wilcoxon test was used to compare the stretching groups. The Wilcoxon test is a non-parametric test used to compare the means of two sets and to determine whether the results of one intervention group are significantly different from the results of the other intervention group. Statistical significance was tested at $p = 0.05$.

The Pearson´s correlation coefficient was used to determine the relationship between the performance achieved in the Illinois test and the sprint test in men, women and all participants with the same type of warm-up.

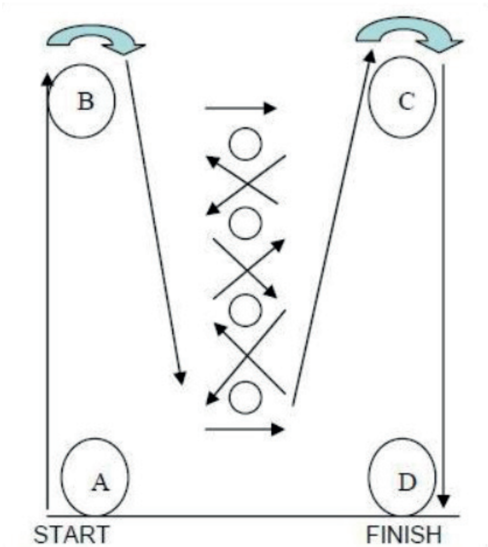


Figure 1. Illinois Agility Test (Miller et al., 2006).

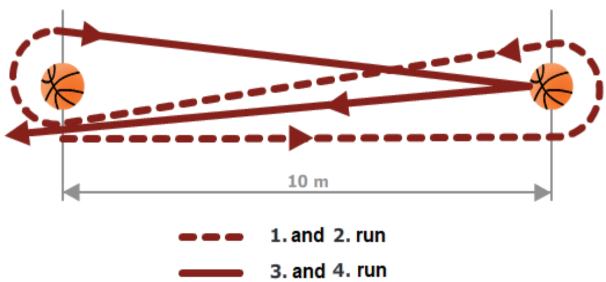


Figure 2. Sprint test 4 x 10 m (Pětivlas & Mrázková, 2012).

Results

In order to use adequate statistical procedures, we first monitored the normality of the variables using the Shapiro-Wilk test. We can state that the monitored quantities have a frequency distribution other than normal, so we will use non-parametric statistical procedures.

The following results present statistically significant differences for individual types of warm-up for the Illinois test. Based on the results of Friedman ANOVA and Kendall Coeff. of Concordance, individual types of stretching in the Illinois test are statistically significant (ANOVA Chi Sqr. ($N = 108$, $df = 4$) = 44.75 $p < 0.00000$; Coeff. of Concordance = 0.10361 Aver. rank $r = 0.09523$). Table 1 contains the comparison of individual stretching exercise protocols for the results of the Illinois test ($p < 0.05$). For the results of the Illinois Agility test, there is a statistical difference between NS & DS, NS & DSS, NS & SDS, SS & DS, SS & DSS and SS & SDS ($p < 0.05$). DS proved to be the most effective, followed by SDS (Figure 3).

Table 1. Comparison of individual types of warm-ups for the Illinois test (N=108)

Type of Stretching	Median (s)	Vs. type of Stretching	Median (s)	Z	p-level
No Stretching	16.89	Static Stretching	16.54	1.58	0.11
		Dynamic Stretching	15.95	4.75	0.00
		Dynamic Stretching + Static Stretching	16.45	3.35	0.00
		Static Stretching + Dynamic Stretching	16.27	4.50	0.00
Static Stretching	16.54	Dynamic Stretching	15.95	4.56	0.00
		Dynamic Stretching + Static Stretching	16.45	2.49	0.01
		Static Stretching + Dynamic Stretching	16.27	3.31	0.00
Dynamic Stretching	15.95	Dynamic Stretching + Static Stretching	16.45	0.91	0.36
		Static Stretching + Dynamic Stretching	16.27	0.73	0.46
Dynamic Stretching + Static Stretching	16.45	Static Stretching + Dynamic Stretching	16.27	2.84	0.00

Wilcoxon Matched Pairs Test (*p < 0.05)

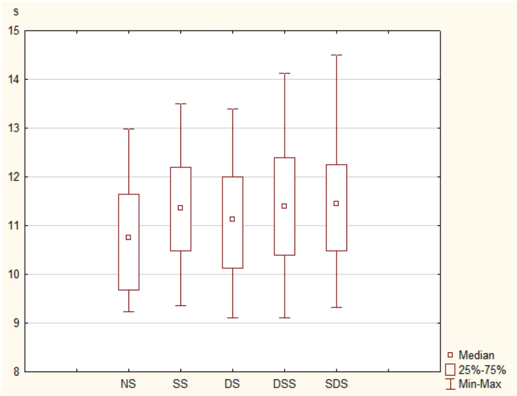
Table 2. Comparison of individual types of warm-up for Sprint test 4 x 10 m (N=108)

Type of Stretching	Median (s)	Vs. type of Stretching	Median (s)	Z	p-level
No Stretching	10.74	Static Stretching	11.35	5.27	0.00
		Dynamic Stretching	11.13	2.99	0.00
		Dynamic Stretching + Static Stretching	11.45	4.49	0.00
		Static Stretching + Dynamic Stretching	11.45	4.93	0.00
Static Stretching	11.35	Dynamic Stretching	11.13	1.53	0.12
		Dynamic Stretching + Static Stretching	11.45	0.48	0.62
		Static Stretching + Dynamic Stretching	11.45	0.66	0.50
Dynamic Stretching	11.13	Dynamic Stretching + Static Stretching	11.45	0.95	0.33
		Static Stretching + Dynamic Stretching	11.45	1.81	0.06
Dynamic Stretching + Static Stretching	11.45	Static Stretching + Dynamic Stretching	11.45	0.75	0.45

Wilcoxon Matched Pairs Test (*p < 0.05)

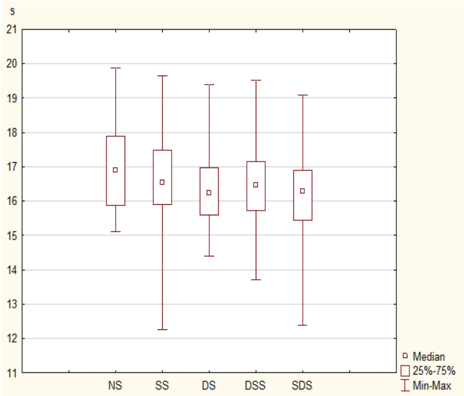
In the shuttle run test, significant differences were also demonstrated for individual types of exercise (ANOVA Chi Sqr. (N = 108, df = 4) = 33.44 $p < 0.00000$; Coeff. of Concordance = 0.07742 Aver. rank r = 0.06880). Table 2 contains the comparison of individual stretching exercise protocols for the results of the shuttle run ($p < 0.05$). The results of the 10 m sprint test showed statistically significant differences between selected types of warm-ups NS & SS, NS & DS, NS & DSS and NS & SDS ($p < 0.05$).

The medians and min and max values are clearly shown in box graphs for both tests (Figure 3, Figure 4), where dynamic stretching appears to be the most effective stretch (Figure 3).



Note: Stretching; NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching.

Figure 3. Box graph – Illinois test.



Note: Stretching; NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching.

Figure 4. Box graph – Sprint test 10 m.

The results in table 3 present a direct relationship between the achieved performances in the Illinois test and the sprint test for men, women and all participants with the same type of warm-up ($p < 0.05$).

Table 3. Rank correlation for men (n = 72), women (n = 36) and total (N = 108)

Stretching	Men			Women			Total		
	R	t(N-2)	p-level	R	t(N-2)	p-level	R	t(N-2)	p-level
NSIL vs. NSCL	0.34	0.34	0.00	0.32	1.99	0.05	0.60	7.77	0.00
SSIL vs. SSCL	0.21	0.21	0.06	-0.12	-0.68	0.50	0.22	2.36	0.01
DSIL vs. DSCL	0.32	0.32	0.00	0.08	0.47	0.64	0.32	3.51	0.00
DSSIL vs. DSSCL	0.42	0.41	0.00	0.31	1.88	0.06	0.44	5.11	0.00
SDSIL vs. SDSCL	0.36	0.36	0.00	0.38	2.46	0.01	0.40	4.49	0.00

NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching; IL: Illinois test; CL: Sprint test. *$p < 0.05$
Pearson´s correlation coefficient (*$p < 0.05$)

Discussion

The study looked at the effect of five different types of stretching after warming up before exercise on the results of motor tests of speed and agility.

Table 1 shows that different protocols of stretching exercises have a statistically significant effect on the values of the Illinois test ($p < 0.05$). It was found that the best results were obtained with dynamic stretching and combined models with dynamic stretching ($p < 0.05$). Moreover, it is understood that the combined models of stretching exercises performed worse than dynamic stretching but better than static stretching. The study supporting our research (Cigerci et al., 2023) studied the acute effects of five different stretching protocols applied during the warm-up phase on speed and agility. Different stretching exercise protocols have a statistically significant effect on Illinois Agility and Reactive Agility values ($p < 0.05$). It was found that the best results were obtained with dynamic stretching, and there was also a significant difference in favour of dynamic stretching between dynamic stretching and other protocols ($p < 0.05$). Combined stretching exercise models, on the other hand, seem to achieve worse results than dynamic stretching but better than static stretching.

Table 2 shows that different protocols of stretching exercises have a statistically significant effect on the values of the 10 m sprint test ($p < 0.05$). It was found that the best results were obtained with no stretching. There was a significant difference in favor of DS among other protocols ($p < 0.05$). Moreover, it is understood that the combined models of stretching exercises performed worse than dynamic stretching but better than static stretching. The results of the study (Cigerci et al., 2023) showed that different stretching exercise protocols have a statistically significant effect on 10 m and 20 m running values ($p < 0.05$). It was determined that the best results were obtained with dynamic stretching and there was a significant difference in favour of dynamic stretching between dynamic stretching and other protocols ($p < 0.05$). In addition, it is understood that the combined stretching exercise models achieved worse results than dynamic stretching but better than static stretching.

Looking at the literature, although static stretching applied during the warm-up process has been reported to negatively affect agility, many studies show that static stretching increases flexibility (Aydin et al., 2019; O´Sullivan et al., 2009; Samson et al., 2012). Static stretching exercises have been reported to improve flexibility; flexibility can increase athletic performance and speed up recovery (Colby, 2007). In addition to this information, it should not be ignored in the literature that providing flexibility can protect athletes from injury (Gibson et al., 2019). The finding that the acute effect of static stretching has a negative effect on agility and sprint performance suggests that dynamic and static + dynamic stretching could be used to achieve better acceleration, speed, and agility performances during warm-up training in tennis players (Kilit et al., 2017).

The effects of static stretching after a dynamic warm-up on speed, agility and strength were investigated in a study involving male university students participating in team sports (Bishop & Middleton, 2013). Interestingly, the results showed that a routine with a combination of dynamic warm-up and static stretching led to a decrease in average performance in all performance measures; 20 m sprint and agility according to the Illinois test (Bishop & Middleton, 2013). Many researchers have shown that static stretching can limit strength, power, and speed (Bradley et al., 2006; Power et al., 2004; Samuel et al., 2008; Sayers et al., 2008; Steward et al., 2007; Yamaguchi & Ishii, 2005).

Results of the study (Miri-Khorasani et al., 2016) evaluating the acute effect of different warm-up stretching methods on the acceleration and speed of soccer players after different warm-up procedures using 10- and 20-meter tests. There were also significant differences between combined stretching compared to static stretching and no stretching protocol.

Result of the study (Van Gelder & Bartz, 2011) evaluating the effect of static stretching and dynamic stretching on performance time in an agility test. These results suggest that compared to static and no stretching, dynamic stretching significantly improves performance in closed agility skills that involve.

The important factor is the total duration of each stretching exercise, not the number of repetitions in which the exercise is performed. The results of the study suggest that short-term static stretching (<30 seconds) can indeed improve acute speed performance (Avloniti et al., 2016).

Research aimed to evaluate the effects of different lengths of dynamic stretching on speed and agility in female gymnasts to compare how different lengths of dynamic stretching affect performance in these areas. From the results of the study, it can be conc concluded that dynamic stretching has a positive effect on speed and agility in female gymnasts. Shorter stretching protocols (20 and 30 seconds) appear to be most effective for improving gymnastic performance (Dallas et al., 2019).

Results of researching the acute effect of static stretching, dynamic exercise, and a combination of static stretching and dynamic exercise before a sporting event on performance in the vertical jump, medicine ball throw, 10-yard sprint, and running speed in the shuttle run test in teenage athletes (15.5 ±0.9 years old) suggest that before a sporting event it can be for teenage athletes, who engage in performance activities, dynamic exercise or static stretching followed by dynamic exercise more beneficial than static stretching alone (Faigenbaum et al., 2006).

The aim (McMillian et al., 2006) was to compare the effects of dynamic warm-up with the effects of static stretching on selected indicators of strength and agility in cadets (14 women and 16 men aged 18–24 years from the United States Military Academy). Data analysis showed that after dynamic warm-up, participants had better performance scores in all three strength and agility tests ($p < 0.01$) compared to static stretching and no warm-up ($p < 0.01$). Dynamic warm-up methods are effective in improving performance (Fletcher & Anness, 2007; Hought et al., 2009; Little & Williams, 2006; Taylor et al., 2009; Young et al., 2004), but they are not as effective in increasing static flexibility compared to static stretching (Covert et al., 2010; O´Sullivan et al., 2009).

Conclusions

According to the information obtained from the studies, it can be said that the types of stretching performed during the pre-exercise warm-up can affect the performance of athletes. Small increases in athletes' performance can sometimes reveal big differences that can affect competition results. Therefore, it is considered that attention should be paid to the selection of the types of stretching that will be applied in the warm-up section, taking into account the needs of the sports sector and the athlete. Dynamic types of stretching should be preferred over activities that require speed and strength. On the other hand, it is undoubtedly important to increase the athlete's flexibility during these challenging movements and prevent injuries. For this reason, in order to increase the speed and agility of the athlete, a dynamic stretching method can be recommended as part of the warm-up, or a model of a combination of static stretching followed by dynamic stretching.

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Conflicts of interest: The authors declare no conflict of interest.

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