

Effects of Different Durations of Static Stretching on Flexibility, Jumping, Speed and Agility Performance

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ABSTRACT The aim of this paper was to research the effect of different static stretching time on some physical performance parameters. A total of 25 male volunteers who were actively involved in sports participated in the study. Flexibility, jumping, speed and agility performances of all the participants were measured after static stretching exercises on 5 different days and within different durations (no stretching, 10 seconds, 20 seconds, 30 seconds, 40 seconds). After static stretching performed in all durations, the value of flexibility was discovered to be higher than the state in which no stretching is performed ($p < 0.01$). The jumping height after static stretching exercises performed in different durations is lower than the state in which no stretching is performed ($p < 0.01$). 20 m running time and agility performance did not differ among the five trials. It was found that the length of static stretching duration increased in flexibility. Also, static stretching decreased vertical jumping performance and did not affect speed and agility.

INTRODUCTION

Warm-up, the basis of sportive performance, is a factor to reach maximal muscle strength and optimal sportive performance (Young et al. 2002). Warm-up before competition is a very important component to increase sportive performance; the warm-up method which is capable of providing optimal performance increase is yet to be established (Fletcher 2010). Since it is believed that warm-up which includes low intensity aerobic and stretching exercises affect the performance in sports competitions and at the same time decreases the risk of injury, it has maintained its importance for years as an indispensable practice before training and competitions (Yamaguchi et al. 2006).

Athletes traditionally performed stretching as a part of warm-up before activity in order to increase their performances, and to decrease the risk of injury (Weerapong et al. 2004). A great number of stretching techniques have been defined depending on the athlete's choice, the training program and the type of sport. These are

static stretching, active stretching, ballistic stretching and PNF (Proprioceptive Neuromuscular Facilitation) stretching. Static stretching involves stretching a muscle (or a muscle group) to the furthest point and keeping this position for a definite period of time (Sozbir 2006). Static stretching which is the most common method (Weerapong et al. 2004) is composed of gradually lengthening a joint to an elongated position just before the pain starts. That is, it is thought that performance increases by maximizing the joint's area of motion and improving coordination. Static stretching method is popular for many reasons; it is easy to learn, it can be done individually and it is effective in increasing the joint's area of motion (Marek et al. 2005). In addition, it has been suggested that static stretching enhances power transmission capacity by increasing flexibility in tendons and muscle fibres and that it is a way of preventing injury in musculo tendinous units (MTU) (Smith 1994). Despite this common practice, there is no definite proof that pre-exercise static stretching decreases the risk of injury (Shrier 2007). Recently, it has been found that static stretching decreases performance in measurements of maximal power production (Cramer et al. 2004; Papadopoulos et al. 2005), jumping height (Behm et al. 2006; Wallmann et al. 2005), sprint speed (Fletcher et al. 2004; Little et al. 2006), reaction time and balance (Behm et al. 2004). All decreases in performance after static stretch-

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ing have been explained through a combination of mechanical and neurological factors.

There are different views in literature on the duration of static stretching. There are studies stating that the recommended periods for hold in static stretching vary between 15, 30 and 60 seconds (Winnick and Short 1999) and 10-30 seconds (Sevim 1997; Power et al. 2004). It is believed that static or gradual stretching methods are useful in preventing injury and increasing performance by increasing range of motion (Sevim 1997; Power et al. 2004). It is also reported that using the hold duration between 10 to 30 seconds for static stretching will be useful (McHugh et al. 1997).

And that there are a great number of studies stating that static stretching exercises cause negative effects when they are done longer than 30 seconds (Nelson et al. 2001; Cramer et al. 2005). This result has brought to the fore-front the fact that some approaches which support stretching for 15-30 seconds before performance, and which require maximal strength especially during the warm-up period will be more useful (Siatras et al. 2008). Avloniti et al. (2015) found that static stretching of short duration (<30 sec) may actually improve acute speed performance, whereas static stretching of moderate duration may not hamper speed and agility performance. Smith's (2015) paper was to examine the effects of 30 and 60-seconds of static stretching on vertical jump performance. It proves that limited-duration static stretching may not impair vertical jump performance.

Studies which investigate the effects of static stretching effects on exercise performance have shown a lot of inconsistencies in data. Results are different for each study. The purpose of this study is to present the effects of static stretching exercises with different durations on speed, agility, jumping and flexibility performance and to determine the suitable stretching duration by finding out which stretching duration affects performance positively or negatively. And to make suggestions to athletes and trainers in the light of this information.

MATERIAL AND METHODS

Samples

A total of 25 male students (athletes) studying at Ondokuz Mayıs University Yasar Dogu

Faculty of Sports Sciences voluntarily participated in this study. The average age of the subjects was 21.84 ± 1.81 years, while their average weight was 71.36 ± 7.23 kg and their average height was 175.56 ± 5.88 cm respectively. The study was conducted in accordance with the 2013/461 Ethical Board decision of Ondokuz Mayıs University Faculty of Medicine.

Study Method

The subjects' ages, genders, heights and weights were recorded. The conditions of participation in the study were volunteering, not having sustained an injury, and not having gone through an operation in the last six months. Before the measurements, all participants were warned not to have an intense training or not to drink alcohol on the day before the measurements.

Performances of all the subjects who participated in the study were measured following stretching exercises of different durations on four different days, and also on another day their performances were measured after general warm-up without stretching exercises. In short, a total of 5 measurements were made on all subjects. The subjects were divided in five groups randomly (Table 1), they performed their warm-up as instructed every other day and their measurements were taken. The reason why this was necessary was to prevent adaptation and to learn the measurements. Static stretching exercises of different durations were made every other day, and 4 different static stretching periods were as follows;

- 12 repetitions of 10 seconds (stretching 1),
- 6 repetitions of 20 seconds (stretching 2),
- 4 repetitions of 30 seconds (stretching 3),
- 3 repetitions of 40 seconds (stretching 4).

There were 5 seconds of rest between the repetitions.

Before all static stretching practices, all the athletes were made to run for 5 minutes with aerobic intensity and then have a rest walk for 2 minutes for general warm-up. Following this, they made stretching exercises of different durations and then their flexibility, vertical jump, 20 m sprint and agility measurements were taken. When their performance measurements were taken without stretching (no stretching), the athletes were made to run for 5 minutes with aerobic intensity and then have a rest walk for 2 minutes for general warm-up. After this, their performance measurements were taken.

Table 1: The subjects' division into groups and their measurement ranks

Subjects	N	Subject grouping and measurement time				
		1. measurement	2. measurement	3. measurement	4. measurement	5. measurement
1 group	5	10sec	20sec	30sec	40sec	No stretch
2 group	5	20sec	30sec	40sec	No stretch	10sec
3 group	5	30sec	40sec	No stretch	10sec	20sec
4 group	5	40sec	No stretch	10sec	20sec	30sec
5 group	5	No stretch	10sec	20sec	30sec	40sec

Static Stretching Exercises

After general warm-up, static stretching exercise was performed. Static stretching exercises were designed depending on the lower extremity muscle groups (Gluteus, quadriceps, hamstring and gastrocnemius). Static stretching exercises were applied as described in the studies of Ozenig (2007) and Unlu (2008).

Performance Measurements

Flexibility Test

The subjects' flexibility measurements were made by sit and reach test. The test was repeated twice and the higher value was recorded as the flexibility measurement value (Gunay et al. 2013).

Static Jump (Vertical Jump)

Static jump test was made by using Newtest Powertimer 300. The measurements were taken Sozbir (2006). Static jump repeated three times and the best value was recorded as the vertical jump value (Sozbir 2006).

Sprint (20 m) Test

The athletes' speed performances were determined by 20 meter sprint test. The measurements were taken as Tamer (2000). The test was performed twice on each athlete and the best degree was recorded.

Agility Run Test

This test was used to measure agility. The participant stood 1 meter behind the photocell gate of the start and began to run when he was ready. The track was 18 meters long and there were 3 cones placed with spaces of 1.2 meters at

turning points. The distance in between the cones in the mid part was 4.5 meters. The athletes were asked to do the agility test with maximum speed. The test was performed once.

Statistical Analysis

The statistical analysis of the data obtained from the study was made by using SPSS 21 package program. Kolmogorov-Smirnov test was used to test whether the data was distributed normally and the data was found to be distributed normally. The arithmetic mean and standard deviation of the data were measured and variance analysis and Bonferroni corrected pairwise comparison test were used in repeated measurements to test whether there was difference between the five trials. Statistical significance was accepted as ($p < 0.05$) and ($p < 0.01$).

RESULTS

Flexibility value measured without static stretching was found to be statistically lower than the values measured after static stretching of 10 sec, 20 sec, 30 sec and 40 sec ($p < 0.01$) in Table 2. After 40 sec stretching, the flexibility was found to be 15.91 cm while without stretching, the flexibility was 10.56 cm.

Jumping height measured after static stretching of 10 sec, 20 sec, 30 sec and 40 sec was found to be statistically lower than the values measured without static stretching ($p < 0.05$). Jumping power measured after static stretching of 10 sec, 20 sec and 30 sec was found to be statistically lower than the values measured without static stretching ($p < 0.05$) in Table 3.

When the measurements were examined, no statistically significant difference was found between 20 meter sprint times performed after static stretching of different durations ($p > 0.05$). Statistical analyses showed that running speed did not differ significantly after static stretching of different durations ($p > 0.05$) in Table 4.

Table 2: Flexibility test measurements of the subjects based on different static stretching times

Variables	Stretching time	Mean	SS	F	P
Flexibility (cm)	No stretch (1)	10.56	4.44	46.469	1<2,3,4,5** 2<3,4,5** **3<5**
	10sec (2)	12.65	5.04		
	20sec (3)	14.14	5.05		
	30sec (4)	14.81	5.16		
	40sec (5)	15.91	4.88		

**p<0.01

Table 3: Jump test measurements of the subjects based on different static stretching times

Variables	Stretching time	Mean	SS	F	P
Flight Time (ms)	No stretch (1)	561.43	28.30	0.672	-
	10sec (2)	556.00	28.96		
	20sec (3)	557.65	23.19		
	30sec (4)	559.47	22.92		
	40sec (5)	557.78	19.52		
Jump Height (cm)	No stretch (1)	39.42	4.06	13.674	2,3,4,5<1*
	10sec (2)	37.57	4.09		
	20sec (3)	37.42	3.86		
	30sec (4)	37.52	4.23		
	40sec (5)	36.96	4.06		
Jump Power(W)	No stretch (1)	3556.04	387.47	2.645	2,3,4<1*
	10sec (2)	3447.52	350.59		
	20sec (3)	3438.73	389.89		
	30sec (4)	3440.86	381.30		
	40sec (5)	3289.69	760.83		

Table 4: Sprint test measurements of the subjects based on different static stretching times

Variables	Stretching time	Mean	SS	F	P
Running Time (ms)	No stretch (1)	3068.18	113.95	2.130	-
	10sec (2)	3084.00	146.81		
	20sec (3)	3089.95	124.32		
	30sec (4)	3021.31	157.94		
	40sec (5)	3032.13	145.78		
Running Speed (m/sn)	No stretch (1)	6.52	0.24	0.470	-
	10sec (2)	6.52	0.25		
	20sec (3)	6.47	0.26		
	30sec (4)	6.47	0.75		
	40sec (5)	6.60	0.30		

It was found that stretching exercise of different durations did not have a statistically significant influence on agility performance ($p>0.05$)

in Table 5. Agility run performance was the same after 10 sec, 20 sec, 30 sec and 40 sec stretching or no stretching.

Table 5: Agility test measurements of the subjects based on different static stretching times

Variables	Stretching time	Mean	SS	F	P
Agility (ms)	No stretch (1)	24760.48	822.66	1.633	-
	10sec (2)	24775.70	1270.84		
	20sec (3)	24488.57	1059.38		
	30sec (4)	24432.17	1123.17		
	40sec (5)	24643.87	876.07		

DISCUSSION

This study examines the effect of different durations of static stretching on some physical performance values. When the results of flexibility values were examined, it was found that the lowest flexibility values were found when no static stretching was done after run. As can be understood from this result, flexibility values are low when no stretching exercises are done. The best flexibility value was found after 40 seconds of static stretching. That is, it was found that flexibility value increased as the duration of static stretching increased. When the literature is reviewed, there are a great number of studies in line with the results of this study (Kokkonen et al. 1998; Power et al. 2004; Nelson 2005). Feland (2001) examined the effects of three different durations (15 sec, 3, sec and 60 sec) of stretching exercises for 5 days a week during 6 weeks on the range of motion of hamstring muscle group, and found out that the highest range of motion was achieved with 60 seconds of static stretching exercises. Feland advocated that the best result for range of motion could be achieved when 60 seconds or longer static stretching was performed. In his study, Ozengin (2007) stated that 15 and 30 seconds of static stretching and warm-up exercises increased flexibility in acute phase. In addition, Ozengin also found out that when measurements after 15 and 30 seconds of stretching exercises were examined, flexibility values were found to be higher after 30 seconds of stretching exercises. Ozkaptan's (2006) study found a significant difference between the flexibility values after 20 seconds of stretching exercises and no stretching exercises and concluded that 20 seconds of stretching exercises affected flexibility values positively. Catikkas (2008) stated that as a result of the increase in the number of sarcomere due to the positive effect of static flexibility exercises on flexibility performance, an increase was observed in the muscle length and the muscle's extensibility increased. Stretching exercises before training or competition decrease stiffness of the muscles. With the decrease in stiffness, an increase is seen in muscle adaptation and flexibility increases (Magnusson 1998; Weldon et al. 2003). This situation can explain the highness in flexibility in this study as the duration of static stretching increased. There are also studies results in opposite direction of the results of this study. Siatres et al. (2003) performed

3 different stretching protocols for male gymnasts on separate days. They did not find a difference in flexibility values. In addition, Bandy et al. (1997) found that static stretching exercises between 30 to 60 seconds did not improve flexibility. There are some studies which support these results (Marek 2005; Yamaguchi 2005; Winchester 2008). Most of the studies on static stretching have used protocols of 15 and 30 seconds and recorded that there was no change in the extensibility of the muscle in stretchings longer than 30 seconds (Kaya 2004). The reason for the different results in these studies and this study may result from the difference in study groups and protocols.

This study examined the jumping values measured after different durations of static stretching and after without stretching. Jumping height and power values measured without stretching were found to be higher than the values measured after different durations of static stretching (10 sec, 20 sec, 30 sec, 40 sec). This means a negative change was found in the vertical jump values measured after static stretching. When studies with similar subjects were examined, a great number of studies were found in line with the results of this study. Wright et al. (2006) examined the effects of static stretching, dynamic stretching and warm-up on vertical jump in 36 athletes between the ages 18 and 30. The athletes were made to perform static stretching, dynamic stretching and 10 minutes of warm-up on different days and they were assessed in terms of vertical jump. The results of the study reported that static stretching decreased vertical jump performance. Smith's (2015) study was to examine the effects of 30 and 60-seconds of static stretching on vertical jump performance. He found out that limited-duration static stretching may not impair vertical jump performance.

In their study with 14 male athletes (football and hockey), Young and Eliot (2001) found a decrease in drop jumping performance after static stretching while Faigenbaum et al. (2005) also found a decrease in vertical jump performance with static stretching protocol in 60 athletes (swimming and football). Brill et al. (2005) found a significant decrease in the vertical jump of 14 male footballers following a static stretching exercise. In line with the literature, the reason for this decrease was explained by various reasons in general. It can be thought that this decrease could be the result of inhibitor neural mecha-

nism such as reverse myotatic reflex and the increase in musculo tendinous compliance (Young and Eliot 2001), or the result of the decrease in the strength of skeleton system or through more compliant tendons (Cornwell et al. 2001). Besides the thought that the decrease in strength results from the decrease in musculo tendinous stiffness (Kokkonen et al. 1998), it can also be thought that strength performance decreases as a result of the decrease in muscle activation caused by static stretching (compliance in the stretching ability of muscles on the basis of cell) (Fowles and Sale 1997). Nevertheless, it is thought that the decrease in vertical jump performance can be due to neuromuscular inhibitor mechanisms rather than the decrease in muscle viscosity (Knudson 2001; Evetovich 2003) in addition, the decrease in vertical jump performance can result in the reverse myotatic reflex of different stretching and the insufficiency of the available motor unit in stretching resulting in a decrease in muscle activation (Church et al. 2001).

When the results of this study were examined, it was found that different durations of static stretching did not change the 20 meter sprint time and sprint speed. There are studies in literature in line with this result. In his study, Ozkapitan (2006) did not find a difference between the speed performance after a general warm-up without stretching exercises and static stretching exercises after a general warm-up. In their study, Little and Williams (2006) stated that static stretching exercises did not cause a decrease in 10 meter sprint performance. Knudson et al. (2004) found that static stretching exercises did not cause a decrease in speed performance. Saoulidis et al. (2010) found that static stretching exercises which did not cause a pain in the muscles did not affect 20 meter sprint performance in handball players. Chatzinikolaou et al. (2013) found that long durations of static stretching did not have any effect on 10 m and 20 m speed performance values. There are also studies in literature suggesting that static stretching exercises affect speed performance negatively (Yildiz 2005; Fletcher and Jones 2004; Nelson et al. 2005; Unlu 2008). Avloniti et al. (2015) found that static stretching of short duration (<30 sec) may actually improve acute speed performance, whereas static stretching of moderate duration may not hamper speed and agility performance.

When the results of the agility test were assessed, it was found that different durations of

static stretching exercises did not significantly change the agility performance. There are contradictory results on the effect of static stretching on agility performance in literature. In their study which examined the effect of durations of static stretching on speed and agility values, Chatzinikolaou et al. (2013) found that static stretching did not have an influence on agility. McMillan et al. (2006) and Little and Williams (2006) reported that static stretching did not change agility performance. In their study with 21 participants (13.3±0.5 years of age) in which they tried to present the acute effects of different durations of static stretching and different distance of dynamic exercises on agility performance, Gelen et al. (2007) found that static stretching exercises decreased agility performance. In their study they examined the acute effects of different methods of stretching on agility test in footballers, Mohammadtaghi et al. (2010) found significant decreases in agility time following static stretching. The reason for different results between some studies and this study in terms of speed and agility performance can be the difference in subject groups and protocols.

CONCLUSION

This study establishes the fact that longer duration of static stretching increases flexibility. Static stretching was found to have decreased vertical jump performance; but it was found not to have affected speed and agility.

RECOMMENDATIONS

Longer durations of static stretching are recommended before branches of sports which require flexibility. Before branches of sports which require speed and agility, shortest duration will be enough if static stretching is to be done. In order not to have injuries, stretching exercises should be made compulsory before competitions; however, after static stretching, branch oriented active warm-up exercises should be made compulsory.

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