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ACUTE EFFECT OF DIFFERENT WARM UP PROTOCOLS ON ATHLETE'S PERFORMANCE

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Abstract:
The aim of present study was to investigate the acute effect of different warm-up protocols on elite athlete's performance. Subject group of the study was consisted of twenty volunteer male students from Uludag University Sport Sciences Faculty who have been playing soccer at various leagues for at least seven years. Three different warm-up methods were applied to the subjects at 24 hours intervals. These were (1) stretching exercises protocol (SEP), plyometric exercises protocol (PEP) and suspension exercises protocol (SUEP). Subjects performed general warm up during 5 minutes and after then pre-tests were measured before each warm up protocol. After each warm up protocol, post-tests were measured. All subjects were tested on static balance, vertical jump, 30 m. sprint, reaction time and flexibility performances. All data were analyzed using Paired Sample T-tests using SPSS Statistics v.22 (Chicago, IL, USA), and significance was set at an alpha level of 0.05. As a result of analysis of test data, no significant difference was detected in the static balance test in the three protocols ($p<0.05$). When the vertical jump test (anaerobic power test) results were analyzed, whilst a statistically significant decrease was detected in SEP, no difference was detected in PEP and SUEP ($p<0.05$). When the reaction time test results were analyzed, no difference was detected in the three protocols ($p<0.05$). When the speed test results were analyzed, a statistically significant decrease in SEP and statistically significant increase in PEP and SUEP were detected ($p<0.05$). When the flexibility test results were analyzed, a statistically significant increase was detected in the three protocols ($p<0.05$). A statistically significant decrease in the values of anaerobic power and speed, significant improvement in flexibility was observed in GEP. A significant improvement was observed in the values of speed and flexibility in PEP and SEP. According to the

results, in sports that require speed and jumping, whilst plyometric and suspension warm up exercises are thought to be beneficial, in sports that require flexibility, the inclusion of static stretching to these exercises is thought to be beneficial.

Keywords: warm up, balance, speed, reaction, flexibility, suspension, plyometric, stretching

1. Introduction

Warm up is the most important movements made before training and competition in order to increase the performance of the athletes physiologically, psychologically and neurologically and to reduce the risk of disability (ACSM, 2006; Faigenbaum et al., 2005; Özdal et al., 2016; Özdal, 2016; O'Brien et al., 1997; Robergs et al., 1991, Arabacı, 2008). Previous studies have indicated that the importance OF speed, anaerobic power, balance, reaction time and flexibility features has increased at sport branches such as football. Since such features also require high strength, the risk of disability is high and therefore a good warm up is needed. For this reason, scientists are constantly working on new methods of improving warmth.

Athletes usually prefer a warm-up protocol that starts with mid-level runs and then makes static stretching movements. Some of the investigations have suggested that pre-exercise static stretching activities develop posture, reduce the risk of injury, and provide good performance improvement (Duncan & Woodfield, 2006). Therefore, static stretching movements are accepted as the gold standard for both children and adults (Young & Behm, 2002). However, some studies on adult sports have emphasized that static stretching exercises have a negative effect on sports that require maximal strength (Behm et al., 2004; Church et al., 2001; Fletcher et al., 2004; Hamada et al., 2000; Little et al., 2006; Cilli et al., 2014). The observation of the negative effects of static stretching movements has caused coaches and athletes to be interested in alternative warm-up exercises to static stretching exercises and thus a number of warm up methods have emerged (Cilli et al., 2014). One of the most preferred of these warm-up exercises is the method of warm up with severe dynamic movements after jogging. This method, also called dynamic warm up exercises, is a method of warm up that involves resistance exercises and is specific to the sports branch.

Exercises made by the athlete with their own body weight are preferred in the warm up by resistance exercises (Tahayori, 2009; Thompsen et al., 2007). In the sport world, many methods have been used in recent years for resistance exercises made with their own body weight. Plyometric training is one of them. Plyometric training is the training method involving leaping movements that allow the muscle to reach maximal

force as soon as possible. Some studies examining the application of Plyometric exercises in the warm-up period emphasize that these exercises contribute to the performance of the athlete (DeVillareal et al., 2007).

Among the resistance exercises made with body weight, one of the most recent is suspension exercises (Snarr et al., 2013). Suspension training is a method of training that improves athletic performance by improving muscle strength (Cheatham & Kolber, 2012; Dudgeon et al., 2011; Willardson, 2007). Suspension exercise, with the help of dangling threads, is training method in a non-stabilizing state using one's own body weight. There are many suspension devices available today (Calatayud et al., 2014). The most preferred of these tools is the TRX® Suspension device. Lately, coaches have been using TRX® instruments a lot in their training programs. There are some studies on the TRX® suspension device (McGill et al., 2014; Calatayud et al., 2014; Maté-Muñoz et al., 2014; Mok et al., 2015; Snarr et al., 2013.) However, in our knowledge, there is no study about the acute effect of using of the TRX® Suspension device during warm up on athletic performance.

For this reason, the main purpose of this study is to examine the acute effects of suspension exercises applied on warm up on elite athlete's speed, balance, reaction time, anaerobic power and flexibility. Secondly, it examines the acute effect of the Plyometric and stretching exercises on the performance of the athlete. Expected result from this study is that acute effect of suspension exercises applied warm up on athlete's performance is positive. Also, it is expected that static stretching will negatively impact performance, Plyometric and suspension exercises will have a positive effect, but suspension exercises will be more effective than Plyometric exercises.

2. Method

20 male volunteers (mean age 21.35 ± 1.66 years, weight 66.66 ± 7.49 kg, height 175.30 ± 6.59 cm) who had played football for at least seven years in Bursa participated in the study. All participants filled in a voluntary consent form informing them that they voluntarily joined the study and allowed the use of the data obtained. The study was carried out in accordance with the Helsinki Declaration. The study was also conducted in accordance with the decision of the Ethics Committee for Clinical Investigations of Uludağ University Faculty of Medicine, 2015-5 / 9. The study was supported by the Scientific Research Projects Unit of Uludağ University with the project numbered 2015/36.

Before starting the research, participants were given a meeting and information about the applications to be conducted in the investigation. Also, participants were given a daily exercise and device presentation training to familiarize themselves with

the exercises and test equipment to be applied. All tests and warm-up protocols were applied at intervals of one day during the players' competition season. Participants were warned not to exercise heavily on the day before the measurement, to consume alcohol, and not to go out of their daily diet and sleeping habits. Participants performed three different warm up protocols on intervals of one day, and tested and recorded data before and after each warm-up protocol (Figure 1). In the three warm-up protocols, general warm-up was applied in the same way. Static stretching exercises (SEP) in the first protocol, Plyometric exercises (PEP) in the second protocol and suspension exercises (SUEP) in the third protocol were performed. Vertical jump, speed, flexibility capacity, reaction time and equilibrium skill tests were applied 1 minute after the general warm-up in all three protocols (pre-test). One minute after the warm-up was completed, the same tests were performed a second time (post-test). The participants were taken individually into the warm-up schedule and all the tests. All tests and warm-up protocols were applied in the study in a synthetic sole with a temperature of 20-24^{0}C. Each warm-up protocol is scheduled for 12 minutes, excluding the general warm-up period.

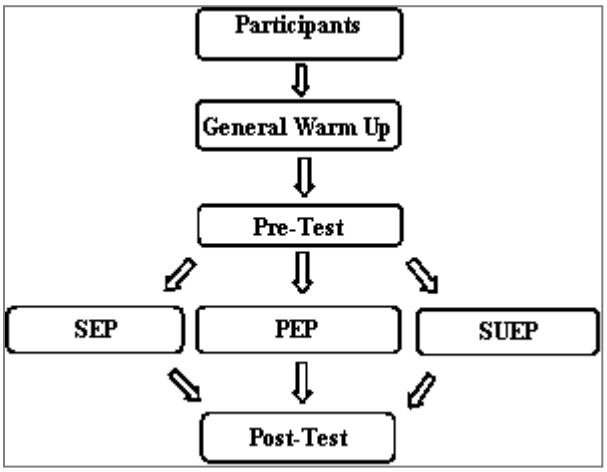

Figure 1: Experimental Procedure

Participants in the general warm-up performed jogging for 500 meters (about 4 minutes). They ran in the last 200 meters of the run by turning their arms forward, back respectively. Then they ran by the legs opened and closed to the sides for a minute and the general warm up was completed. Warm up protocols are shown in Table 1 in detail. Participants were measured for height, body weight, and body mass index before pre-testing. Height measurements were made with a measuring device with a sensitivity of 0.01 m. Tanita BC 418 (Japan) brand body composition analyzer was used for the weight and body mass index measurements. Tests measuring static balance, anaerobic power, speed, reaction and flexibility skills were applied to participant at pre-test and

post-test. A Prokin Tecnobody PK 200 (Italy) balance meter was used for static balance measurements. The Static Equilibrium Test was performed with the eyes open in the standing position on the double leg in the fixed platform. The optimal position for the double leg test was determined to be equally spaced from the origin point, with the feet open at the shoulder width and the legs standing on the x and y axis of the feet. During the test, which lasted for 30 seconds, the position protection was demanded and the position was monitored from the screen.

The test was started by pressing the start button on the computer keyboard and was automatically terminated by the computer at the end of the test period. In the static balance test, the environmental length was used as data in centimeters. The balance of the individual is worse as the balance score increases, the balance is better assumed as the score is smaller. The test was applied twice at intervals of one minute and the best value was used for the study. The anaerobic power was recorded in the Gill Athletics Vertical Jump Mat while the arms were swinging down. The subjects are on the platform and the arms are extended next to the body; Knees, hip and chest stopped in flex. At this point, while jumping to reach as high as possible, the knees, hips and chest were lifted and the arms were lifted onto the head. They jumped three times, the best score was recorded. One minute of active rest was given between the jumping. The power calculation is calculated using the Lewis Measurement Formula.

2.1 Formula

$$\text{Average Power (Watts)} = \sqrt{4.9} \times \text{body mass (kg)} \times \sqrt{\text{jump-reach score (m)}} \times 9.81$$

Biopac MP 36 (USA) measuring instrument and Biopac Student Lab software were used for dominant hand auditory reaction time measurement. Measurements of reaction times were repeated ten times using auditory stimuli coming at random intervals using the dominant hand of participants, and the lowest 2 and highest 2 scores were not evaluated, and the average of 6 scoring close to each other was recorded as reaction time. To measure the speed, a wireless 2-door Sinar (Turkey) photocell tool and a 30-meter sprint test were used. They started running when they were standing 30 cm behind the starting line and the photocell stopped automatically at the finish line. It was measured 2 times with a 3-minute break and the best grades were recorded as data.

Their elasticity is measured using a seat-access pedestal. They were asked to sit at their bare feet so that they could stand straight on the test bench, bend forward from the waist (waist and hip) and stretch their hands without twisting their knees and stretch them as far forward as possible to reach the farthest point they could reach. The best value was recorded by two measurements.

Table 1: Warm Up Protocols

Protocols	Movement	Time (sec)	Rest (sec)	Set	Total Time (sec)
SEP	Calf Stretching (Right Leg) Calf Stretching (Left Leg) Quadriceps Stretching (Right Leg) Quadriceps Stretching (Left Leg) Adductor Stretching Hamstring Stretching Hip Rotator Stretching (Right Leg) Hip Rotator Stretching (Left Leg) Plantar Fleksiyon	30	10	2	80
PEP	Skipping Single Foot Jumping Side jump over obstacle Hexagonal Jumping Depth Jumping Squat Jumping	30	30	2	120
SUEP	TRX Lunge and Jumping (Right) TRX Lunge and Jumping (Left) TRX Hamstring Curl TRX Mountain Climber TRX Sprinter Start TRX Squat TRX Crossing Balance Lunge (Right) TRX Crossing Balance Lunge (Left)	30	15	2	90

SEP- Stretching Exercises Protocol; PEP- Plyometric Exercises Protocol;
SUEP- Suspension Exercises Protocol; Sec- Second

2.2 Statistical Analysis

SPSS 22.0 for Windows (Chicago, IL, USA) package program was used for the analysis of the data. The distributions of the obtained data were examined by Shapiro Wilks Test, the data showed normal distribution; The homogeneity of the group variances was examined with the Levene Test. Paired Sample T-Test was used from the parametric tests with homogeneity and the significance value was accepted as $p < 0.05$.

3. Results

As shown in Table 2, in the measurements made before and after the warm up protocols, in all protocols in terms of speed and flexibility, there was a significant difference in SEP only in vertical jump. Although there are differences in other protocols and tests, they are not significant. See Table 2 for details.

Table 2: Pre-test and post-test results of the participants

Variables	Groups	Pre-test Mean ± SD	Post-test Mean ± SD	Difference	t	p
Statıc Balance (Cm)	SEP	228.93 ± 56.23	231.22 ± 55.99	-1.00	-1.28	0.21
	PEP	229.36 ± 55.88	227.79 ± 54.24	0.68	1.17	0.25
	SUEP	227.01 ± 53.47	225.37 ± 53.54	0.72	0.91	0.37
Vertıcal Jump (W)	SEP	938,82 ± 110,36	913,32 ± 116,17	-2,72	4,18	0,001*
	PEP	937,35 ± 106,46	949,56 ± 113,26	1,30	-1,762	0,94
	SUEP	931,79 ± 114,06	934,35 ± 119,89	0,27	-0,425	0,676
Reactıon Tıme (Sec)	SEP	0.19 ± 0.03	0.19 ± 0.02	0.00	-0.23	0.81
	PEP	0.19 ± 0.02	0.19 ± 0.02	0.00	1.78	0.09
	SUEP	0.19 ± 0.02	0.19 ± 0.02	0.00	0.59	0.55
Speed (Sec)	SEP	4.27 ± 0.15	4.32 ± 0.14	-1.15	-3.37	0.003*
	PEP	4.24 ± 0.14	4.21 ± 0.14	0.70	2.56	0.01*
	SUEP	4.24 ± 0.14	4.22 ± 0.12	0.47	2.15	0.04*
Flexıbıty (Cm)	SEP	28.20 ± 6.46	31.05 ± 6.49	10.10	-6.26	0.001*
	PEP	28.10 ± 5.24	30.05 ± 5.03	6.93	-4.07	0.001*
	SUEP	28.15 ± 5.33	29.90 ± 4.91	6.92	-3.97	0.001*

SEP- Stretching Exercises Protocol; PEP- Plyometric Exercises Protocol; SUEP- Suspension Exercises Protocol; Sec- Second; Cm- Centimeter ; W- Watt; SD- Standard Deviation *P <0.05

When the vertical jump values of the participants were examined, in Stretching Exercises Protocol the mean value of 1148,69 ± 84,21 W in pre-test was decreased to 1116,69 ± 87,47 W in post test and it was found to be statistically significant ($p < 0.05$).

When the 30 m sprint test values of participants were examined, in the Stretching Exercises Protocol the value of 4.27 ± 0.15 seconds in the pre-test was measured as 4.32 ± 0.14 seconds in the post test and it was found to be statistically significant ($p < 0.05$).

When the Plyometric Exercise Protocol was examined, the value of the pre-test was 4.24 ± 0.14 sec was measured as 4.21 ± 0.14 sec in the post test and it was found to be statistically significant ($p < 0.05$). When the Suspension Exercise Protocol was examined, the value of 4.24 ± 0.14 sec in the pre-test was measured as 4.22 ± 0.12 sec in the post test and it was found to be statistically significant ($p < 0.05$).

When the flexibility values of the participants were examined, the value of 28.20 ± 6.46 cm in the pre-test was measured as 31.05 ± 6.49 cm in the post test in the Stretching Exercises Protocol and it was found to be statistically significant ($p < 0.05$).

When Plyometric Exercise Protocol was examined, the value of 28.10 ± 5.24 cm in the pre-test was measured as 30.05 ± 5.03 cm in the last test, it was found to be statistically significant ($p < 0.05$). When Suspension Exercise Protocol was examined, the

value of 28.15 ± 5.33 cm in the pre-test was measured as 29.90 ± 4.91 cm in the post test and it was found to be statistically significant ($p < 0.05$).

4. Discussion and Conclusion

This study was conducted to investigate the acute effects of three different warm up methods on balance, anaerobic power, reaction, speed and flexibility skills of athletes. Three different warm up protocols were applied to the participants during the study on different days and the static balance, speed, anaerobic power, reaction, speed and elasticity properties of the participants were determined before and after the protocols.
The pre-test and post-test values of the participants' balance skills were compared in three different warm up protocols and it was determined that there was no statistically significant difference. Although there was no statistically significant difference in the measurement of the static balance between the pre-test and the post-test, there was a decrease of 1.00% of SEP, a progress of %0.68 in PEP and %0.72 in SUEP. Static balance results show us that the PEP and SUEP balance values are better than the SEP values. In addition, although the difference between PEP and SUEP was not statistically significant, SUEP was found to have a better effect on static balance than PEP.

Behm et al. (2004) found a 2.2% regression in the dual leg static balance in the static stretching group despite not being statistically significant, and reported that this situation may be due to the length of the applied stretching exercises. Costa et al. (2009) found that static stretching exercises for 15 seconds positively affect balance performance, while static stretching exercises for 45 seconds have no effect on balance performance. This is due to the fact that long-term stretching activities may negatively affect the balance due to reduced reflex activity due to decreased sensitivity of muscle spindles. They also argued that the 15 sec static stretching affected the balance well due to the changes in the muscle - tendon unit. Kim et al. (2014) found that plyometric warm up did not have a significant effect on balance performance. The results of this study are parallel to our results. Romero-Franco and Jiménez-Reyes (2015) found that the warm-up protocol involving plyometric movements had a positive effect on balance performance. We attributed the different results of our study to the fact that the final tests were carried out after a five-minute rest in this study. No studies have been found on the use of suspension exercises as a warm-up protocol in literature review. However, when we investigate non-stabilized resistance exercises, as Suspension exercises are similar to unstable resistance exercises, Behm and Colado Sanchez (2013) found that exercises with a 5-week BOSU ball in their study improved the balance skills of the subjects by 33%. We think that the reason of different result is because of using different tools and exercises lasting 5 weeks in the study.

When pre-post test vertical jumping values of three warm up protocols were examined, only a statistically significant difference was found at SEP ($p < 0.05$). In the vertical jump distance, there was a %2.72 reduction in SEP between pre-test and post-test, whereas there was a progress as % 1.30 in PEP and %0.27 in SUEP. These results show us that the PEP and SUEP vertical jump values are better than the SEP values. In addition, although the PEP did not differ statistically from the SUEP, the PEP was found to have a better effect on the vertical jump than the SUEP. Unick et al. (2005) noted that Ballistic and Static stretching did not affect the vertical jump performance in their work. They think that the reason for this is that the relaxation between the stretching phase and the splashing phase can cause allowing the fix of neuromotor excitability. Also, they think that another reason of this is that the subjects used in the study were well trained female athletes and stretching time was short (15sec.). we think that the result of this study was different from the result of our study because of the use of female subjects and the shortening of stretching times.

Gelen et al. (2008) noted that dynamic type warm up exercises have a positive contribution to vertical jump performance. Gelen et al. (2008) noted that 15 m dynamic exercise applications seem to affect the vertical jump performance positively.

Faigenbaum et al. (2006) investigated the acute effects of different warm-up protocols on anaerobic performance on adolescent athletes in their studies. They emphasized that dynamic warm up and combined static stretching and dynamic warm up protocols positively affect speed, health ball shot and vertical jump performance.

Thompsen et al. (2007) noted that using dynamic motions for warm-up was more effective than cycling and static stretching exercises, and recommended using dynamic exercises on warm up. The common result of these studies is that dynamic warm up including plyometric exercises has a positive effect on the vertical jump performance of the athletes. In our study, it was seen that there was a positive effect even though there was no significant difference.

Behm and Colado Sanchez in their study of college students in 2013 found that exercises performed in nonstable conditions increased subjects' vertical jump skills by 9%. They think that the reason for this development is related to the development of balance skills. We think that the reason of different result is because of using different tools and exercises lasting 5 weeks in the study.

When pre-post reaction values of three warm up protocols were examined, it was found that there was no significant difference. Arabacı (2009) found that warm up protocols including dynamic stretching has significantly positive effect on leg reaction time to warm up protocols without any stretching. Also, he found that there is no significant difference between warm up protocol with dynamic stretching and warm up protocol with static stretching, between warm up protocol with static stretching and

warm up protocol without any stretching. We think that the reason of different result is because of differentiation of warm up protocols and measuring leg reaction.

Chatzopoulos et al. (2014) found that there was no significant difference between static stretching and dynamic warm up at the time of reaction in their study. Perrier et al. (2011) investigated the effect of static stretching and dynamic warm up on reaction time. They found that there was no significant effect of static stretching and dynamic warm up protocols on reaction time. Likewise, Alpkaya and Koceja (2007) found that 3 sets of static stretching from 15 seconds had no effect on reaction time. There are few studies in the literature that examine the effect of different warm up methods on reaction time, and it can be useful to examine the effect of different methods on the reaction time.

When pre-post 30 m speed values of three warm up protocols were examined, there was a significant difference between pre-test and post-test values in the three warm-up protocols. In the 30 m speed test, there was a % 1.15 reduction in SEP between pre-test and post-test, whereas there was a progress as % 0.70 in PEP and % 0.47 in SUEP. The 30-meter speed test results showed us that the PEP and SUEP values were better than the SEP values. It also showed that the PEP values were better than the SUEP values, although there was no significant difference between them. Alikhajeh et al. (2012), found that there were positive effects of dynamic warm up and negative effects of static warm up on speed significantly. Needham et al. (2009) found that static stretching had a negative impact on 10-meter and 20-meter sprint performances. Similarly, Siatras et al. (2003) found that the stretching exercises protocol negatively affected the speed performance of the athletes. The results of our study are parallel to the results of these studies. Ceylan et al. (2014) found that static stretching is better than jogging warm up in the 30-meter sprint test, and dynamic warm up is better than static stretching and jogging. In this study, it was found that static germen had a positive effect and it was a negative effect in our study. We attribute this difference to longer stretching times in our work. Needham et al. (2009) found that dynamic warm up is a positive effect on speed performance.

Alikhajeh et al. (2012) found a positive effect of dynamic warm up on the speed performance. Faigenbaum et al. (2006) found that dynamic warm up was a positive effect on young athletes. Creekmur, Haworth, Cox and Walsh (2016) found that plyometric studies positively affected the speed performance. When we evaluate suspension training in the category of force and dynamic exercises, Needham et al. (2009) found that dynamic exercises combined with resistance exercises made with 20% of body weight positively affected the speed performance. This study is parallel to our study.

When pre-post flexibility values of three warm up protocols were examined, there was a significant difference between pre-test and post-test values in the three warm-up protocols. In the flexibility test, a progression of 10% in the SEP, 6.93% in the PEP and 6.92% in the SUEP was observed. Test results show that the SEP values are better than the PEP and SUEP values. Çoknaz, Yıldırım and Özengin (2008) found that stretching exercises performed for 10 reps for 15 sec caused a statistically significant increase in the value of elasticity compared to those who did 5 repetitive static stretching exercises for 30 sec and no stretching athletes ($P < 0.05$). In our study, stretching statically for a long time increases flexibility as in this study. Unlu (2008) found that flexibility values of dynamic warm up are higher than the values of general warm up, while The values of static stretching is better than the values of dynamic warm up. The results of our study are supported by the results of this study. Unick et al. (2005) reported that static stretching exercise in their study did not affect the elasticity value. Faigenbaum et al. (2006) found that no protocols affected flexibility in their study. The reason of the difference between the results of the last two studies mentioned above and our study can be because of using different warm up methods.

It is well known that warm up is essential for training and competition to improve performance and prevent injuries. According to the results obtained in our research, it can be said that suspension exercises made on warming have acute effects on elite soccer players' speed, balance, anaerobic power and flexibility. According to the results, it is thought that warm up with plyometric and suspension exercises in sports that require jump and speed and warm up with stretching exercises in sports that require flexibility should be more beneficial. In addition, it is expected that the application of static stretching on warm up will negatively impact performance, plyometric and suspension exercises will have a positive effect, but suspension exercises will be more effective than plyometric exercises.

In future studies, the effect of plyometric and suspension exercises on different muscle groups or at different durations can be investigated. In addition, more studies should be done to investigate the balance performance in different warm up methods.

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