Biomedical Research 2017; 28 (17): 7540-7545

ISSN 0970-938X
www.biomedres.info

Effects of different warm-up methods on repeated sprint performance.

Halit Harmancı*, Mihri Barış Karavelioğlu

Physical Education and Sport, Dumlupınar University, Turkey

Abstract

The purpose of this study was to investigate the effect of different warm-up protocols (Post Activation Potentiation model warm-up (PAP) and Static Stretching model warm-up) on Running-based Anaerobic Sprint Test (RAST) in male athletes. 44 male athletes age: 22.23 ± 1.85 y; height: 176.16 (5.84) cm; weight: 77.49 (11.21) kg volunteered to participate in this investigation. The athletes who participated in this study were randomly divided into three groups: Post Activation Potentiation Group (PAPG) (n=15), Static Stretching Group (SG) (n=14) and Control Group (CG) (n=15). Initial measurement values of repetitive sprint test for all athletes were made followed by 5 min passive rest after 5 min warm-up at 8 km/h on treadmill. The second measurements of the athletes were performed 48 h after the first measurements. In analyzing the data, a two-way repeated measure Analysis of Variance (ANOVA) was conducted. The results indicated that significant group χ time interactions were observed for RAST test scores in the athletes subjected to different warm-up protocols. As a result, post activation potentiation warm-up method leads to an acute increase in peak power and mean power scores after the repeated sprint test (p<0.05) while static warm-up method causes a significant decrease (p<0.05).

Keywords: Repeated sprint, Post activation potentiation (PAP), Static stretching.

Accepted on August 11, 2017

Introduction

Warm-up prior to vigorous physical activities are commonly accepted movements among athletes [1,2]. The overall aim of warm-up is to increase the flexibility of muscles and tendons, provide blood flow to peripheral, enhance body temperature and improve free and coordinated movements [3,4]. Many athletes are required to put preliminary warm-up exercises in their training programs particularly before a severe activity [1,2,5]. Warm-up is regularly used by athletes to achieve high performance during training and matches and to protect against injuries [6]. On the other hand, warm-up is a type of sporting activity that requires many researches on it [7]. Although the effects of different warm-up protocols are still being investigated in various sporting activities, additional research is needed to ensure specific warm-up needs for athletes if optimum performance is achieved [7-10].

The positive or negative effects of warming on sportive performance may vary depending on the type of warm-up. Some of the studies illustrate that stretching exercises are used as part of the warm-up may inhibit the sportive performance [7,11-14]. There has been a great deal of evidence state that acute muscle stretching exercises can lead to a decrease in performance with maximum power, torque output, force and speed [13,15-19]. Two hypotheses have been proposed to explain the decline in sportive performance caused by stretching: (1) Mechanical factors including viscoelastic properties of muscle; (2) Neural factors such as the change of the motor control strategies or reflex sensitivity [20]. Wilson et al. has stated that a rigid musculotendinous system can cause an improvement in power production through contractile structures, while relaxed and extended muscle leads to lower power production [21].

Post Activation Potentiation (PAP) is defined as an improved neuromuscular state observed after high-intensity exercise where an increase in muscle contraction force following maximal or near maximal voluntary contraction [7,14,22,23]. This acute increase is thought to be influenced by contributing factors including the phosphorylation of the myosinin regulatory light chains, increased motor unit recruitment and change in pennation angle [22]. Researchers are focused on three main theories explaining the physiological mechanisms of PAP [1,22,24]: (1) Previous stimulation phosphorylates the regulatory light chain of myosin, moving them from the myosin thick body and approximate them actinine's filaments and enhance sensitivity to Ca^{+2} ion which facilitate interactions within the sarcomeric apparatus [22,24,25]. (2) Preliminary activities are increase the transmission of excitation potentiation's at the synaptic junction and spinal cord levels [24]. (3) The idea that a decrease in the pennate angle following PAP may cause the increase in strength and force and this change allows the muscle force a more direct transmission from the muscle fiber to the tendon [22,24]. Based on this result, the aim of this study was to investigate the effects of post activation model and static stretching model warm-up exercises on repetitive sprint performance.

Methods

Subjects

44 healthy, male athletes age: 22.23 ± 1.85 y; height: 176.16 (5.84) cm; weight: 77.49 (11.21) kg volunteered to participate in this study. The athletes who participated in this study were randomly divided into three groups: Post Activation Potentiation group (PAPG) (15 subjects; x̄ age: 22.14 ± 1.96 y), static stretching group (SG) (14 subjects; x̄ age: 22.43 ± 1.87 y) and control group (CG) (15 subjects; x̄ age: 22.07 ± 1.91 y). Subjects were informed about the study and signed informed consent form. Before the data were collected, participants were familiarized with test procedures (Table 1).

Table 1. Physical characteristics of the male athletes.

Physical characteristics	PAP group Mean ± SD	Static stretching group Mean ± SD	Control group Mean ± SD
Age (y)	22.14 ± 1.96	22.43 ± 1.97	22.07 ± 1.91
Height (cm)	173.09 ± 6.42	177.32 ± 4.54	178.23 ± 5.56
Weight (kg)	79.30 ± 12.70	73.91 ± 8.16	79.43 ± 12.37

Measurement tools

Height measurements: Height measurements were measured by using a wall-mounted stadiometer (Holtain Ltd., UK) at anatomic standing structure and head at frontal plane position to the nearest 1 mm.

Weight measurements: Weight measurements were measured using digital weighing scale (Tanita TBF 401 A, Japan) in standard sportswear (shorts and t-shirts) to the nearest 0.1 kg.

Running-based anaerobic sprint test (RAST) measurements: Before the RAST test was administered, total body mass of the participants was measured. RAST test was performed on the tartan floor. This test consisted of 6 repeated 35-meter maximum sprints with 10 s passive recovery between each sprint. The time for each sprint effort was measured by photocell system (Newtest Powertimer 300-series) and start for each sprint occurred with a sound from the photocell equipment.

Data collection

The research sample consisted of power athletes who perform intense exercise at least 5 y and over 3 d per week. Before the research study was administered, the participants were randomly assigned to three groups (Post activation potentiation group (n=15), Static Stretching group (n=14) and Control group (n=15)). Participants were instructed to refrain from intensive physical activity for 24 h prior to each testing session.

The study was conducted in two phases. In the first phase; all the athletes participating in the study were subjected to a 5 min warm-up at a speed of 8 km/h on a treadmill, then 5 min passive recovery was applied. After the 5 min of passive recovery, all the athletes were performed a 6 repeated 35-meter maximum sprint test.

The second measurements of the athletes were performed minimum 48 h and maximum 72 h after the first measurements. In the second phase, all of athletes were performed 5 min warm-up at 8 km/h on treadmill and then 5 min passive recovery was given again. After the 5 min of passive recovery session, static stretching group was applied 6 static stretching exercises according to the procedures of Faigenbaum et al. (Table 2) [15]. 2 repetitions of each stretching exercise were held 15 s at a point of mild discomfort by the subjects. Between stretching repetitions, the leg was returned to a neutral position for a 5 s rest period. All stretching exercises were applied to both legs. Immediately after the application of the stretching exercise, subjects were administered 5 min of passive recovery and then RAST test was performed. On the other hand, PAP group was applied one set of five repetitions of back squat at their 90% of 1 RM after the same warm-up and passive recovery session. After the execution of PAP warm-up protocol, subjects were performed the RAST test following 5 min of passive recovery. The control group was directly subjected to RAST test after 5 min of warm-up and 5 min of rest (Figure 1).

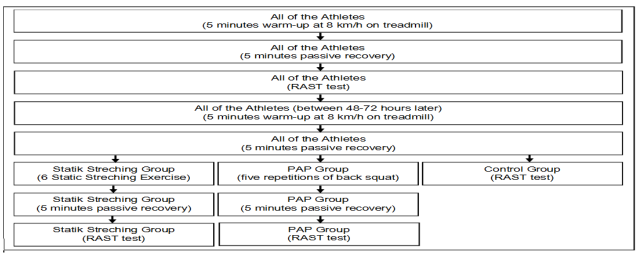

Figure 1. Study design for PAP group, static stretching group and control group.

Table 2. Static stretching exercises.

1.	**Adductor stretching exercise:** This stretching movement starts in sitting position with an erect spine, both knees bend, both soles touch each other and allow knees to fall to the side.
2.	**Modified hurdles stretching exercise:** This stretching movement starts in sitting position with one leg straight, one leg bent in front of the body and the soles toward the inner thigh of the straight leg and reach forward.

3.	**Hip Rotator stretching exercise:** This stretching movement starts in a supine position with both knees bent and cross the one leg over the other, flex both hips to or past 90 degrees by pulling on the uncrossed leg.
4.	**Bent-over toe raise:** This stretching movement starts in a standing position with the heel of one foot slightly in front of the toes of the other foot, the front leg is in a stretched position and rear leg is lifted up while leaning downward with upper body.
5.	**Quadriceps stretching exercise:** This stretching movement starts in a standing position with the back straight, bend one knee, grasp top ankle or forefoot behind and bring soles towards buttocks.
6.	**Calf stretching exercise:** This stretching movement starts in a standing position with your hands on the wall, front foot is one step behind the wall, take a big step backwards with other leg. Keeping back leg straight and front leg bent. Afterwards, stretching the back of the outstretched leg.

Statistical analysis

Descriptive statistics (mean ± SD) for age, height and weight variables were calculated. Normal distribution of data was tested by Kolmogorov-Smirnov (K-S) test. It was observed that all variants were normally distributed ($p>0.05$). A two-way repeated measure Analysis of Variance (ANOVA) was used to analyze differences between pre-test and post-test power scores for the RAST test. First of all, Mauchly's sphericity test was used to test of sphericity assumption in within-subject of repeated measure ANOVA. In cases where the assumption of sphericity was not met, Greenhouse Geisser corrections were applied. A repeated measures ANOVA with a Greenhouse-Geisser correction showed that peak and mean power scores for RAST test differed significantly between time points ($p<0.05$). Bonferroni post hoc test was used to determine differences between three warm-up groups. Statistical analysis of the measurements is performed by using SPSS 17.0 for Windows and $P<0.05$ is used to determine statistical significance.

Results

Pre-test and post-test RAST scores for 3 different warm-up groups (Static Stretching Group, Post Activation Group and Control Group) are presented in Table 3. The results indicated that there was a significant interaction between group χ time for the peak power ($F=15.820$, $p<0.05$) and mean power ($F=30.726$, $p<0.05$) scores. We also examined the simple main effect for group × time and time for peak power and mean power scores. There was a significant decrease in peak power and mean power scores for the Static Stretching Group from pre-test to post-test ($p<0.05$). There was also a significant increase in peak power and mean power scores for the Post Activation Group from pre-test to post-test ($p<0.05$). In other words, post activation potentiation warm-up method leads to an acute increase in peak power and mean power scores after the repeated sprint test while static warm-up method causes a significant decrease. After post hoc test, there were no significant differences between three warm-up groups in terms of both peak and mean power scores ($p>0.05$).

Table 3. *3X2 repeated ANOVA results for RAST test following 3 different warm-up protocols.*

Variables		**Pre-test Mean ± SD**	**Post-test Mean ± SD**	**Group X Time F**
RAST Test Peak power (watt)	SS group	828.29 ± 155.11	777.36 ± 133.42	15.820*
	PAP group	754.40 ± 151.89	803.67 ± 125.47	
	Control group	850.80 ± 172.73	842.40 ± 154.56	
RAST Test Mean power (watt)	SS group	758.29 ± 152.67	689.57 ± 143.15	30.723*
	PAP group	682.27 ± 118.90	724.80 ± 102.30	
	Control group	777.00 ± 154.26	766.27 ± 145.09	

Note: *P<0.05; SS Group: Static Stretching Group; PAP Group: Post Activation Potentiation Group.

Discussion

Results of this study indicate that post activation potentiation warm-up method leads to an acute increase in peak power and mean power scores after the repeated sprint test while static warm-up method causes a significant decrease in male athletes. Several studies have stated that stretching exercises, which have been traditionally utilized during warm-up exercise, may inhibit strength, force production, speed, agility and jump performance [3,11,12,17,18,20,26]. Besides the static stretching exercises, it is stated that other stretching types may also reduce the power performance [13]. Static Stretching exercise may also impair the viscoelastic properties, sarcomeric cross-bridge kinetics, and stiffness of muscle-tendon unit [20,21,27] and neural factors like reflex sensitivity [28]. Therefore, exercise performance following static Stretching movements can be affected by these results. However, Behm et al. suggested that the performance reductions due to a stretching may be related to muscular inactivation sourced from the stretching event rather than changes in the elasticity of the muscle-connective tissue components [11]. Despite several studies suggesting that static stretching exercises may reduce exercise performance, some studies have also failed to find any effect [11-19,29]. This discrepancy may be due to differences in static Stretching implementation duration, physical fitness level of participants and muscle groups stretched. Some studies suggested that short duration stretching warm-up do not reduce exercise performance, but the performance will be adversely affected as the warm-up time lengthens [27,30].

PAP refers to a physiological phenomenon that is an acute increase in muscle power production and exercise performance because of previous contraction [23,31]. Despite there is a great deal of evidence about the effects of PAP warm-up on muscle performance, some studies have failed to demonstrate this effect [7,10,24,32-34]. Inconsistencies between studies in the PAP research have been attributed to differences in conditioning level and muscle fiber composition of the subjects, intensity of the PAP warm-up, recovery time between PAP warm-up and following an execution of high intensity exercise [7,22,35-38].

One of the important factors affecting PAP warm-up is recovery time [23,39]. A suitable resting period is important for demonstrating the effect of PAP warm-up on muscle performance [31,39]. The recovery time is neither too long to remove the PAP effects nor too short to cause fatigue [23,40-42]. There is an optimal time interval between PAP warm-up and following an execution of high intensity exercise depending on the type and intensity of the stimulus [23,39,40]. Most studies have reported that time interval between PAP warm-up and following an execution of high intensity exercise varied between 3 and 8 min [24,34,40]. However, a suitable resting period following PAP warm-up may also be related to intensity of the stimulus [22]. Some studies have used longer recovery times following high intensity warm-up stimulus and stated that a PAP warm-up effect may last upto 20 min [35,37,38,43].

Most of the current literature stated that conditioning background may be one of the important factors in influencing the degree of PAP [7,32]. Chiu et al. reported that elite athletes are likely to make further improvements in athletic performance than recreationally trained individuals following PAP stimulus [32]. Wilson et al. stated that regulatory myosin light chain phosphorylation activity of the elite athletes is greater than untrained individuals [43]. As a consequence, the greater regulatory myosin light chain phosphorylation activity in the trained individuals, the greater the amount of energy in the muscle and muscular power following PAP stimulus.

Another important factor that affects PAP warm-up stimulus is muscle fiber type and its distribution within the muscle which is commonly determined by genetic factors [36]. Studies indicated that individuals with higher type II muscle fibers demonstrated greater PAP response [36,44]. The advantage of a higher percentage of type II muscle fiber is enabled to generate greater force in a shorter time [45].

Increases in performance following PAP warm-up may also depend on severity of the stimulus used during PAP movement [36]. Vandervoort et al. stated that contractions at below 75% of the maximal voluntary contraction produce little or no potentiation effect [46]. Most of the current literature was used high intensity stimulus during PAP warm-up exercise and showed a significant increase in exercise performance [22,40,46].

Conclusion

Warm-up prior to strenuous physical activities has always attracted the attention of sport scientists. Approaches with regarding to warm-up exercise have been continuously changed and brings about the contradictions related to the effects of warm-up type on the performance. Besides, variables such as duration and severity of the warm-up and recovery time between warm-up and following an execution of high intensity exercise may improve or inhibit the execution of power activities. In this study, we evaluated the repeated sprint test results of male athletes subjected to different warming protocols. As a result of this study, we found that post activation potentiation model warm-up method increases the repeated sprint values in male athletes during RAST test while static stretching model warm-up method decrease.

References

1. Hawley JA, Williams MA, Williams MM, Hamling GC, Walsh RM. Effects of a task-specific warm-up on anaerobic power. Brit J Sports Med 1989; 23: 233-236.
2. Shellock FG. Physiological benefits of warm-up. Phys Sports Med 1983; 10: 134-139.
3. Mcmillian DJ, Moore JH, Hatler BS, Taylor DJ. Dynamic vs. static stretching warm up: the effect on power and agility performance. J Strength Cond Res 2006; 20: 492-499.
4. Smith CA. The warm up procedure: To stretch or not to stretch. A brief review. J Orthopaed Sports Phys Ther 1994; 19: 12-17.
5. Harmancı H, Karavelioğlu MB, Şentürk A, Kalkavan A, Yüksel O. Effects of different warm-up durations on wingate anaerobic power and capacity results. Sportif Bakış: Spor ve Eğitim Bilimleri Dergisi 2014; 1: 43-52.
6. Sotiropoulos K, Smilios I, Christou M, Barzouka K, Spaias A, Douda H, Tokmakidis SP. Effects of warm-up on vertical jump performance and muscle electrical activity using half-squats at low and moderate intensity. J Sports Sci Med 2010; 9: 326-331.
7. Smith CE, Hannon JC, McGladrey B, Shultz B, Eisenman P, Lyons B. The effects of a post activation potentiation warm-up on subsequent sprint performance. Hum Movement 2014; 15: 36-44.
8. Andrews TR, Mackey T, Inkrott TA, Murray SR, Clark IE, Pettitt RW. Effect of hang cleans or squats paired with countermovement vertical jumps on vertical displacement. J Strength Cond Res 2011; 25: 2448-2452.
9. Matthews MJ, Comfort P, Crebin R. Complex training in ice hockey: The effects of a heavy resisted sprint on

subsequent ice-hockey sprint performance. J Strength Cond Res 2010; 24: 2883-2887.

10. Linder EE, Prins JH, Murata NM, Derenne C, Morgan CF, Solomon JR. Effects of preload 4 repetition maximum on 100-m sprint times in collegiate women. J Strength Cond Res 2010; 24: 1184-1190.
11. Behm DG, Button DC, Butt JC. Factors affecting force loss with prolonged stretching. Canad J Appl Physiol 2001; 26: 261-272.
12. Church JB, Wiggins MS, Moode FM, Crist R. Effect of warm-up and flexibility treatments on vertical jump performance. J Strength Cond Res 2001; 15: 332-336.
13. Nelson AG, Kokkonen J. Acute ballistic muscle stretching inhibits maximal strength performance. Res Q Exerc Sport 2001; 72: 415-419.
14. Young W, Elliot S. Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching, and maximum voluntary contractions on explosive force production and jumping performance. Res Q Exerc Sport 2001; 72: 273-279.
15. Faigenbaum AD, Bellucci M, Bernieri A, Bakker B, Hoorens K. Acute effects of different warm-up protocols on fitness performance in children. J Strength Cond Res 2005; 19: 376-381.
16. Young WB, Behm DG. Effects of running, static stretching and practice jumps on explosive force production and jumping performance. J Sports Med Phys Fitness 2003; 43: 21-27.
17. Cornwell A, Nelson AG, Heise GD, Sidaway B. The acute effects of passive muscle stretching on vertical jump performance. J Hum Movement Studies 2001; 40: 307-324.
18. Fowles JR, Sale DG, Macdougall JD. Reduced strength after passive stretch of the human plantarflexors. J Appl Physiol 2000; 89: 1179-1188.
19. Kokkonen J, Nelson AG, Cornwell A. Acute muscle stretching inhibits maximal strength performance. Res Q Exerc Sport 1998; 69: 411-415.
20. Cramer JT, Housh TJ, Johnson GO, Miller JM, Coburn JW, Beck TW. Acute effects of static stretching on peak torque in women. J Strength Cond Res 2004; 18: 236-241.
21. Wilson GJ, Murphyi AJ, Pryori JF. Musculotendinous stiffness: its relationship to eccentric, isometric, and concentric performance. J Appl Physiol 1994; 76: 2714-2719.
22. Tillin N, Bishop D. Factor's modulating post-activation potentiation and its effect on performance of subsequent explosive activities. Sports Med 2009; 39: 147-166.
23. Robbins DW. Postactivation potentiation and its practical applicability: A brief review. J Strength Cond Res 2005; 19: 453-459.
24. Lima LC, Oliveira FB, Oliveira TP, Assumpcao CO, Greco CC, Cardozo AC, Denadai, BS. Post activation potentiation biases maximal isometric strength assessment. Bio Med Res Int 2014; 1-7.
25. Szczesna D, Zhao J, Jones M, Zhi G, Stull J, Potter JD. Phosphorylation of the regulatory light chains of myosin affects Ca+2 sensitivity of skeletal muscle contraction. J Appl Physiol 2002; 92: 1661-1670.
26. Fletcher IM, Jones B. The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. J Strength Cond Res 2004; 18: 885-888.
27. Avloniti A, Chatzinikolaou A, Fatouros IG, Avloniti C, Protopapa M, Draganidis D, Stampoulis T, Leontsini D, Mavropalias G, Gounelas G, Kambas AL. The acute effects of static stretching on speed and agility performance depend on stretch duration and conditioning level. J Strength Cond Res 2016; 30: 2767-2773.
28. Avela J, Kyrolainen H, Komi PV. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. J Appl Physiol 1999; 86: 1283-1291.
29. Favero J, Midgley AW, Bentley DJ. Effects of an acute bout of static stretching on 40 m sprint performance: Influence of baseline flexibility. Res Sports Med 2009; 17: 50-60.
30. Kay AD, Blazevıch AJ. Effect of acute static stretch on maximal muscle performance: A systematic review. Med Sci Sports Exerc 2012; 44: 154-164.
31. Lorenz D. Clinical commentary: post activation potentiation: an introduction. Int J Sports Phys Ther 2011; 6: 234-240.
32. Chiu LZ, Fry AC, Weiss LW, Schilling BK, Brown LE, Smith SL. Postactivation potentiation response in athletic and recreationally trained individuals. J Strength Cond Res 2003; 17: 671-677.
33. Till KA, Cookei C. The effects of post activation potentiation on sprint and jump performance of male academy soccer players. J Strength Cond Res 2009; 23: 1960-1967.
34. Hanson ED, Leigh S, Mynark RG. Acute effects of heavy- and light-load squat exercise on the kinetic measures of vertical jumping. J Strength Cond Res 2007; 21: 1012-1017.
35. Bevan HR, Cunningham DJ, Tooley EP, Owen NJ, Cook CJ, Kilduff LP. Influence of post activation potentiation on sprinting performance in professional rugby players. J Strength Cond Res 2010; 24: 701-705.
36. Xenofondos A, Laparidis K, Kyranoudis A, Galazoulas C, Bassa E, Kotzamanidis C. Post-activation potentiation: Factors affecting it and the effect on performance. J Phys Edu Sport 2010; 28: 32-38.
37. Kilduff LP, Bevan HR, Kingsley MIC, Owen NJ, Bennett MA, Bunce PJ, Hore AM, Maw JR, Cunningham DJ. Postactivation potentiation in professional rugby players: Optimal recovery. J Strength Cond Res 2007; 21: 1134-1138.
38. Docherty D, Robbins D, Hodgson M. Complex training revisited: A review of its current status as a viable training approach. J Strength Cond 2004; 26: 52-57.
39. Sotiropoulos K, Smilios I, Douda H, Christou M, Tokmakidis SP. Contrast loading: power output and rest interval effects on neuromuscular performance. Int J Sports Physiol Performance 2013; 9: 567-574.

40. Weber KR, Brown LE, Coburn JW, Zinder SM. Acute effects of heavy-load squats on consecutive squat jump performance. J Strength Cond Res 2008; 23: 723-730.
41. Gullich A, Schmidtbleicher D. MVC-induced short-term potentiation of explosive force. Int Amateur Athletic Feder 1996; 11: 67-81.
42. Hodgson M, Docherty D, Robbins D. Post-activation potentiation: underlying physiology and implications for motor performance. Sports Med 2005; 35: 585-595.
43. Wilson JM, Duncan NM, Marin PJ, Brown LE, Loenneke JP, Wilson SMC, Jo E, Lowery RP, Ugrinowitsch C. Meta-analysis of post activation potentiation and power: Effects of conditioning activity, volume, gender, rest periods, and training status. J Strength Cond Res 2013; 27: 854-859.
44. Houston ME, Green HJ, Stull JT. Myosin light chain phosphorylation and isometric twitch potentiation in intact human muscle. Pflugers Archiv 1985; 403: 348-352.
45. Cissik J. Means and methods of speed training. Strength Cond J 2004; 26: 24-29.
46. Vandervoort AA, Quinlan J, McComas AJ. Twitch potentiation after voluntary contraction. Exp Neurol 1983; 81: 141-152.

*Correspondence to

Halit Harmancı

Physical Education and Sport

Dumlupınar University

Turkey