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Investigation of Acute Effects of Different Warm-Up Protocols on Athletic Performance in Football

Futbolda Farklı Isınma Protokollerinin Sportif Performansa Akut Etkilerinin İncelenmesi

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INVESTIGATION OF ACUTE EFFECTS OF DIFFERENT WARM-UP PROTOCOLS ON ATHLETIC PERFORMANCE IN FOOTBALL

ABSTRACT

In football, warm-up is important for physical preparation, injury prevention, and performance enhancement. This study aimed to determine the acute effects of four different warm-up techniques, static, dynamic, self-myofascial stretching (SMR), and massage with Graston mobilization technique (GMTM), on sports performance in football. A total of 20 football players, 13 males and 7 females, who were actively studying at Yalova University Faculty of Sports Sciences and who had a football license for at least one year, were included in the study. In the study, 4 different warm-up programs were applied to each participant in random order on separate weeks, at the same time of the day and at the same day of the week. Passing, dribbling, agility, and vertical jump tests were performed before and after each warm-up program. Skewness, kurtosis values, descriptive statistics, Paired Samples T-test, and Two-Way Repeated Measures ANOVA test were used to analyze the data. As a result of the study, it was found that static warm-up, dynamic warm-up, warm-up with SMR, and warm-up with GMTM significantly increased dribbling, agility, and vertical jump performance ($p<0.05$), but had no effect on total pass number ($p>0.05$). No significant difference was found between the changes these warm-up types created in the total number of passes, dribbling and vertical jump performance within the scope of the warm-up type x time interaction ($p>0.05$), but it was determined that they created different effects on agility ($p<0.05$). Warming up in football acutely improves athletic performance. However, branch-specific warm-ups or special training methods may be preferred to improve passing performance. In particular, while warming up with GMTM increases agility performance more than other warm-up types, the effect of SMR is lower than the others. In future studies, football-specific mixed warm-up methods can be created and their effects on athletic performance can be examined in detail.

Keywords: Football, Warm-Up, Sportive Performance, Graston, Myofascial Release.

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FUTBOLDA FARKLI ISINMA PROTOKOLLERİNİN SPORTİF PERFORMANSA AKUT ETKİLERİNİN İNCELENMESİ

ÖZ

Futbolda ısınma fiziksel aktiviteye hazırlık, yaralanmalardan korunmak ve performansın arttırılması için önemlidir. Bu çalışmanın amacı statik, dinamik, self miyofasial gevşeme (SMR) ile ve Graston mobilizasyon tekniğiyle masaj (GMTM) ile oluşturulan dört farklı ısınma tekniğinin futbolda sportif performans üzerindeki akut etkisinin belirlenmesidir. Çalışmaya Yalova Üniversitesi Spor Bilimleri Fakültesi'nde okuyan aktif olarak futbol lisansı bulunan en az bir yıldır lisanslı 13 erkek, 7 kadın olmak üzere toplam 20 futbolcu dahil edilmiştir. Çalışmada 4 farklı ısınma programı her katılımcıya sırası rastgele olacak şekilde ayrı haftalarda ve haftanın aynı günü ve aynı saatinde uygulanmıştır. Her ısınma programı öncesi ve sonrasında katılımcıların pas verme, top sürme, çeviklik ve dikey sıçrama testleri alınmıştır. Verilerin analizinde çarpıklık, basıklık değerleri, tanımlayıcı istatistikler, Bağımlı Örneklem T testi ve Tekrarlı Ölçümlerde İki Yönlü ANOVA testi kullanılmıştır. Çalışma sonucunda statik ısınma, dinamik ısınma, SMR ile ısınma ve GMTM ile ısınmanın top sürme, çeviklik ve dikey sıçrama performansını anlamlı düzeyde arttırdığı ($p<0,05$), ancak toplam pas sayısına etki etmediği belirlenmiştir ($p>0.05$). Bu ısınma türlerinin ısınma türü x zaman etkileşimi kapsamında toplam pas sayısı, top sürme ve dikey sıçrama performansında yarattıkları değişim arasında anlamlı bir farklılık bulunamamıştır ($p>0,05$), çeviklik üzerinde farklı etkileri yarattıkları tespit edilmiştir ($p<0,05$). Futbolda ısınma akut olarak sportif performansı arttırmaktadır. Ancak pas atma performansının arttırılması için branşa özgü ısınma veya özel antrenman yöntemleri tercih edilebilir. Özellikle GMTM ile ısınma çeviklik performansını diğer ısınma türlerine göre daha fazla arttırmakta iken SMR'nin etkisi diğerlerine göre daha düşüktür. İleride yapılacak çalışmalarda futbolda özgü karma ısınma yöntemleri oluşturularak sportif performans üzerindeki etkileri detaylı bir şekilde incelenebilir.

Anahtar Kelimeler: Futbol, Isınma, Sportif Performans, Graston, Miyofasiyal Gevşetme.

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INTRODUCTION

Warming up in football is important as it prepares the body for physical activity, improves athletic performance, and minimizes the risk of injury (Young & Behm, 2002; Makuch et al., 2022). It is believed that using stretching exercises during the warm-up process can improve performance according to various

studies (Carvalho, 2012). Traditionally, the warm-up routine consists of aerobic activity and stretching exercises such as static stretching, dynamic stretching, ballistic stretching, and proprioceptive neuromuscular facilitation (Behm & Chaouachi, 2011; Franco, 2012).

Static stretching aims to bring the limb to its maximum length and hold it in the stretched position for 15-60 seconds (Behm & Chaouachi, 2011). Although this stretching is claimed to reduce the risk of muscle injury (Amako et al., 2003), some studies have shown that static stretching as part of warm-up has a negative effect on performance parameters (McMillian, 2006; Bradley, 2007). Dynamic stretching movements, which include sport-specific movement patterns, are recommended instead of static stretching in warm-up protocols (Torres et al., 2008; Turki et al., 2019; Judge et al., 2020). It has been reported that dynamic stretching performed with low to moderate-intensity movements in a dynamic warm-up increases body temperature, improves motor unit excitability and positively affects Counter Movement Jump (CMJ) performance (Dalrymple et al., 2010). It also enhances sprint performance (Brahim & Chan, 2022).

Another warm-up method commonly used by athletes is the self-myofascial release (SMR) technique (Popelka et al., 2024). This technique reduces restrictive barriers and fibrous adhesions in fascial tissue (Barnes, 1997). The device used in SMR is the foam roller. This device uses body mass to apply pressure to specific areas of the muscle or between the origin and insertion points for a particular number of repetitions and sets (Paolini, 2009; MacDonald, 2013). Research has shown that SMR produces similar results to dynamic stretching in jump and strength performance parameters while contributing more positively to joint range of motion (Behara & Jacobson, 2017). Furthermore, another study observed that SMR increased joint range of motion more than dynamic and static stretching exercises, and that peak muscle power production capacity was more positively affected after dynamic stretching and SMR compared to static stretching (Su, 2017). However, Wiewelhove et al. (2019) showed that the effects of foam roller use during warm-up on jump performance, strength, and recovery were generally negligible. Kondrad et al. (2021) also found in their study that the combined use of stretching and SMR did not affect athletes.

Another myofascial release technique is Instrument-Assisted Soft Tissue Mobilization. Graston Mobilization Technique (GMT) is a form of instrument-assisted soft tissue mobilization that aims to treat soft tissue restrictions by triggering the body's healing response. It is proposed that GMT uses cross-frictional massage on the tissue, which creates microtrauma to promote healing by stimulating blood flow to the treated area (Laudner et al., 2014). A study of collegiate wrestlers showed that warm-up with GMT improved sprint performance (Jaskolski, 2016).

A study comparing GMT with static stretching found that GMT was as effective as static stretching in increasing muscle flexibility (Çakır & Karadenizli, 2019). No study was found that included GMT in warm-up programs for football players.

Many studies in the literature have investigated how different types of warm-ups affect performance, and the search for the most effective warm-up strategy continues. Within the scope of the original value of this study, it is aimed to examine the effects of new warm-up protocols such as SMR and GMTM on the performance of football players, apart from traditional static and dynamic warm-up techniques, and to determine how modern methods affect football performance at the acute level. Thus, by revealing the advantages of different warm-up techniques, this study will help soccer players determine the most appropriate warm-up protocols that can help them improve their performance at professional and amateur levels. It will contribute to making training programs more efficient by investigating the most effective warm-up methods that can improve performance parameters such as agility, speed, dribbling, and jumping.

METHODS

Research Group

Table 1. The demographic information of the participants

Variables	n	Min	Max	Mean	SD
Age (years)	20	18.00	28.00	20.60	2.56
Weight (kg)	20	50.00	85.00	66.15	10.86
Height (cm)	20	155.00	185.00	170.90	9.53
BMI (kg/m^2)	20	20.00	24.95	22.34	1.81

Abbreviations: Min: Minimum; Max: Maximum; SD: Standard deviation; BMI: Body mass index

The study included 22 footballers, 13 male and 7 female, who were studying at Yalova University Faculty of Sports Sciences and had a football licence with an average of 4.20±3.17 years in the branch. A participant who did not regularly participate in the measurements was excluded from the study. One participant dropped out of the study due to a sports injury. The study was completed with a total of 20 participants. The demographic information about the participants is shown in Table 1. The criteria for inclusion in the study included being a student at Yalova University Faculty of Sports Sciences, having a football licence for at least 1 year, have been training regularly for the last 6 months (2-3 days a week) and not having suffered from any injuries in the last 6 months and having an active licence in the football branch. The criteria for exclusion from the study included having any physical or neurological disability and not fulfilling the procedures required by the study.

Research Design

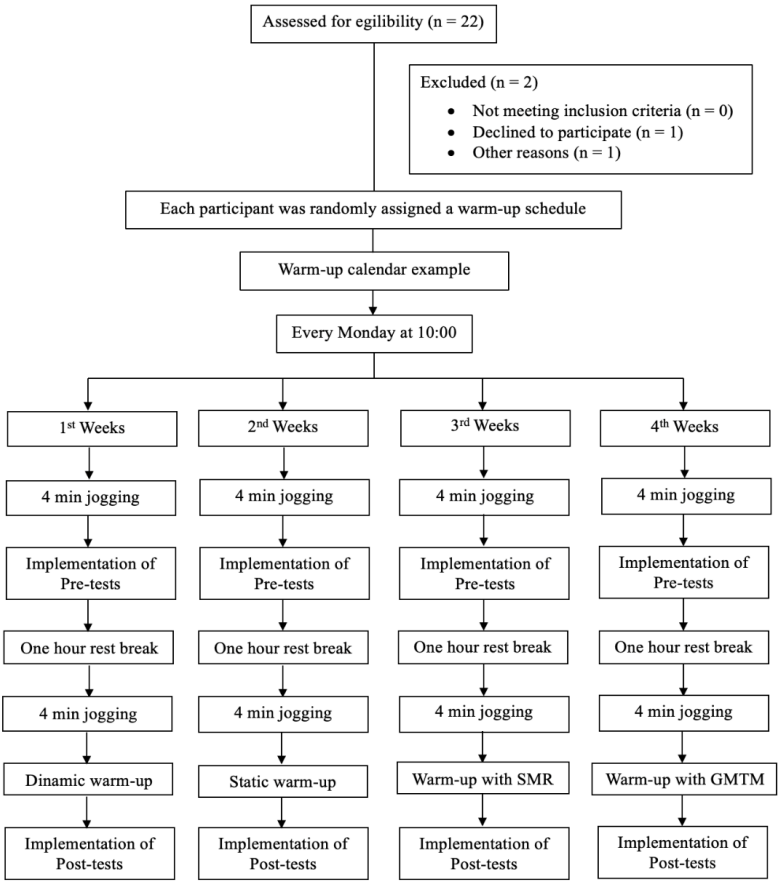

Figure 1. Example warm-up calendar for a participant

A randomized controlled cross-over model was used in the study design. Four different warm-up techniques were used at four different times during the study. The warm-up techniques used included static warm-up, dynamic warm-up, foam roller warm-up, and warm-up using the Graston technique. Each warm-up was performed on the same day and time of the week but in different weeks. The participants' agility, dribbling, passing, and vertical jump tests were performed before and after the warm-up. There was a one-week interval between the different warm-ups and measurements to ensure that the effect of one warm-up did not influence the next. On each warm-up day, the participants' first measurement was taken,

then they rested for 1 hour, after which they jogged for 4 minutes, followed by the warm-up scheduled for that day in the calendar, and the second measurement was taken. An example of a warm-up schedule for one participant is shown in Figure 1. The order of the weekly warm-up techniques was randomized for each participant to eliminate potential bias by preventing the long-term effects of the warm-up techniques on the tests.

Data Collection Process

Mor Christian Passing Test: This test measures how many accurate passes the participant can make to a designated area. During the test, a test sheet, pen, tape measure, cones, footballs, and marking tape were used. An area 15 meters long and 4 meters wide was prepared for the passing test. A mini-goal of 91 cm in width and 45 cm in height was created for the test using marking cones. Three impact points were marked on the goal. Two of these were placed at a 45-degree angle to the left and right of the goal line, 13.5 meters away. The third was directly opposite the goal, 13.5 meters away, at a 90-degree angle to the goal line. The passing test was first visually explained to the participant, and during the application, accurate passes were counted while standing next to the goal. The participant made a total of 12 passes, four from each of the three strike points. The participants were allowed to use their preferred foot for the passes. Two attempt passes were allowed from each strike point. One point was scored for each accurate pass. Balls that hit the goalposts (cones) were considered accurate. The final score of the test was the sum of accurate passes from the 12 trials (Aktuğ et al., 2019; Mülazımoğlu, 2020).

30-Meter Dribbling Test: The purpose of this test is to measure the ability to dribble a ball at maximum speed in a straight line. The test protocol is described below. Four cones, a soccer ball, a steel tape measure, and a stopwatch were used during the test. A straight course was prepared with a distance of 30 meters between the start and finish lines. The start and finish lines of the course were marked with two cones. Photocells were placed in the marked areas. The participant was positioned on the start line with a football. The participant was instructed to complete the course by dribbling the ball in the shortest possible time. The time it took the participant to cover the distance between the start and finish lines was recorded in seconds (Mülazımoğlu, 2020).

Illinois Agility Test: The Illinois Agility Test is a field test that measures the ability to sprint and change direction, allowing the assessment of agility performance in athletes. The duration of the test was measured using a photocell. The test was conducted in an area 5 meters wide and 10 meters long. The 10 m length was divided into three equal sections (approximately 3.3 m each) by cones placed

along the center line. The test consisted of approximately 40 meters of straight driving and 20 meters of slalom driving between the cones. The test included 5 full 180° turns and 6 additional partial turns between the cones. Photocells were placed at the entrance and exit of the test area. The participant was initially positioned 1 meter behind the start photocell. The footballer started the run at any time and completed the course by moving in the direction indicated by the arrows, starting from the start photocell and finishing at the end photocell (Mülazımoğlu, 2020).

Free Counter Movement Jump Test: Free Counter Movement Jump (FCMJ) test was administered to the participants as a vertical jump test. It is a test used to measure explosive power. The FCMJ test was used to determine the participants' airtime. Test data were collected using the OptoJump device. Before starting the test, the participants were allowed to practice to familiarise themselves with the test technique. The participants were then positioned in the OptoJump Next (Microgate, Bolzano, Italy) device with their hands-free. They were instructed to "Minimize the transition between the descending and ascending phases and jump as high as possible as quickly as possible. The participants should not make any movements during the flight time. Their hands will be free during the jump and landing and they can move them as they wish. Care was taken to ensure that the knees, hips, and ankles were flexed to perform a squat before the jump, and that the landing was performed with the hips, knees, and ankles in extension. Each participant was allowed three attempts with a one-minute rest in between, and the best time was recorded. Jumps were not accepted if the landing occurred with the knees and hips in flexion during the test and the test was repeated (Acero et al., 2012).

Warm-up Techniques Protocols

Before each warm-up protocol, participants jogged at a light pace for 4 minutes.

Static warm-up protocol: Static stretching is a method used to relax muscles by holding them in an extended position for a prolonged period. In this study, static stretching was applied to the calf muscles, hip adductors, hamstrings, and quadriceps as part of the static warm-up. The muscles were held in the stretched position for 15 seconds, followed by 20 seconds of relaxation. The movement was repeated three times for each muscle (Polat et al., 2019).

Dynamic warm-up protocol: Dynamic stretching is a type of stretching that involves extending the muscle during movement. The dynamic warm-up protocol was designed to dynamically stretch the quadriceps, hamstrings, calves, and hip adductors (Köse et al., 2021; Seçer & Kaya, 2021). It began with 4

minutes of light jogging. Each movement in the protocol was performed for 15 seconds in a round, followed by a 10-second rest. The warm-up was completed in 10 minutes with repetitions of each movement. The following movements were used in the dynamic warm-up protocol:

- High Knee Walk
- Forward Gate Swings
- Backward Gate Swings
- Lunge Walk
- Toy Soldier Walk
- Lateral Lunge Walk
- Calf Raise and Stretch

Warm-up with Self Myofascial Release: Self Myofascial Release (SMR) is a warm-up method that uses foam rolling to promote relaxation. In this study, SMR was applied to the quadriceps, hip adductors, gastrocnemius, and hamstrings. The participants were instructed to use a rolling speed of 5 rolls per 30 seconds, targeting the muscle group with as much pressure as possible (Edis & Vurgun, 2021; Beyleroğlu et al., 2021). SMR exercises were performed on both sides of the hamstrings, quadriceps, hips and gastrocnemius muscles for 2 x 30 seconds with 10 seconds of passive rest in between. A 30-second rest was allowed between sets of exercises.

Warm-up with Graston Mobilization Technique-Massage: Graston Mobilization Technique-Massage (GMTM) is a massage technique that promotes myofascial release. This technique was applied to the calf, hamstring, adductor, and quadriceps muscles. The application was performed in a sweeping motion parallel to the muscle fiber at an angle of 45° for 2 minutes. The technique was applied in a unidirectional sweeping motion from distal to proximal. Massage oil was used as a lubricant for the GMTM warm-up. The GMTM application was stopped in case of excessive hyperemia (Çakır & Karadenizli, 2021).

Research Ethics

Ethics committee permission for the study was received from Yalova University Human Research Ethics Committee on 14.03.2024 with protocol number 2024/11. Participants were informed about the study and filled out an informed consent form. Participants were included in the study on a voluntary basis. The current research is in accordance with the Declaration of HELSINKI.

Analysis of Data

SPSS 26 software was used for data analysis. The normality distribution of the data was determined by the Shapiro-Wilk test and the Skewness and Kurtosis values. Since the Skewness and Kurtosis values were within the range of (-7.5) to (7.5) (Hair et al., 2010), the data were considered to show a homogeneous distribution (George and Mallery, 2010; Gürbüz and Şahin, 2018). Parametric tests were applied as the data followed a normal distribution. Descriptive statistics such as minimum, maximum, mean and standard deviation, Paired Sample T-test, and Two-Way Repeated Measures ANOVA (Types of warm up (4) x Time (2)), post hoc test were used in the analysis of the data. Statistically, the significance value was accepted as $p<0.05$. The effect of the mean score difference between the variables was evaluated using Cohen's d and eta squared ($\eta 2$) values. Cohen's d was considered a small effect when in the range of "0.20-0.49," a medium effect when "0.50-0.79," and a large effect when ">0.80." The $\eta 2$ value range was interpreted as "0.01-small effect size, 0.06-medium effect size, 0.14 and above-large effect size" (Büyüköztürk, 2011).

RESULTS

Table 2. Effect of warm-up protocols on football performance parameters

Variables			n	Mean	SD	t	df	p	Cohen's *d*
Static warm-up	Total pass number	Pre-test	20	8.15	2.03	-1.245	19	0.228	0.31
		Post-test	20	8.85	2.46				
	Dribbling (sec)	Pre-test	20	5.40	0.51	5.290		**<0.001**	0.55
		Post-test	20	5.10	0.58				
	Agility (sec)	Pre-test	20	17.81	0.95	4.659		**<0.001**	0.47
		Post-test	20	17.38	0.87				
	Free CMJ height (cm)	Pre-test	20	31.73	6.26	-4.369		**<0.001**	0.39
		Post-test	20	34.38	7.40				
Dynamic warm-up	Total pass number	Pre-test	20	8.85	1.63	0.742		0.467	0.19
		Post-test	20	8.50	2.06				
	Dribbling (sec)	Pre-test	20	5.38	0.64	5.338		**<0.001**	0.50
		Post-test	20	5.08	0.57				
	Agility (sec)	Pre-test	20	18.08	1.20	3.662		**0.002**	0.43
		Post-test	20	17.61	0.99				
	Free CMJ height (cm)	Pre-test	20	31.01	6.23	-4.402		**<0.001**	0.39
		Post-test	20	33.49	6.50				
SMR warm-up	Total pass number	Pre-test	20	8.47	2.01	-0.717		0.482	0.21
		Post-test	20	8.84	1.56				
	Dribbling (sec)	Pre-test	20	5.14	0.59	3.738		**0.001**	0.37
		Post-test	20	4.93	0.56				
	Agility (sec)	Pre-test	20	18.02	1.21	5.084		**<0.001**	0.45
		Post-test	20	17.52	1.02				
	Free CMJ height (cm)	Pre-test	20	31.56	4.74	-3.908		**0.001**	0.42
		Post-test	20	33.57	4.80				
GMTM warm-up	Total pass number	Pre-test	20	7.75	2.55	-1.945		0.067	0.36
		Post-test	20	8.60	2.19				
	Dribbling (sec)	Pre-test	20	5.21	0.63	5.755		**<0.001**	0.54
		Post-test	20	4.88	0.60				
	Agility (sec)	Pre-test	20	17.89	1.05	3.416		**0.003**	0.60
		Post-test	20	17.27	1.02				
	Free CMJ height (cm)	Pre-test	20	30.96	5.38	-8.118		**<0.001**	0.55
		Post-test	20	34.13	6.08				

Abbreviations: Free CMJ: Free Counter Movement Jump test; SMR: Self Myofacial Releasing; GMTM: Massage with Graston Myofacial Technique

Table 2 shows the effect of four different warm-up techniques on the total number of passes, dribbling, agility performance, and vertical jump height. It was found that all the warm-up techniques used in the study significantly increased dribbling performance, agility performance, and vertical jump height ($p<0.05$). However, the warm-up types did not significantly change the total pass number ($p>0.05$). When analyzed in terms of effect sizes, static, dynamic and GMTM warm-ups have a moderate effect on dribbling performance, while SMR warm-up has a low effect. While the effect of warming up with GMTM on agility and vertical jump performance is moderate, the effect of other warm-up types is low (Table 2).

Table 3. Comparison of the effects of different warm-up types on performance parameters

	Source	Type III Sum of Squares	df	Mean Square	F	p	η2	Post-hoc (Bonferroni)
Total pass number	WUT	6.44	2.27	2.84	0.69	0.526	0.035	p>0.05
	Error	178.14	43.13	4.13				
	Time	6.15	1.00	6.15	3.93	0.062	0.171	p>0.05
	Error	29.77	19.00	1.57				
	WUT*Time	8.56	3.00	2.85	1.02	0.390	0.051	p>0.05
	Error	159.09	57.00	2.79				
Dribbling (sec)	WUT	1.29	3.00	0.43	3.60	0.019	0.159	1>4, MD±SD=0.21±0.07, p=0.047
	Error	6.81	57.00	0.12				
	Time	3.79	1.00	3.79	50.42	<0.001	0.726	1>2, MD±SD=0.31±0.04, p<0.001
	Error	1.43	19.00	0.08				
	WUT*Time	0.01	1.83	0.01	0.06	0.928	0.003	p>0.05
	Error	3.23	34.77	0.09				
Agility (sec)	WUT	3.49	3.00	1.16	3.61	0.019	0.160	1<3, MD±SD=-0.32±0.11, p=0.05
	Error	18.34	57.00	0.32				
	Time	4.08	1.00	4.08	24.76	<0.001	0.566	1>2, MD±SD=0.32±0.06, p<0.001
	Error	3.13	19.00	0.16				
	WUT*Time	4.14	2.00	2.07	9.63	<0.001	0.336	For 1.WUT: pre>post, MD±SD=0.43±0.09, p<0.001; For 2.WUT: pre>post, MD±SD=0.47±0.13, p=0.002; For 3.WUT: pre<post, MD±SD=-0.23±0.05, p=0.001; For 4.WUT: pre>post, MD±SD=0.61±0.18, p=0.003
	Error	8.16	37.94	0.22				
Free CMJ height (cm)	WUT	13.51	2.20	6.13	0.57	0.586	0.029	p>0.05
	Error	449.95	41.88	10.74				
	Time	265.51	1.00	265.51	71.85	<0.001	0.791	1<2, MD±SD=-2.58±0.30, p<0.001
	Error	70.21	19.00	3.70				
	WUT*Time	6.81	3.00	2.27	0.93	0.432	0.047	p>0.05
	Error	139.16	57.00	2.44				

Abbreviations: MD= Mean Differences; SD: Standard deviation; Free CMJ: Free Counter Movement Jump test; SMR: Self Myofacial Releasing; GMTM: Massage with Graston Myofacial Technique, WUT: Warm-up techniques, For WUT: 1= Static warm-up, 2= Dynamic warm-up, 3= SMR warm-up, 4= GMTM warm-up, For time: 1=pre-test, 2= post-test

The effects of different warm-up techniques (static, dynamic, SMR, GMTM) and measurement times (before and after) on a total number of passes, dribbling (sec), agility (sec), and Free CMJ heights (cm) were analyzed by Two-Way Repeated Measures ANOVA test and the results of the analysis are given in Table 3. According to these results, no significant difference was found in the total number of passes between the warm-up techniques regardless of time ($F(2.27, 43.13) = 0.69$, $p = 0.526$, $\eta^2 = 0.035$). This shows that four different warm-up techniques had similar effects on the total number of passes. Again, no significant difference was

found in the total number of passes before and after the measurement regardless of the warm-up technique ($F(1, 19) = 3.93$, $p = 0.062$, $\eta^2 = 0.171$). When the effect of warm-up techniques and measurement times on the total number of passes was analyzed, no significance was found ($F(3, 57) = 1.02$, $p = 0.390$, $\eta^2 = .051$). This result shows that different warm-up techniques do not affect the total number of passes according to the time factor.

When the dribbling duration change was examined, a significant difference was found in dribbling time according to warm-up techniques regardless of time ($F(3, 57) = 3.60$, $p = 0.019$, $\eta^2 = 0.159$). As a result of the post hoc test, it was observed that warming up with GMTM increased dribbling performance at a high effect level by decreasing dribbling time compared to the static warm-up technique ($p = 0.047$). There was no significant difference in dribbling duration between before and after measurement regardless of warm-up technique ($F(1, 19) = 50.42$, $p < 0.001$, $\eta^2 = 0.726$). When the effect of warm-up techniques and measurement times on dribbling duration was analyzed, no significant difference was found ($F(1.83, 34.77) = 0.06$, $p = 0.928$, $\eta^2 = 0.03$). This result shows that different warm-up techniques do not have a significant effect on dribbling duration according to the time factor.

When the agility test duration change was analyzed, a significant difference was found according to the warm-up techniques regardless of time ($F(3, 57) = 3.61$, $p = 0.019$, $\eta^2 = 0.160$). It was determined that this result was due to the statistically significant improvement of agility performance of static warm-up type compared to warm-up with SMR ($p = 0.05$). Regardless of the warm-up technique, it was determined that there was a significant difference in agility test duration before and after the measurement ($F(1, 19) = 24.76$, $p < 0.001$, $\eta^2 = 0.566$). Regardless of the warm-up, the agility test duration of the participants decreased significantly in the post-test ($p < 0.001$). When the effect of warm-up techniques and measurement times on agility test duration was analyzed, a significant difference was found ($F(2, 37.94) = 9.63$, $p<0.001$, $\eta^2 = 0.336$). This difference was found in all warm-up techniques as seen in Table 4, and it was determined that an increase in agility test performance was achieved in static, dynamic and GMTM warm-ups compared to warming up with SMR.

When the change in free CMJ height was examined, no significant difference was found in free CMJ height according to warm-up techniques independent of time ($F(2.20, 41.88) = 0.57$, $p = 0.586$, $\eta^2 = 0.029$). Regardless of the warm-up technique, a significant difference was found in free CMJ height before and after the measurement ($F(1, 19) = 71.85$, $p<0.001$, $\eta^2 = 0.791$). Vertical jump heights of the participants increased significantly in the post-test regardless of warm-up ($p<0.001$). When the effect of warm-up techniques and measurement times on

Free CMJ height was analyzed, no significant difference was found ($F(3, 57) = 0.93$, $p = 0.432$, $\eta^2 = 0.047$). This result shows that different warm-up techniques did not have a significant effect on dribbling time according to the time factor.

DISCUSSION

This study investigated the effects of four different warm-up methods, including static stretching, dynamic stretching, SMR, and GMTM, on the passing, dribbling, agility, and vertical jump performance of football players.

Football, a globally popular sport (Reilly et al., 2000), requires high levels of lower extremity muscle strength for demanding activities such as directional change, dribbling, and passing (Meylan et al., 2009). Studies have shown that increasing joint range of motion through stretching exercises has a positive effect on muscle strength production (Herda et al., 2013). SMR breaks down fascial adhesions, removes tissue restrictions, and increases joint range of motion (Cafarelli and Flint, 1992). GMTM also removes myofascial adhesions and can positively affect muscle strength by stimulating nerves in the muscles (Markovic, 2015; Mondal Entaj et al., 2022). It is argued that GMTM increases flexibility, muscle strength, and endurance (Schaefer and Sandrey, 2012). Furthermore, studies have shown that GMTM affects flexibility, strength, and power, but has minimal effect on speed and agility (Markovic, 2015). In addition, SMR has been demonstrated to increase strength, power, speed, and agility (Macdonald, 2013; Markovic, 2015; Sullivan et al., 2013; Cheatham et al., 2016). In the present study, it was found that warming up with SMR and GMTM increased dribbling, agility, and vertical jump performance in football players. However, neither warm-up technique was found to affect passing performance in footballers. In addition, it has been determined that warming up with SMR and GMTM affects the other performance parameters considered.

According to the results of the current study, it was determined that warming up with SMR and GMTM as well as static and dynamic warm-up did not affect the total number of passes in football players. In the study by Dinç (2019), the effect of dynamic warm-up and branch-specific warm-up on the passing test result was compared, and it was observed that branch-specific warm-up increased the passing score. The fact that the 4 different warm-up techniques used in the current study did not increase the passing scores shows that movements for passing should be added to the warm-up. In future studies, it is recommended to create warm-up protocols including branch-specific movements to increase passing scores and to evaluate the effectiveness of these protocols.

According to the results of the present study, static warm-up, dynamic warm-up, warm-up with SMR, and warm-up with GMTM increase dribbling performance. In addition, it was revealed in the present study that warming up with GMTM

is more effective in increasing dribbling performance than static warm-up regardless of time. In addition, according to the warm-up type x time interaction, it was determined that four different warm-up types affected dribbling performance at a similar level. In the studies examining the effect of warm-up on dribbling in the literature, it has been shown that dynamic warm-up increases dribbling performance in football players compared to static warm-up (Gelen, 2010; Fletcher & Monte-Colombo, 2010) and branch-specific warm-up increases dribbling performance in football players compared to dynamic warm-up (Dinç, 2019). In addition, Gelen (2010) showed that static warm-up decreased slalom dribbling performance and dynamic warm-up and dynamic-static mixed warm-up types increased this performance. In the present study, linear dribbling was measured. Within the scope of the results obtained in the study, the effect of dynamic warm-up is consistent with the literature. Since the effects of warming up with SMR and GMTM were measured for the first time, it can be added to the warm-up protocols of football players to improve dribbling performance. However, there are contradictions about the effect of static warm-up on dribbling. It is recommended to conduct more detailed studies on this subject.

When the effects of static and dynamic warm-ups on agility are considered, studies are showing that the two types of warm-ups have similar effects (Birinci et al., 2022; Rana et al., 2018). Toprak et al. (2022) suggested that static and dynamic post-activation potentiation (PAP) conditioning activities increase agility in football players at a similar level and therefore can be used in the warm-up. In contrast, some studies show that dynamic warm-up is more effective in increasing agility levels (Ben Maaouia et al., 2020). In the literature, only one study was found that examined the effect of SMR and GMTM in football players. In this study, it was revealed that the two practices increased vertical jump, speed, and agility in football players, but they created similar changes in these (Mondal Entaj et al., 2022). In the present study, it was determined that all warm-up methods used increased agility performance in football players. However, it was determined by two-way repeated measures ANOVA test that the highest performance increase was achieved by warming up with GMTM. Static warm-up was also found to be more effective in increasing agility performance than warm-up with SMR in the present study. The reason why the effect of SMR is low may be due to the possibility of tiring the athletes because the movements used by the athletes in warming up with SMR are performed with body weight. It is recommended to conduct more detailed studies on this subject. Although the results of the study are generally consistent with the literature, the comparative results of warm-up with SMR and GMTM with dynamic and static warm-up are new findings in the literature. For the necessity of using these techniques in the warm-up process, it is recommended to carry out similar studies on professional football players with a higher sample size.

Güngör (2024) determined that warm-up routines generally increased vertical jump performance. Yapıcıoğlu et al. (2013) found that dynamic stretching increased vertical jump performance in university athletes, but static stretching had no effect. Similarly, Ferreira et al. (2013) determined that dynamic stretching increased vertical jump height in football players, while static stretching did not affect it. Demirci and Toptaş Demirci (2018) showed that a dynamic warm-up increased vertical jump height more than a static warm-up. İnce and Yıldırım (2019) argued that static stretching performed at a certain knee angle and duration has a positive effect on vertical jump height. In contrast, Popelka et al (2024) found that static warm-up, dynamic warm-up, warm-up with foam rollers, and mixed warm-up methods had similar effects on vertical jump height. Similarly, Birinci et al (2022) found that static and dynamic warm-ups had no difference in vertical jump performance. In the present study, it was found that static warm-up, dynamic warm-up, and other types of warm-up increased the vertical jump height. It was determined that the change caused by these warm-up types was similar. The finding that warming up with GMTM affects vertical jump height is a new finding. However, the inconsistency between the effects of dynamic warm-up and static warm-up continues. In future studies, the effects of static and dynamic warm-ups on football players should be examined in more detail, mixed warm-up models should be created and their effects on performance should be examined.

CONCLUSION AND RECOMMENDATION

Types of warm-up acutely affects sportive performance in football players. As a result of the study, it was concluded that static warm-up, dynamic warm-up, warm-up with SMR, and warm-up with GMTM increased the agility, dribbling, and vertical jump performances of football players, but did not affect the total number of passes. This may be because branch-specific warm-up methods were not used in the study, which constitutes a limitation of this study. The lack of a significant difference in total passing performance indicates that there may be a need for specific warm-up protocols for movements related to passing. Future studies can comparatively examine the effect of branch-specific warm-up and the warm-up types used in the present study on performance. When four different warm-up types were compared, the GMTM warm-up technique specifically improved dribbling and agility performance compared to the other techniques. Warming up with GMTM can be added to the warm-up protocols of footballers and may even have more long-term effects. Warm-up with SMR does not affect agility performance as well as other warm-up techniques. More detailed studies in which fatigue is measured are needed. Based on the findings of the study, football players should warm-up before training and competition in order to increase their sportive performance. Footballers may prefer static warm-up, dynamic warm-up, warm-up with SMR, and warm-up with GMTM. Their performances based on passing skills do not inc-

rease instantly with a warm-up, so appropriate training programs can be applied for this reason. We suggest that control groups should be added to future studies and mixed programs for warm-up types should be applied and tested comparatively. In addition, future studies should examine the acute effect of warm-up types as well as the long-term effect of the warm-up types to be applied.

Conflict of Interest Declaration

There is no personal or financial conflict of interest within the scope of the study.

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