INVESTIGATION OF THE EFFECT OF DIFFERENT WARM-UP EXERCISES ON SOME PHYSICAL FITNESS PARAMETERS IN FOOTBALL PLAYERS

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ABSTRACT

This study investigates the effects of different warm-up protocols on physical fitness parameters such as agility, balance, flexibility, and vertical jump in football players. Conducted on a sample of 34 male football players with extensive playing experience, the research examines static, dynamic, proprioceptive neuromuscular facilitation (PNF), and culturally specific warm-up protocols (e.g., Turkish folk dances). Data collection included anthropometric measurements, flexibility tests, heart rate monitoring, and performance assessments, analyzed using SPSS 25. Findings indicate that dynamic warm-up protocols significantly enhance explosive power, as demonstrated by improvements in standing long jump performance, and optimize cardiovascular readiness, evidenced by increased heart rates. Static warm-up protocols were observed to provide the highest gains in flexibility, though the difference was not statistically significant. These results underscore the importance of tailoring warm-up protocols to the specific demands of football performance and suggest dynamic warm-ups are particularly beneficial for activities requiring explosive power, while static warm-ups may suit flexibility-focused tasks. This study contributes to the literature by highlighting the physiological and performance-related implications of diverse warm-up approaches, providing valuable insights for optimizing athlete preparation and reducing injury risk in football.
Keywords: Balance, Flexibility, Warm-up, Agility, Football

1. INTRODUCTION

Football is a dynamic sport that involves intermittent high-intensity activities as well as prolonged low-intensity activities. Football players perform explosive actions such as acceleration, change of direction, sprinting and jumping while travelling an average distance of 10-12 km during the match (Bangsbo, Iaia, & Krustrup, 2008; Mohr, Krustrup, & Bangsbo, 2003). Therefore, not only aerobic capacity but also physical parameters such as strength, agility, and flexibility should be at high levels (Stølen, Chamari, Castagna, & Wisløff, 2005; Vigne, Gaudino, Rogowski, Alloatti, & Hautier, 2010). Understanding the physical demands of football plays an important role in optimising training protocols to both improve players' performance and reduce the risk of injury (Santos, Lima, & Greco, 2020).

Warm-up is an exercise routine to prepare muscles for physical activity and reduce the risk of injury (McMillian, Moore, Hatler, & Taylor, 2006). While general warm-up includes low-intensity aerobic exercise and stretching, specific warm-up includes movements appropriate for the specific sport and is structured to improve performance to further prepare the muscles (Young & Behm, 2002). This process aims to reduce muscle viscosity by increasing muscle temperature and increase the conduction velocity of nerve impulses (Woods, Bishop, & Jones, 2007). However, the effects of warm-up practices on performance show conflicting results in the literature. While some studies indicate that a significant increase in parameters such as agility, speed and strength is observed after warm-up (Burkett, Phillips, & Ziuraitis, 2005; Sotiropoulos et al., 2010), other studies show that warm-up does not contribute significantly to physical performance (Zois, Bishop, Ball, & Aughey, 2011; Christensen & Nordstrom, 2008).

The effects of warm-up protocols are not only related to general and specific warm-up, but also to the types and duration of warm-ups. Studies show that warm-up duration and intensity shape the effects on muscle fatigue and performance (Andrade et al., 2014; Bishop, 2003). In particular, explosive muscle performance is a determining factor in important parameters such as speed and agility of footballers. However, some authors have suggested that warm-up protocols may cause muscle fatigue and negatively affect performance (Zois et al., 2015). Furthermore, determining the optimal duration and intensity of warm-ups is essential to optimize the performance of soccer players (Fradkin, Gabbe, & Cameron, 2006).

In this context, examining the effects of different warm-up exercises on physical fitness parameters such as agility, balance, flexibility and vertical jump in football players is of great importance both to contribute to the sports science literature and to provide useful information to practitioners in practice. Although studies have shown that warm-up protocols can significantly affect the performance of football players, more research is needed to accurately measure this effect (Mohr et al., 2004; Towlson, Midgley, & Lovell, 2013). This study aims to investigate the effects of warm-up exercises on the physical parameters of football players in more depth.

2. MATERIAL AND METHOD

2.1. Participants

The sample group consisted of 34 male students (age: 19.35 years, height: 176 cm, body weight: 69.08 kg) who played football for at least 8 years and studied at Hasan DOĞAN Faculty of Sport Sciences. All participants were informed about the possible risks and details before starting the study and a consent form was signed. All tests and measurement practices applied in this study were approved by Istanbul Aydın University Social and Human Sciences 2024/12 Ethics Commission Board.

2.2. Anthropometric Measurements

The height measurements of the individuals participating in the study were made with a wall-mounted stadiometer (Holtain Ltd, UK) with a precision of 0.01 mm. Body analyses, body weights (kg) and body fat percentages (%) of the participants were determined by Inbody 270 (Seoul, South Korea) brand professional body analyser.

2.3. Flexibility Measurement

Flexibility measurements of the participants were made with the sit reach test. The test was performed with a table with a length of 35 cm, a width of 45 cm, a height of 32 cm, a top surface length of 55 cm, a width of 45 cm, and a top surface 15 cm away from the surface on which the feet rested, with a 0-50 cm measuring scale on the top surface (Tamer) and the athletes were shown how to perform the measurement before the measurement. The test was performed twice and the higher measurement result was recorded.

2.4. Heart Rate Measurements (HR)

HR and HR after 1-MT were obtained after the non-warm-up phase, static warm-up, dynamic warm-up, PNF warm-up and Turkish folk dance method warm-up. HR monitor (Polar V800, Electro, Kempele, Finland) was used to determine the heart rate of the athletes. The system consists of a transmitter unit fixed on the subject with an elastic chest strap and a telemetric monitor attached to the subject's arm (Kafkas et al., 2018).

2.5. Maximal Repetition Test (1-MT)

All present determined their starting weight according to personal preference before the full squat test. Participants in the MT test were advised to initially use a weight of 30-40% of their body weight (Baechle et al., 2000). In this way, it was aimed to prevent possible muscle injuries during the test. The participants performed the free squat movement with their own weight. Depending on the weight they lifted and the strength of their emotions, they were asked to repeat the movement with additional movements of 2.5-5 kg at each opportunity and their strength values were measured. The process of increasing weight was continued until they could perform only one repetition. Participants indicated that the test could not be lifted any further. All tests were performed and recorded in kilograms. Squat test, learning with a free barbell (Kafkas et al., 2018).

2.6. No Warm-Up Phase (IUE)

After the participants were briefly informed about the test details before the test, they were instructed to run in the gym for 5 minutes intermittently with their heart rate reaching 140 per minute. In addition, after resting for 3 minutes and when their heart rate decreased to 110-120 per minute, the movement was repeated at a rate of increase between 2.5-5 kg, depending on the weights they lifted and the degree of difficulty they felt, and their strength values were recorded. The weight increase was continued until they were unable to perform only one repetition and their maximum squat performance was observed on the floor (Adler et al. 2007, Mann et al., 1999).

2.7. Turkish Folk Dance Protocol

Participants performed four Turkish Folk Dance dances lasting 10 minutes (2.5 minutes each), Adana Köprübaşı, Üç Ayak, Çiftetelli, Acem Regiment, which are dances from Adana Region. The students moved continuously during the Turkish Folk Dance dance protocol. The selection criteria for the above dances were different rhythmic speed (movement related to time and flow parameters), space (in terms of different directions and levels) and combination of simple and complex motor skills. The order of the dances was as follows; (Çiftetelli 90 metronome speed, Üç ayak 95 metronome speed, Adana Köprübaşı 120 metronome speed, Acem Alayı120 metronome speed).

Table 1. Warm-up exercises

Static Warming	Dynamic Warming	PNF	Turkish Folk Dances
5 Min Light Tempo Running	5 Min Light Tempo Running	5 Min Light Tempo Running	5 Min Light Tempo Running
Latissimus Dorsi Kas Grubu	High Glute Pull	Right and Left Flank	2.5 mins Duetelli
Pectoralis Mojor Kas Grubu	Walking Lung	Adductor Area	2.5 min three legs
Trapetsilihaste rühm	Light High Kness	Hamstring Region	2.5 min Adana Koprubasi
Kõhulihaste rühm	High Knee Pull	Quadriceps Region	2.5 min Koprubasi
Gluteus Maximus Muscle Group	Straight Leg Kick	Kalf Region	
Quadriceps Muscle Group	Carioka		
Hamstring Muscle Group	Skip A		
Calf Muscle Group	Skip B		

2.8. Data Collection

Before data collection, participants attended an orientation session where they were familiarized with the warm-up procedures and performance measurements. After the orientation program, anthropometric measurements and field test protocols were administered to the volunteers participating in the study. The tests were performed between 10.00 and 12.00 hours. Participants were informed the day before to avoid different types of exercise, not to consume stimulating tea, coffee, alcohol and acidic beverages and to have their last meal at least 2 hours before. Heart rate (HR) values were measured before and after warm-up and after 1MT in different warm-up protocols (Borg 1982). After completing one of the warm-up protocols, the participants performed the test measurements. The interval between finishing the warm-up and starting the test was 2 minutes. A similar experimental setup was used by Chaouachi et al. (2010) and Chatzopoulos et al.

2.9. Data Analysis

After the data were transferred to the computer, they were analyzed using SPSS 25 (Statistical Package for Social Sciences) statistical package program. Mean (Mean), standard deviation (Std. Deviation), and frequency (n) values of the obtained data are presented. Shapiro Wilk analysis test was used in the normality analysis of the data. Friedman test for repeated measures and Wilxocon test for comparison of dependent groups were used to compare parameters that did not show normal distribution. The statistical significance level was accepted as 0.05 and all analyses were performed at 95% confidence interval.

3. RESULTS

Table 2. Demographic characteristics of the participants

Variables	N	Ort.	Sdt. Deviation	The smallest	The biggest
Age	**35**	19,35	±1,15	18,00	22,00
Height	**35**	176,52	±4,39	170,00	185,00
Body Weight	**35**	69,08	±7,87	55,90	82,50
VYY	**35**	12,87	±2,89	9,60	20,50
VKK	**35**	34,08	±2,82	29,50	39,80
Spor Age	**35**	8,76	±1,28	7,00	11,00

Table 2 shows the demographic characteristics of the participants according to the research groups. The mean age of the participants was 19.35±1.15 years, the mean height was 176.52±4.39 cm, the mean body weight was 69.08±7.87 kg, the mean body fat ratio was 12.87±2.89, the mean body muscle ratio was 8.76±1.28, and the mean sports age was 8.76±1.28 years.

Table 3. Standing long jump and flexibility performance values of the participants according to different warm-up protocols

Variables	Warming Protocols	Rank averagw	Chi-Square	Sd.	P	Difference
Standing long jump (cm)	**Pre-Test (a)**	2,18	42,039	4	0,000	a-b (p=0,163) a-c (p=0,000) a-d (p=0,000) a-e (p=0,003) b-c (p=0,000) b-d (p=0,027) b-e (p=0,001) c-d (p=0,004) c-e (p=0,020) d-e (p=0,612)
	Static Warming (b)	2,35				
	Dynamic Warming (c)	4,09				
	PNF (d)	3,18				
	Dance (e)	3,21				
Flexibility (cm)	**Pre-Test (a)**	2,91	2,601	4	0,627	a-b (p=0,021) a-c (p=0,630) a-d (p=0,339) a-e (p=0,507) b-c (p=0,016) b-d (p=0,160) b-e (p=0,043) c-d (p=0,025) c-e (p=0,821) d-e (p=0,302)
	Static Warming (b)	3,32				
	Dynamic Warming (c)	2,82				
	PNF (d)	3,06				
	Dance (e)	2,88				

Table 3 shows the comparison of the participants' standing long jump and flexibility performances according to different warm-up protocols. When the long jump scores of the participants according to different warm-up protocols were analyzed, a statistically significant difference was found as a result of the comparisons between repeated measurements (Chi-square=42,039; p=0,000). After the Dynamic Warm-up protocol, it wasobserved that the participants' long jump performance was higher than the pre-test average (Z=- 4,754; p=0,000), static warm-up average (Z=-4,141; p=0,000), PNF average (Z=-2,845; p=0,004) and folk dance average (Z=-2,324; p=0,002). The mean long jump performance of the participants are given in Figure 1.

When the flexibility scores of the participants according to different warm-up protocols were analyzed, no statistically significant difference was found as a result of comparisons between repeated measurements (Chi-square=2,601; p=0,627). It was determined that flexibility performances after the static warm-up protocol were higher than the pre-test average, dynamic warm-up average, PNF average and folk dance average. The flexibility performance averages of the participants are given in Figure 2.

Figure 1. Standing long jump values according to different warm-up protocols

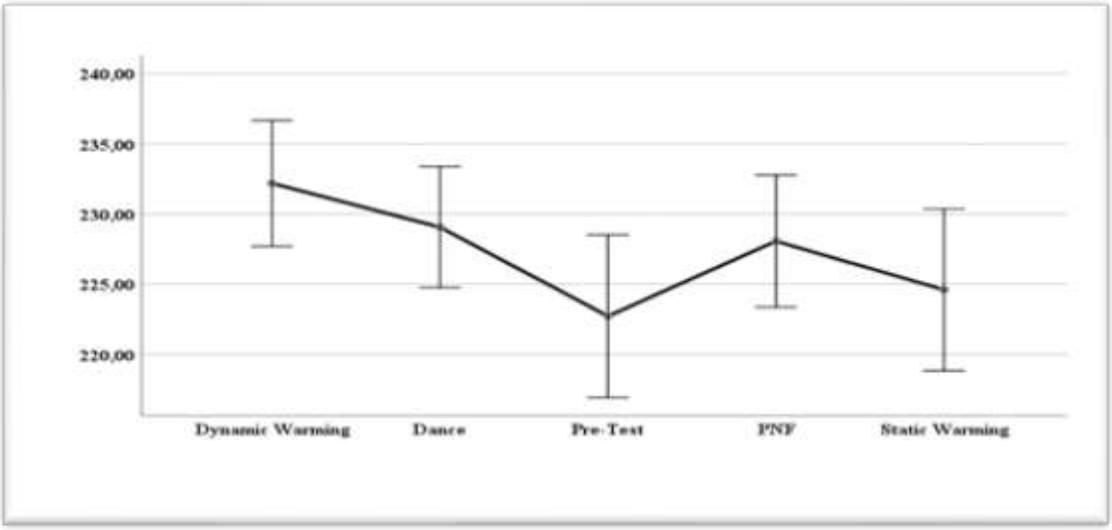


Figure 2. Flexibility values according to different warm-up protocols

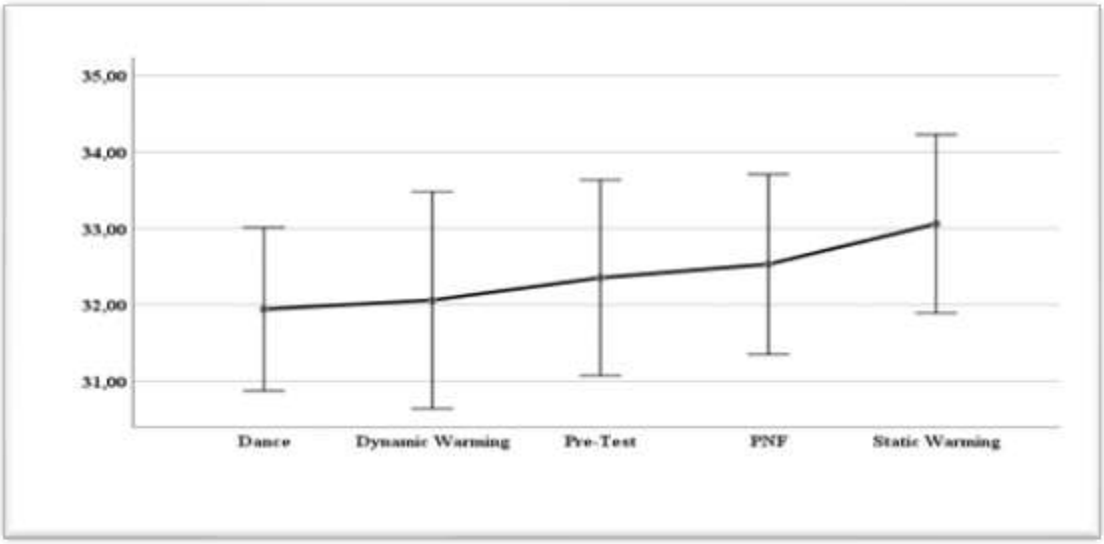


Table 4. Heart rate values of the participants according to different warm-up protocols

Variables	Warming Protocols	Row average	Chi-Square	Sd.	P	Difference
Heart Rate	**Pre-Test (a)**	2,35	85,203	4	0,000	a-b (p=0,007) a-c (p=0,000) a-d (p=0,426) a-e (p=0,048) b-c (p=0,000) b-d (p=0,000) b-e (p=0,010) c-d (p=0,000) c-e (p=0,000) d-e (p=0,927)
	Static Warming (b)	1,91				
	Dynamic Warming (c)	5,00				
	PNF (d)	2,88				
	Dance (e)	2,85				
Heart Rate after 1 TM	**Pre-Test (a)**	2,91	35,514	4	0,000	a-b (p=0,059) a-c (p=0,000) a-d (p=0,699) a-e (p=0,139) b-c (p=0,000) b-d (p=0,132) b-e (p=0,005) c-d (p=0,000) c-e (p=0,177) d-e (p=0,001)
	Static Warming (b)	2,12				
	Dynamic Warming (c)	3,91				
	PNF (d)	2,62				
	Dance (e)	3,44				

The comparison of heart rate values of the participants according to different warm- up protocols is shown in Table 4. When the heart rate values of the participants according to different warm-up protocols were examined, a statistically significant difference was found as a result of comparisons between repeated measurements (Chi-square=85,203; p=0,000). It is seen that the mean rank of heart rate values after the Dynamic Warm-up protocol is higher than the pre-test mean rank (Z=-5,092; p=0,000), static warm-up mean rank (Z=-5,089; p=0,000), PNF mean rank (Z=-5,090; p=0,004) and folk-dance mean rank (Z=-5,097; p=0,000). The mean heart rate of the participants is given in Figure 3.

When the heart rate values of the participants after 1 TM according to different warm- up protocols were examined, it was determined that there was a statistically significant difference as a result of the comparisons between repeated measurements (Chi- square=35,514; p=0,000). It was determined that the rank mean of the heart rate values of the Dynamic Warm-up protocol after 1 TM was higher than the pretest rank mean (Z=-3,627; p=0,000), static warm-up rank mean (Z=-4,154; p=0,000), PNF rank mean (Z=-3,862; p=0,004) and folk dance rank mean (Z=-1,349; p=0,177). The mean heart rate of the participants after 1 TM is given in Figure 4.

Figure 3. Mean heart rate values of participants according to different warm-up protocols

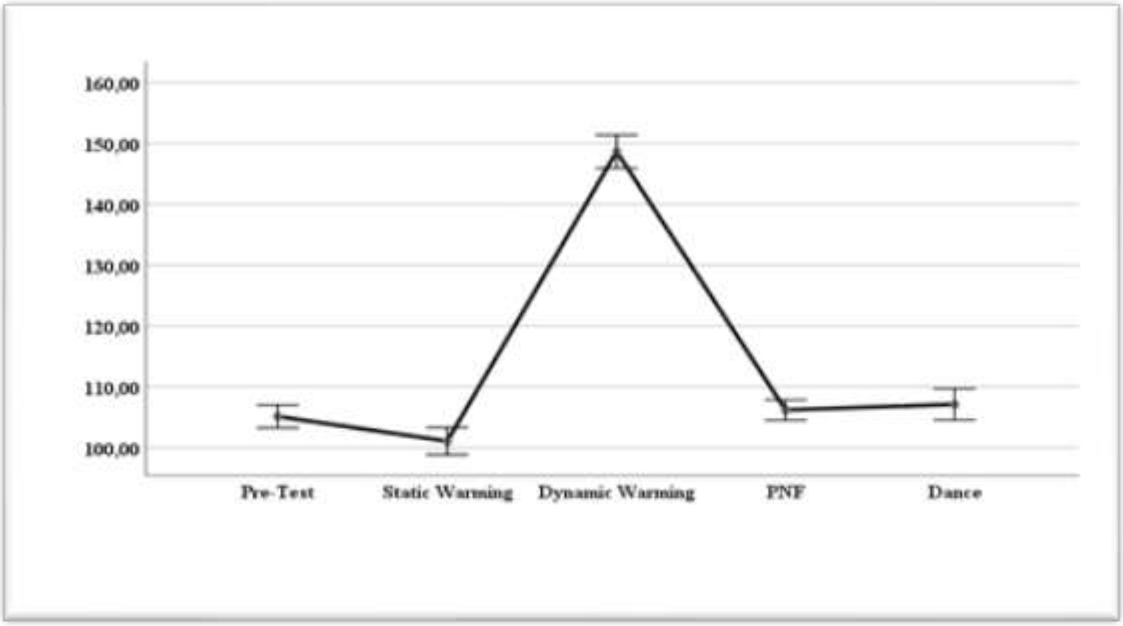
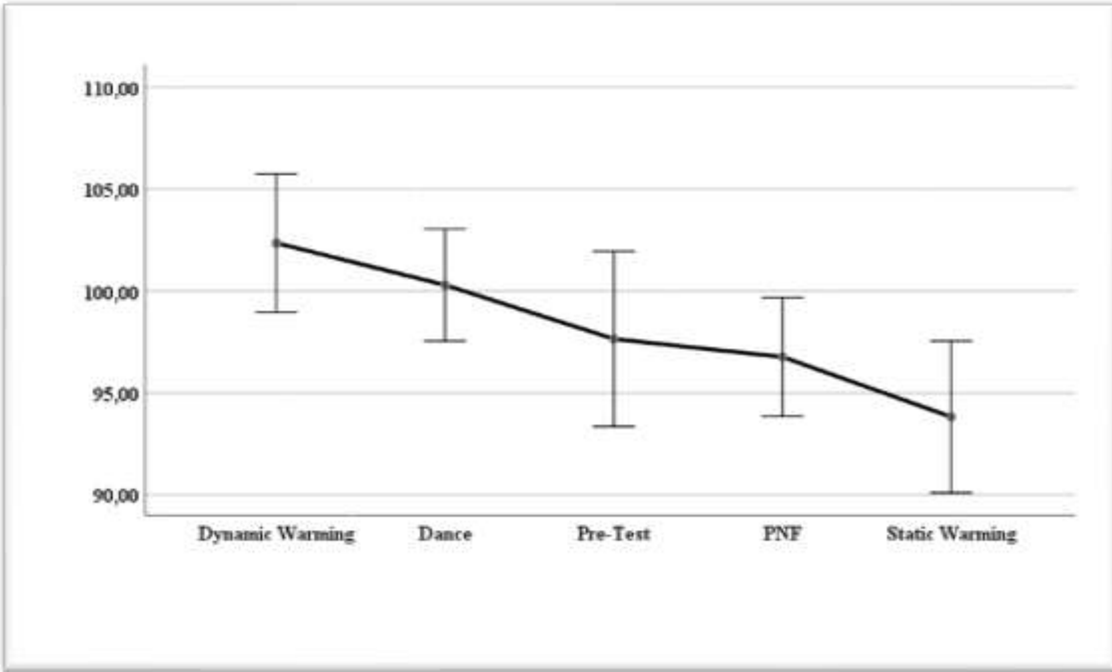


Figure 4. Mean values of participants' heart rate after 1TM according to different warm-up protocols



4. DISCUSSION

This study aimed to examine the effects of different warm-up protocols on soccer players' performance. The findings provide an understanding of the effects of warm-up protocols on standing long jump, flexibility performance and heart rate of soccer players.

Regarding standing long jump performance; In our study, different warm-up protocols were found to have significant effects on standing long jump performance. When the standing long jump scores of the participants according to different warm-up protocols were analyzed, a statistically significant difference was found as a result of comparisons between repeated measurements (p=0.000). After the dynamic warm-up protocol, it was determined that the standing long jump performances were higher than the pre-test average (p=0,000), static warm-up average (p=0,000), PNF warm-up average (p=0,004) and folk dance average (p=0,002). This finding supports the ability of dynamic warm-up to increase muscle strength and explosive power. Dynamic warm-up increases muscle and tendon elasticity by moving the muscles more, thus positively affecting performance (Behm & Chaouachi, 2011). Furthermore, Faigenbaum et al. (2005) reported that dynamic warm-up improves anaerobic performance. Regarding the mechanism by which dynamic warm-up protocols promote explosive power, some scientists argue that this may be related to the fact that dynamic warm-up increases body and muscle temperature. During stretching, muscles actively contract and stretch, increasing temperature while decreasing viscosity; at the same time, increased muscle temperature may result in increased neuroreceptor sensitivity, and this increased sensitivity suggests that neuromuscles may show stronger motor unit activation through increased motor unit recruitment, thereby improving muscle contraction performance (Fletcher et al. 2010). (2024) investigated the acute effect of PNF warm-up with dynamic warm-up on sprint and jump performance of recreationally active men. Thirty (n = 30) men were randomly assigned to three different warm-up sessions with no PNF warm-up, dynamic warm-up or stretching session (control), 72 hours apart. The results of the study indicated that the Dynamic warm-up protocol can be used to achieve a better jump height. A better jump performance and a faster sprint time when using dynamic warm-up could possibly be due to the effect of post-activation potentiation from dynamic stretching (Hough et al. 2009; Mariscal et al. 2021).

When the flexibility scores of the participants according to different warm-up protocols were analyzed, no statistically significant difference was found as a result of comparisons between repeated measurements (p=0.627). It was determined that flexibility performances after the static warm-up protocol were higher than the pre-test average, dynamic warm-up average, PNF average and folk dance average. Static warm-up can increase muscle length and flexibility by stretching the muscles longer (McHugh & Cosgrave, 2010). Matsuo et al. (2023) examined the acute and long-term effects of 300 seconds of static, dynamic and combined stretching (static+dynamic) exercises on flexibility and muscle strength. Twenty healthy young men performed a 300-second static warm-up, dynamic warm-up, and combined warm-up protocol of the right knee flexors on four separate days. Range of motion (ROM), peak passive torque (PPT), passive stiffness, and isometric and concentric muscle forces were then measured. It was reported that all warm-up methods significantly increased range of motion and peak passive torque and significantly decreased isometric knee flexion strength. Li et al. (2021) examined the effect of PNF method on the flexibility and strength quality of the shoulder joint stretching muscles of swimmers. 20 university team swimmers were taken as subjects and a comparative experiment of traditional and PNF stretching methods was performed. When the results of the study were analyzed, it was stated that under the PNF stretching method, the average strength and total work of the shoulder joints improved significantly in high-speed external rotation and there were significant improvements in performance in the 50 m freestyle. However, Kay and Blazevich (2012) suggest that static warm-up may negatively affect muscle strength and performance in the short term.

Regarding Heart Rate; When the heart rate values of the participants according to different warm-up protocols were examined, a statistically significant difference was found as a result of comparisons between repeated measurements (p=0,000). The mean heart rate values after the Dynamic Warm-up protocol were higher than the pre-test mean (p=0,000), static warm-up mean (p=0,000), PNF mean (p=0,004) and folk dance mean (p=0,000). Dynamic warm-up prepares the body for intense physical activity by increasing heart rate and optimizes oxygen consumption during performance (McMillian et al., 2006). Chaouachi et al. (2010) demonstrated that dynamic warm-up effectively prepares the cardiovascular system and improves exercise performance. In addition, 1-MT heart rate values were found to be higher after dynamic warm-up compared to other protocols, which supports the positive effect of dynamic warm-up on overall performance.

5. CONCLUSIONS AND RECOMMENDATIONS

This study aimed to examine the effects of different warm-up protocols on soccer players' performance. Our findings showed that warm-up protocols had significant effects on standing long jump, flexibility performance and heart rate of soccer players. It was found that the dynamic warm-up protocol increased the standing long jump performance more than the other warm-up protocols. This reveals the effectiveness of dynamic warm-up in increasing muscle strength and explosive power. In terms of flexibility performance, it was found that the static warm-up protocol provided a higher effect than the other protocols, but this difference was not statistically significant. Heart rate data showed that the dynamic warm-up protocol increased heart rate more than the other protocols. This suggests that dynamic warm-up effectively prepares the cardiovascular system and improves exercise performance.

In conclusion, warm-up protocols need to be carefully selected to optimize the performance of soccer players. Dynamic warm-ups seem to be a more suitable option for explosive power and overall performance. Especially in sprinting and jumping events, dynamic warm-ups can be used to help maintain or improve the performance outcome of physical activity. However, static warm-ups should also be considered for situations that require flexibility. This study helps us to better understand the effects of different warm-up protocols and contributes to the development of athletes' training programs.

Future studies may examine the effects of warm-up protocols in different sports and in various age groups to increase the generalizability of the findings and allow further refinement of training methods.

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