The Effect of Different Warm-Up Protocols on the Motor and Technical Skills of Handball Players in Sports Education

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Received: December 31, 2022 Accepted: February 25, 2023 Published: March 4, 2023

doi:10.5296/jei.v9i1.20719 URL: https://doi.org/10.5296/jei.v9i1.20719

Abstract

Warm-up programs in sports education can provide positive developments in motor and technical skills. The objective of this study was to determine the acute effects of ballistic, dynamic, and static warm-up protocols on motor and technical skills in male handball players. Twelve male handball players (mean age: 19.50±3.97 years) from the second league in Turkey participated in this study voluntarily. Warm-up protocols were implemented for the participants at the same time on three different days. At the beginning of the study, the height and body masses of the handball players were measured. After each warm-up protocol, 9-m shot, over-the-block shot, vertical jump, T agility, 20-m sprint, flexibility, and flamingo balance tests were conducted on the participants. The normality level of the data was determined by the Shapiro-Wilk test using the SPSS statistical program. While Repeated Measures ANOVA and the Bonferroni test from post hoc analysis were applied to data with normal distribution, the Friedman test and the Wilcoxon signed-rank test with the Bonferroni correction were used for non-normally distributed data. According to our findings, there was a significant difference between the warm-up protocols in the T agility, flexibility, and over-the-block shooting tests ($p < 0.05$), while no significant difference was found in the vertical jump, 20-m sprint, balance, or 9-m shooting tests ($p > 0.05$). The ballistic warm-up protocol applied to male handball players in sports education provided positive improvements in flexibility and over-the-block shooting skills, while the dynamic warm-up protocol yielded positive improvements in agility and flexibility.

Keywords: Ballistic, Dynamic, Handball, Warm-up, Static

1. Introduction

One of the important factors in sports training is warm-up movements. Athletes become physically ready for training by doing these exercises before their training. In addition, warm-up exercises before training and matches in handball are also critical. Handball is a sport involving fast play and intense physical contact requiring a high level of athletic performance on the part of athletes. For this reason, qualities such as endurance, speed, agility, jumping, mobility, explosive power, and prolonged strength that affect performance are all necessities in handball. In addition, warm-up programs prior to training or competitions represent important practices to improve performance and prevent potential injuries (Eler & Bereket, 2001; Granados et al., 2013; Hermassi et al., 2011).

Warm-up consists of exercises performed to prepare athletes for the stresses their bodies will undergo during training or matches, to protect against injury and enhance overall athletic performance. The practice of warming up is defined as the improvement of metabolic responses resulting from a raise in body temperature and an increase in the warmth of the muscles with exercise (Gürses & Akgül, 2019). In a study conducted by Fradkin et al. (2010), warming up was reported to improve performance by 79%. The type, intensity, and duration of the warm-up, together with the recovery time between warm-up and sports activities, have united sports scientists and trainers on the effects of warming up on performance, and studies on this topic have revealed that many different methods are employed prior to competition or training (Sarı & Bilici, 2022).

While dynamic and static stretches are generally used in warm-ups, sport-specific ballistic movements, including activities relying on explosive power, may also be employed. Warm-up exercises incorporating such movements have been reported to be effective in improving performance while providing the benefit of preventing sports injuries (Chiu et al., 2003). Dynamic stretches are warm-up movements performed within the limits of certain regions of the body with controlled and soft jumping or swinging movements (Walker, 2013). Static stretches are movements that involve slowly pushing a muscle beyond its normal range of motion and holding it there for approximately 10-30 seconds, depending on the purpose of the exercise. Although athletes may be able to perform some of these movements by themselves, they can extend the length of the muscle by using an assistant for some of them (Sevim, 2007). Ballistic stretching includes movements that involve rhythmic springing following a short stretching session (Woolstenhulme et al., 2006).

Knowing which warm-up protocol is more appropriate in sports education and sports branches helps to achieve educational goals. Since handball is a sport played with a ball involving intense explosive motor movements, warm-up exercises are of critical importance in terms of performance. A topic of some curiosity is the effect of warmups incorporating handball-specific ballistic movements on performance. The present study, in which the subject of warming up in sports education was examined, aimed to determine the acute effects of ballistic, dynamic, and static warm-up protocols on 9-m shooting, over-the-block shooting, vertical jumping, agility, speed, flexibility and balance in male handball players.

2. Method

2.1 Research Group

Twelve male handball players who compete in the second league of the Van Metropolitan Municipality Sports Club, with an average of seven years of experience training in the sport, voluntarily participated in this study. The athletes were provided detailed information regarding the work involved before the start of the study and all signed a voluntary consent form. Exclusion criteria included chronic illness, musculoskeletal injury, or diagnoses requiring continuous use of medication. Prior to data collection, all participants were warned not to engage in vigorous physical activity the day before the tests or to consume alcohol, caffeine, etc. Measurements made within the scope of the study were obtained in an indoor gym. The general characteristics of the research group are presented in Table 1.

Table 1. Descriptive statistical results regarding the general characteristics of the study participants

General Characteristics	n	Mean±SD	Min.	Max.
Age (years)	12	19.50±3.97	16.00	27.00
Height (cm)	12	178.00±6.99	162.00	187.00
Body mass (kg)	12	70.08±9.69	60.00	86.10
Training experience (years)	12	6.08±2.11	3.00	10.00

2.2 Ethics Committee Approval

Ethical approval to conduct the study was granted by the Scientific Research and Publication Ethics Committee of Muş Alparslan University in order to conduct the research (decision no. 73209, dated 04.12.2022).

2.3 Data Collection Tools

2.3.1 Height Measurement

A stadiometer (Seca) was used to measure height while the athletes stood in an anatomical position, joined the heels of their feet, and held their heads upright. The measurement was recorded by taking the value corresponding to the upper part of the head.

2.3.2 Body Mass Measurement

Body mass was measured using a digital scale while the participants were dressed only in shorts and t-shirts.

2.3.3 Vertical Jump Test

A Microgate Witty (Bolzano, Italy) brand splash mat was employed for the vertical jump test. The athletes were asked to squat until their knees were bent 90 degrees, with their hands on their waists, and quickly jump as high as possible. They were allowed to jump two times and the higher value was recorded.

2.3.4 Agility T-test

This test, which utilized an Infinitek (Turkey) brand photocell, consists of four points in a T-shaped configuration comprising an area 10 m long by 10 m wide. Athletes begin from the starting line, run straight towards the first point, then slide right to touch the second point, slide left to meet the third point, before returning to the first point and finally running back to the finish line. The participants completed the test twice, with the better value recorded. Prior to and during the test, the athletes received verbal motivation.

2.3.5 20-Meter Sprint Test

An Infinitek (Turkey) brand photocell was used in this test, in which photocell gates were placed in a straight line at the starting point and at a distance of 20 m. The photocell doors were set at a height of 1m from the floor and the athletes started the test 50 cm behind the door. The participants were given two chances to perform the test and the superior result was recorded. The athletes were verbally motivated before and during the test.

2.3.6 Flexibility Test

A sit and reach bench measuring 35 cm long, 45 cm wide, by 32 cm high was employed in the sit and reach test to measure the flexibility of the hamstring and back muscles. The athletes stood with the soles of their feet on the bench and reached forward as far as they could reach without bending their knees; the distance reached was recorded in centimeters. The test was repeated and the better result was accepted as the flexibility value.

2.3.7 Flamingo Balance Test

The athletes stood on a wooden block, balancing with one foot in the air for one minute. The total number of times the participants lost their balance (in which the raised foot fell to the ground) was recorded.

2.3.8 9-m Shot Test

In this test, the goal was closed off in such a way that only the upper and lower right and left corners remained 50 cm open. Each athlete was given 5 balls and instructed to dribble each ball in the midfield and shoot from the 9 m line with a foothold or a three-step jump. Shots that hit the target were recorded.

2.3.9 Over-the-Block Shot Test

To conduct this test, the goal was closed so that only the right and left upper and lower corners were left open 50 cm and a 2 m long obstacle (block) was placed on the 9 m line. Similar to the previous test, each participant was given 5 balls with the instruction to dribble each ball in the midfield, shooting over the obstacle located at the 9 m line with a foothold or three-step jump. Shots that hit the target were recorded.

2.4 Experimental Procedure

Prior to the start of the study, the male handball players were given detailed information regarding the purpose of the study, tests, and warm-up protocols. The participants were allowed to experiment without performing the actual tests. Ballistic, dynamic, and static warm-up protocols were followed at the same time on three different days at 48-hour intervals. The dynamic warm-up protocol was implemented on the first day, the static protocol on the second, and the ballistic warming protocol was applied on the third testing day. Following each warm-up protocol, the participating handball players underwent the following tests (in order): balance, flexibility, vertical jump, 9-m shot, over-the-block shot, 20-m sprint, and T agility.

2.4.1 Warm-up Protocols

In this study, the athletes followed three different warm-up routines: dynamic warm-up, static warm-up, and ballistic warm-up. These routines were created in accordance with the purpose of this study and the sport of handball.

Each individual exercise within the dynamic, static, and ballistic warm-up routines was applied for 15 seconds and the total time allotted for each warm-up was 25 minutes (Table 2).

Following the warm-up, the participants were tested for balance, flexibility, vertical jump, 9-m shot, over-the-block shot, 20-m sprint, and T agility tests, in that order. Between each test, the participants were allowed active and full rest. The warm-up routines were conducted at 15:00 on 3 different days separated by 48-hour intervals, in consideration of recovery times for the athletes.

Table 2. Warm-up Protocols

1st Day Dynamic Warm-up (25 min)	2nd Day Static Warm-up (25 min)	3rd Day Ballistic Warm-up (25 min)
5-minute run		
1. Turn the neck right and left 2. Turn arms forward and backward 3. Make a circle with arms outstretched to the side 4. Move posterior shoulder muscles of a single arm 5. Lean to side while standing upright 6. Circular movements from the hip 7. Half-step forward hamstring stretch 8. Lean forward from the waist 9. Squats	1. Triceps 2. Deltoid 3. Pectorals 4. Latisumus Dorsi 5. Trapezius muscle group 6. Forearm flexors 7. Forearm extensors 8. Hip flexors *Stretches for the above muscle groups were held for 15 seconds.	1. Reciprocal bouncing pass with the ball 2. Throw the ball forward and backward 3. Rapid ball exchange (single ball) at 6m line 4. Defensive/offensive practice with the ball 5. Catch a fast attack ball 6. After the reciprocal pass, the two-foot drop and pass the defense with a cheating move.

2.5 Data Analysis

The SPSS (Statistical Package for the Social Sciences) program was used for data processing and statistical analysis. The significance level of 0.05 was accepted for this study. The normality levels of the data were determined using the Shapiro-Wilk test. For data with normal distribution, the Repeated Measures ANOVA procedure for parametric tests and the Bonferroni test for post hoc analysis were applied to data with normal distribution, while the Friedman test and the Wilcoxon signed-rank test with the Bonferroni correction were performed for non-normally distributed data. The new significance level was calculated as 0.05/3 = 0.0167 since three pairwise comparisons would be made within the group with the Bonferroni correction.

3. Results

Results of the statistical comparisons of the male handball players' 9-m shot, over-the-block shot, vertical jump, T agility, 20-m sprint, flexibility, and balance tests following the application of the ballistic, dynamic, and static warm-up protocols are shown in Tables 3 and 4.

Table 3. ANOVA test results for repeat measurements of biomotor characteristics

Test	**Group (n = 12)**	**Mean±SD**	**f**	***p***	**Post Hoc**
Vertical jump (cm)	Ballistic warm-up protocol[1]	41.68±7.30	0.672	.521	
	Dynamic warm-up protocol[2]	44.38±9.06			
	Static warm-up protocol[3]	42.38±6.94			
T agility (sec)	Ballistic warm-up protocol[1]	11.67±1.00	13.785	**.002***	**2 < 1,3**
	Dynamic warm-up protocol[2]	10.75±0.80			
	Static warm-up protocol[3]	11.47±0.86			
20-m sprint (sec)	Ballistic warm-up protocol[1]	3.01±0.19	0.579	.569	
	Dynamic warm-up protocol[2]	2.96±0.24			
	Static warm-up protocol[3]	3.00±0.20			
Flexibility (cm)	Ballistic warm-up protocol[1]	73.17±5.37	3.704	**.041***	**1,2 > 3**
	Dynamic warm-up protocol[2]	73.33±5.68			
	Static warm-up protocol[3]	71.33±5.96			
Balance (points)	Ballistic warm-up protocol[1]	4.17±1.53	0.054	.947	
	Dynamic warm-up protocol[2]	4.00±1.35			
	Static warm-up protocol[3]	4.08±1.24			

Note. *p < 0.05.

According to Table 2, with the respect to the participants' vertical jump, 20-m sprint, and balance test results, there were no statistically significant differences between the various warm-up protocols (p > 0.05), although statistically significant differences were observed for the T agility and flexibility tests (p < 0.05 for both). Regarding the T agility test, the dynamic (10.75±0.80 sec) warm-up protocol values of the male handball players were significantly lower than those of the ballistic (11.67±1.00 sec) and static (11.47±0.86 sec) protocols. As for flexibility, the ballistic (73.17±5.37 cm) and dynamic (73.33±5.68 cm) warm-up protocol values were determined to be significantly higher than those of the static (71.33±.5.96 cm) protocol.

Table 4. Friedman test results for 9-m and over-the-block shooting

Test	Group (n = 12)	Mean±SD	Mean rank	χ^2	*p*	Post Hoc
9-m shot (points)	Ballistic warm-up protocol[1]	15.83±4.69	2.08	0.205	.903	
	Dynamic warm-up protocol[2]	14.17±4.69	1.92			
	Static warm-up protocol[3]	15.00±4.26	2.00			
Over-the-block shot (points)	Ballistic warm-up protocol[1]	13.75±3.77	2.42	6.086	**.029***	**1 > 2**
	Dynamic warm-up protocol[2]	9.17±4.69	1.50			
	Static warm-up protocol[3]	12.08±3.96	2.08			

Note. *p < 0.05.

As seen in Table 3, while there was no statistically significant difference between the warm-up protocols in the 9-m shot test results (p > 0.05), a statistically significant difference was found in the over-the-block shot test (p < 0.05). The Wilcoxon test with the Bonferroni correction was used to analyze intra-group variation for the over-the-block shot test. For this test, ballistic (13.75±3.77 points) warm-up protocol values were significantly higher than those of the dynamic (9.17±4.69 points) protocol (p < 0.0167).

4. Discussion

In this study, the acute effects of ballistic, dynamic, and static warm-up protocols applied to male handball players on 9-m shooting, over-the-block shooting, vertical jump, T agility, 20-m sprint, flexibility, and balance parameters were compared. Our findings showed significantly improved performances in the T agility test following the dynamic warm-up protocol, in flexibility using the ballistic and dynamic protocols, and in over-the-block shooting with the ballistic protocol. No difference was observed between the various warm-up protocols in the vertical jump, 20-m sprint, balance, and 9-m shooting tests.

For the agility test, the dynamic warm-up protocol improved the performance of the male handball players compared to the ballistic and static protocols. Previous studies in the literature have obtained similar results. McMillian et al. (2006) reported that dynamic warm-up provides a significant improvement in T agility performance compared to static warm-up. The mechanism of deterioration in explosive power and speed performance resulting from static stretching has been linked to muscle damage during stretching (Shrier, 2004). Although dynamic movements are incorporated in the ballistic warm-up protocol, agility performance is not believed to improve due to factors such as central nervous system fatigue, lactate accumulation, etc., since these movements comprise high-intensity activities. In a study on basketball players, Gabbett et al. (2008) determined that there was no significant difference in agility following the application of two different dynamic warm-up methods. These conflicting findings in the literature may be explained by factors affecting acute performance such as research design, differences in the study participants, and intensity and/or duration of the warm-up protocol implemented.

The ballistic and dynamic warm-up protocols employed in the present study were found to yield higher values for the flexibility test than the static method. In a study conducted by Köse and Atan (2015), values for the flexibility test following a static warm-up protocol were higher than those of dynamic and jogging warm-up methods. In another study, the effect of different stretching exercises on the flexibility of football players was examined. According to the results of the study, static and dynamic stretching exercises improved flexibility performance compared to the control measurements, although there was no significant difference between the two methods (Akyüz, 2017). In the present study, the improved performance following the ballistic and dynamic protocols in comparison with the static warm-up may be attributed to an increase in joint range of motion and muscle temperature. The movements and time used in the static warm-up protocol may have been insufficient to increase flexibility.

While the present study found no significant difference between the warm-up protocols with regard to the 9-m shot test results of the participants, the ballistic warm-up values were higher than those of the dynamic protocol for the over-the-block shot test. To the best of our knowledge, no study has been published investigating the effect of different warm-up practices on shooting performance in handball. Pilça and Altun (2019), examining how shooting performance is affected by different training methods in handball, compared strength and technical training. Their results indicated that the 9-m shot target hit rate of the handball players who received technical training for 12 weeks increased significantly. Proceeding from this finding, our results indicated that ballistic warm-up movements with the ball provided a significant improvement in performance on the over-the-block test, although not for the 9-m shot; thus, we can conclude that the athletes were positively affected by the exercises performed with the ball. Considering that the main objective in handball is to score goals, warm-up movements that involve the use of the ball should improve shooting performance.

Concerning the vertical jump test of the handball players in our study, no significant difference was determined between the various warm-up protocols. A search of the literature has uncovered studies that support our findings as well as ones that do not. Aydın (2011) investigated the acute and chronic effects of long-term static warm-up exercises on performance, concluding that they had no effect on vertical jump test results. In a study on the acute effects of different warm-up protocols on jump performance by Gelen (2008), static stretching was found to decrease vertical jump heights, whereas dynamic warm-up improved performance. Sevim (1988), analyzing the effect of combined strength training on jumping and shooting strength in handball, determined that following a combined training protocol yielded a significant difference in the vertical jump test results of 24 handball players. Although there was no statistically significant difference between the warm-up methods in our study, a comparison of the mean values reveals that the dynamic warm-up protocol tends to improve vertical jump performance. Ballistic warm-up methods are suspected of causing fatigue in agility performance.

The 20-m sprint tests of the male handball players participating in the present study showed no significant differences between the three warm-up protocols. However, there are studies in the literature reporting results that contradict this finding. In a study by Saoulidis et al. (2010) on the acute effects of passive and dynamic stretching exercises on the 20-m sprint performance of handball players, dynamic stretching resulted in improved performance compared to passive stretching. Similar studies have determined that dynamic warm-up protocols improved speed performance (Fletcher & Jones, 2005; Little & Williams, 2006; Fletcher & Anness, 2007). In yet another study, Alemdaroğlu and Koz (2009) reported that PNF (proprioceptive neuromuscular facilitation), static, and ballistic protocols impaired both 10-m and 20-m sprint performance, although ballistic stretching resulted in less negative effects than the other two methods.

In our study, for the balance test, no significant difference was observed between the different warm-up protocols. The finding that balance is not affected by warm-up and stretching practices has been reported in the literature. For example, Kim et al. (2014) found that warming up did not affect balance. In a study investigating static stretching, the authors determined that balance was not affected by stretching 3 times for 45 seconds (Lewis et al., 2009). Contrary to these findings, however, a study conducted by Daneshjoo et al. (2022) examining the effect of a handball warm-up program on dynamic balance in elite adolescent handball players, observed an improvement in balance. Köse and Atan (2015) found that static and dynamic warm-ups generated better results for the balance test than the jogging warm-up method. In another study, researchers analyzing static and dynamic stretching applications for 20 seconds reported that static stretching did not affect balance, whereas dynamic stretching improved it (Morrin & Redding, 2013).

There are certain limitations inherent in the present study. First and foremost, study participants were limited to only 12 male handball players playing in the 2nd league in Turkey; the results obtained herein may not apply to athletes playing in higher level leagues. In addition, although warm-up exercises were performed on different days, all twelve participants implemented the same protocol on the test days (i.e., the test days for the protocols were not randomized). Due to familiarization, the participants may have become more accustomed to the tests by the final day of testing. These limitations should be taken into account when evaluating the results of this study.

5. Conclusion

In conclusion, the present study found significantly improved performance in the T agility test following the dynamic warm-up protocol, in the flexibility test with the use of the ballistic and dynamic protocols, and in the over-the-block shooting test when the ballistic protocol was applied. No significant differences were observed between the warm-up protocols in the vertical jump, 20-m sprint, balance, and 9-m shot tests. Further research is needed to clarify the results with regard to improving handball performance using different warm-up methods in sports education.

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