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The Acute Effects of Specific Preconditioning Activities on Penalty Kick Performance in Soccer Players

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KEYWORDS Elastic Band. Postactivation Potentiation. Squat Exercise. Whole-body Vibration

ABSTRACT The aim of this study was to compare the acute effects of various preconditioning activities on football penalty kick performance. 21 football players performed four different preconditioning activities in random order on non-consecutive days. The preconditioning activities were composed of only 10 minutes of jogging (OW), 10 minutes of jogging and squats with body weight (SBW), 10 minutes of jogging and elastic band (EB), and 10 minutes of jogging and whole-body vibration (WBV). After the completion of each preconditioning activity, the football penalty kick performance of the subjects was tested. The difference between OW and SBW (5,2%), and EB (4,7%) and WBV (5 %) were considered to be meaningful ($p<0,01$). However, no difference was noted between SBW, EB and WBV ($p>0,01$). According to the findings, SBW, EB and WBV applications, which were used as preconditioning activities after a low intensity aerobics-based joggings acutely, increase penalty kick performance.

INTRODUCTION

In explosive movements like kicking, jumping and throwing, the rate of force development (ROFD) is relatively significant and necessary. Therefore, training methods used to enhance the ROFD can positively affect performance in explosive movements. The training strategies designed to activate Post-activation Potentiation (PAP) could include these kinds of methods.

PAP is defined as the temporary rise in muscle contractile capacity after a previous contraction bout. Although the correct mechanisms or PAP are still under investigation, contemporaneous theories state that there could be chemical, neuromuscular and mechanical changes, which could temporarily aid the contractile characteristics of muscle tissue (Güillich and Schmidtbleichher 1996; Sale 2002). PAP occurs as a result of multiple physiological mechanisms. The main mechanism that enables the formation of PAP is seen as a more beneficial mutual effect between actin and myosin, which occurs as a result of myosin light-chain phosphorylation (Low et al. 2015; Gossen and Sale 2000; Sale 2002). The other possible mechanisms include neurologic factors that can also affect PAP. In addition to the theories of mechanism change causing potentiation, previous studies have shown that characteristics such as strength levels or fiber type distribution of sports people could determine the capability of PAP production. The methods used to uncover PAP vary. These methods are mainly composed of either a dynamic movement (Gelen 2010; Gourgoulis et al. 2003; Hrysomallis and Kidgell 2001; Jensen and Ebben 2003) or an isometric maximum voluntary contraction (Güillich and Schmidtbleichher 1996; Vandervoort et al. 1983). The PAP production methods in previous studies included either high power low speed movements like squats and bench presses (Gourgoulis et al. 2003; Hrysomallis and Kidgell 2001; Jensen and Ebben 2003) or low power high speed movements like jumping (Masamoto et al. 2003).

In recent years, vibration has been used as a special exercise and training method both in sports and in the area of fitness science and has considerably drawn the attention of researchers (Lienhard et al. 2015; Bosco et al. 2000; Cardinale and Bosco 2003; Cochrane and Stannard 2005; Cormie et al. 2006; Kin-Isler et al. 2006; Rittweger et al. 2000). It has been asserted that the application of vibration causes minor changes in muscle length (Bosco et al. 1999a), changes high frequency in afferent stimulants after maximal isometric contractions into neurotransmitter releases (Rittweger et al. 2003), increases the spinal excitability in the α-motor neuron pool (McBride et al. 2010), and additionally vibration trainings have the same effects as weightlifting training

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on muscle performance (Bosco et al. 1999b). It has been suggested that the visible positive effects of vibration trainings appear with the inclusion of inactive motor units in the production. It has been proposed that vibration training produces acute stimulation to the neurological system (Cochrane and Stannard 2005; Cormie et al. 2006; Issurin and Tenenbaum 1999; Jacobs and Burns 2009; McBride et al. 2010; Rhea and Kenn 2009), which shows that the use of vibration exercises prior to physical activities require high power production and contributes to an increase in power production. Many studies have reported acute (Cormie et al. 2006; de Ruiter et al. 2003; Issurin and Tenenbaum 1999; Kin-Isler et al. 2006; Rittweger et al. 2003; Torvinen et al. 2002) and chronic (Cardinale and Bosco 2003; Luo et al. 2005; Roelants et al. 2004) increases in power after WBV training. However, an insufficient number of studies have reported no effect (Cochrane and Stannard 2005) or even a decline (Rittweger et al. 2000). Issurin and Tenenbaum (1999) applied a 44 Hz and 3 mm amplitude acute vibration exercise during bilateral biceps curl exercise, which was done in such a way that it spread from the palm towards upper extremity and it was concluded that this application increased elbow flexibility by 10.4 percent in elite players and 7.9 percent in amateurs. Bosco et al. (2000) reported that Whole-Body Vibration exercises on a vibration platform increased vertical jump ability by 3.8 percent and lower limb force by seven percent. In another study a protocol of 60-second Whole-Body Vibration at a 26 Hz frequency with 60-second relaxation intervals in between was employed and this program demonstrated an increase in strength, power and speed performance among elite female volleyball players (Bosco et al. 1999a).

In this respect, the purpose of this study aimed to evaluate the acute effects of different preconditioning activities on football penalty kick performance. The hypothesis of this study is that specific preconditioning activities like SBW, EB and WBV will increase football penalty kick performance.

METHODOLOGY

Experimental Approach to the Problem

A within subject, balanced, randomized repeated-measures design was used to test the experimental hypotheses. Twenty-one football players were familiarized with all the experimental tests before the baseline performance was determined. The study consisted of four experimental sessions. In each session, the subjects performed 1 of 4 different specific preconditioning activities [squat with body weight (SBW), elastic band exercise (EB), whole-body vibration exercises (WBV) and only jogging warm-up [control] (OW)] after a standardized 10 minutes jogging warm up and the subjects consequently completed the football performance tests. The performance tests consisted of standard football penalty kicks.

Subjects

The study was carried out on twenty-one healthy male volunteer football players who play in the Turkish Super Amateur Football League [mean (SD) 19.7 (1.6) years, 179 (6.0) cm, 70 (5.5) kg]. The players had an average training experience of 7.2 (2.2) years. All the subjects confirmed that they had had no significant recent history of musculoskeletal injury. Before participating in the study, the subjects were informed of the potential risks and benefits involved in the study and provided a written consent to participate in the study in accordance with the policies and procedures of the University of Sakarya's the Human Research Ethics Committee for the use of Human Subjects in Research. During the season, the subjects practiced 9 times per week and played one amateur match, with no additional weight training being undertaken.

Procedures

The four different specific preconditioning activities, which were used in this study, include squat with body weight (SBW), elastic band exercise (EB), whole-body vibration exercises (WBV) and only jogging warm up [control] (OW). Before any kind of data was collected, an introduction and trial session on preconditioning activities and penalty kick test was held for each player who participated in the study two days prior to the first test. An introduction and trial session was held in order to eradicate differences in knowledge about preconditioning activities and penalty kick test. A trainer conducted all the preconditioning activities in groups of tens at around the same time (11:00am). All four preconditioning activities were performed arbitrarily on non-consecutive days. All the study procedures were completed within a period of 9 days.

Each preconditioning activity started with a 10-minute low intensity aerobic jogging. All the players were instructed to run a circuit of the football pitch for 10 minutes at a heart rate of 140 beats per minute. The intensity of the warm up was monitored by connecting a heart rate monitor (810i Polar Electro Inc., Kempele, Finland) randomly on three of the players in each of the 10-player groups. The players did a 2-minute relaxation walk (active relaxation) after the low intensity jogging. The preconditioning activities were performed after the relaxation walk. 3-4 minutes after all the preconditioning activities, the penalty kick test was conducted. A summary of the experimental and testing procedures is shown in Figure 1.

The SBW preconditioning activity was performed after low intensity jogging. The subjects stood with legs akimbo the base of the legs being the same distance apart as the width of the shoulders with their upper body in an up-right position and squatted until a 90 degree angle was formed behind their knees. After a short time the subjects returned to the initial position (squat). Both hands were placed on the waist at every stage of the movement. While performing the squats, particular attention was focused on the rigid base of the heels on the ground. The application was performed thrice with 10-repetition sessions and equivalent (1:1) relaxation intervals in between.

The EB preconditioning activity was performed after low intensity jogging. An elastic band (Thera-Band®, Blue Extra Heavy, Hadamar, Germany) was used for this application. Consequently the elastic band was folded in two—one end attached to the goal post and the other end attached on the ankle of the subjects dominant leg used for penalty kicks. The subject was positioned at approximately 1-meter distance from the goal post. The subject produced resistance in the opposite direction to the elastic band by performing a penalty kick simulation. The application was performed thrice with 10-repetition ses-

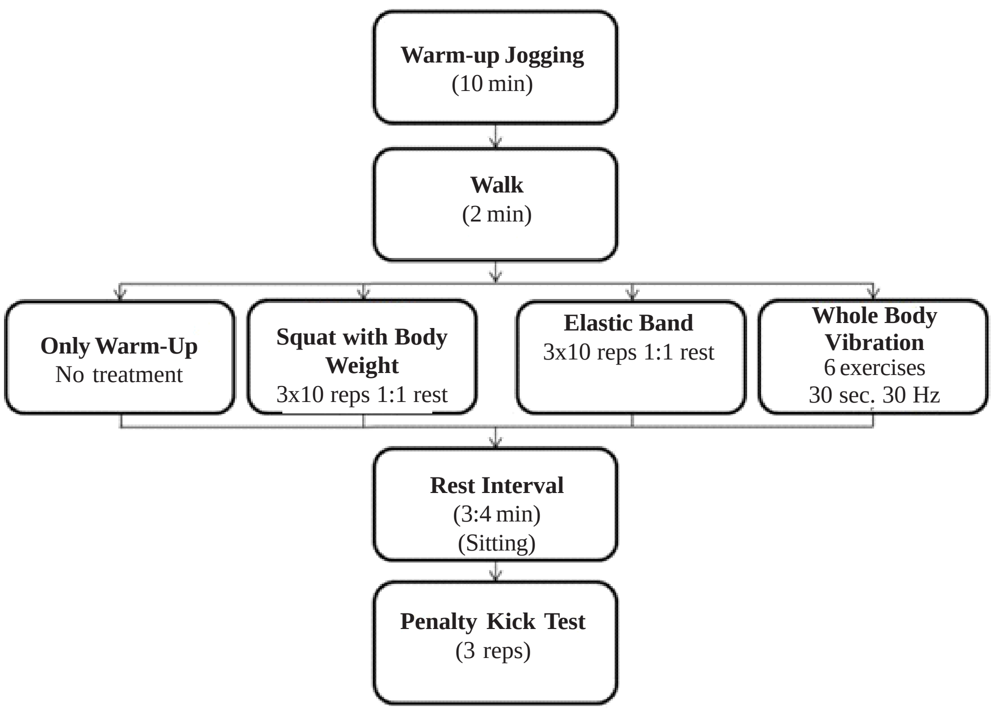


Fig. 1. A summary of the experimental method

sions and equivalent (1:1) relaxation intervals in between.

The WBV preconditioning activity was performed after low intensity jogging. A vibration platform (PowerMax Vibration, Vosburg, SA) was used for this application. The subjects performed a total of 6 exercises in 30 seconds at a vibration frequency of 30 Hz. These 6 exercises were composed in a sequence of a normal straight position, two-foot calf raise, a half squat, a one-foot squat, a forward leg raise and a kick back. Each exercise was performed statically in the designated position. 15 seconds of relaxation intervals were allocated between the exercises.

The OW was merely composed of low intensity jogging. The subject performed no preconditioning activities subsequent to this warm up session. The subjects completed only penalty kicks. Since OW did not include any preconditioning activities, it was designated as a control application in this study.

Football Penalty Kick Test

The participants in the study carried out a standard football penalty kick test after every preconditioning activity. The penalty kick test was carried out at a maximal speed from the penalty spot 11 meters away from the goal line. For the standardization of the kicks, the player who performed the penalty kick was instructed to aim at a plastic figure placed in the middle of the goals between the goal line and the net. The radar gun (SportsRadar 3600, Astro Products, Ontario, CA, USA), which was used to measure the speed of the ball, was placed on a tripod at a 10-degree angle to the side of the player's dominant leg and 5 meters behind the player who performed the penalty kick. The players were given feedback on the speed in order to reach maximal effort. For the data analyses, the fastest (km/h) of the 3 penalty shots that the player took was evaluated as maximal penalty speed (V_{max}) (Gelen 2010).

Statistical Analysis

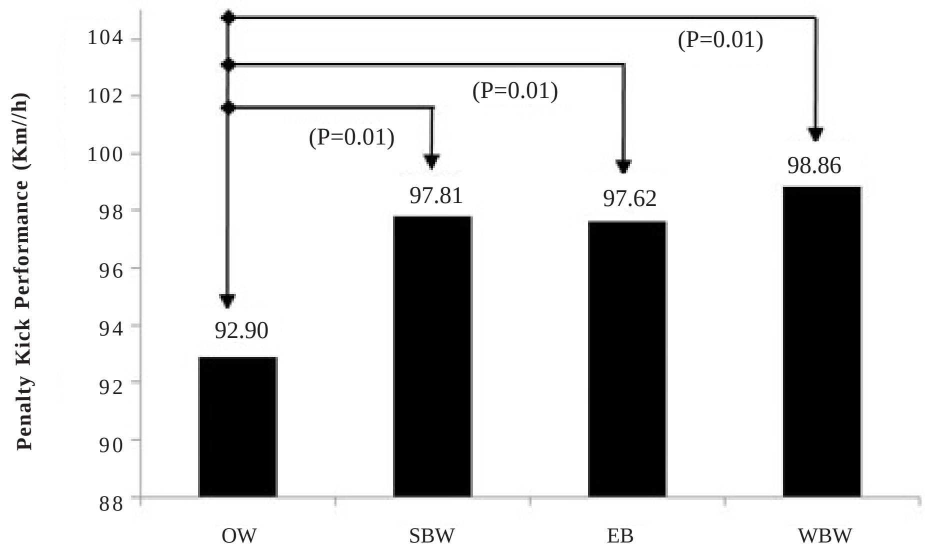
Descriptive statistics (mean ± *SD*) were formulated for the variables of age, height, body weight and penalty kick. The data obtained for each of the four preconditioning activities were analyzed using repeated measures analyses of variance (ANOVA). SBW, EB and WBV comprised the study group, while OW was designed as the control group. When a significant *F* value was achieved, the *post-hoc* comparisons were attained via a least significant different (LSD) test to identify specific differences between the trials. An intra-class correlation (ICC *Rs*) was calculated for each test measure after each of the 4 preconditioning activities to examine the reliability of each test. The statistical significance was fixed at $p>0{,}05$, and all the analyses were carried out using the Statistical Package for the Social Sciences version 15 (SPSS, Inc. Chicago, IL).

RESULTS

The mean scores for the penalty kick performance measurements after the various preconditioning activities are presented in Figure 2. In terms of the penalty kick performance, a 4.9 km/h (5.2 %) difference between OW and SBW, a 4.7 km/h (5 %) difference between OW and EB, and a 6.3 km/h (5.9 %) difference between OW and WBV were found statistically meaningful ($p<0{,}01$). However, no statistical difference was recorded between SBW, EB and WBV, which were accepted as experimental applications in terms of penalty kick performance. The reliability ICC *Rs* for the dependent variables were 0.63 to 0.87. According to the findings, SBW, EB and WBV applications, which were used as preconditioning activities after low intensity jogging acutely, increase penalty kick performance.

DISCUSSION

The aim of this study was to reveal the acute effects of specific preconditioning activities on football penalty kick performance among male players who attend football training regularly. The result of this study revealed that specific preconditioning activities increased football penalty kick performance in male football players. This result reinforces the hypothesis that specific preconditioning like SBW, EB and WBV activities will increase penalty kick performance. An additional result was that in terms of penalty kick performance there was no statistical difference between SBW, EB and WBV applications, which were used as preconditioning activities. Accordingly, the preconditioning activities used in this study have shown similar results.



OW only general warm-up, SBW Squat with body weight, EB Elastic-band, WBV Whole-body vibration

Fig. 2. Penalty kick performance following different preconditioning activities

In the study, penalty kick performance increased by 4.9 percent after SBW applications and 4.7 percent after EB applications. This result supports the previous studies, which revealed that preconditioning activities increase the related performance (Israetel et al. 2010; Jakubiak and Saunders 2008; McBride et al. 2005; Needham et al. 2009; Wallace et al. 2006; Weber et al. 2008).

Needham et al. (2009) studied the acute effects of different warm up protocols on anaerobic performance in twenty elite youth football players. One of the warm up protocols in the study included 8 front squats equal to twenty percent of the bodyweight followed by dynamic stretching. The researchers concluded that when a resistance exercise like squat is added to dynamic warm up, this increases both, the vertical jump and sprint performance. The results of the study in which Yetter and Moir (2008) studied the acute effects of heavy back and front squat on sprint performance have revealed that when a heavy back squat is included in warm up applications, sprint performance increases. Weber et al. (2008) studied the acute effects of heavy load back squat applications on consecutive squat jump performance in twelve Division I male track-and-field athletes. The results revealed that heavy load back squat acutely affected the average and peak jump performance (5.8% and 4.7%, respectively). Similar to other researchers, McBride et al. (2005) in their study asserted that low-volume heavy lifting acutely affected the 40-meter sprint time.

In the studies an extra load was generally added to squat applications. In this study, which varied from the studies referred to above, squat applications were performed without any extra weight added to the bodyweight. What is notable in the study is that a 4.9 percent increase was recorded with squat applications that only used the bodyweight without an extra additional load.

Israetel et al. (2010) studied the kinetic and kinematic change of elastic band applications during squat performance. The results of the study have shown that elastic band applications increased the power and muscle activity during the early portions of the eccentric phase and the latter portions of the concentric phase. Wallace et al. (2006) in their study with ten recreationally resistance-trained subjects studied the force and power characteristics of elastic band use during back squat exercise. The results of their study revealed that peak force and peak power increased during the back squat exercise and this showed that the increase is statistically meaningful. In contrast to other researchers, Corn and Knudson (2003) stated that elastic cord tow training provided no statistical difference in the 20-meter maximal sprint performance. Elastic band applications have chronic effects in addition to the acute effects. In their study, Jakubiak and Saunders (2008) documented a seven percent increase in kicking velocity after 4-week elastic resistance training.

The results of this study have revealed that specific preconditioning activities like SBW and EB prior to penalty kicks increase explosive power production by increasing neuromuscular functions, and consequently producing PAP. Although research into mechanisms that activate PAP is still being carried out, current theories affirm that there may be chemical, neuromuscular and mechanical changes, which could temporarily alleviate the contractile characteristics of muscle tissues (Güillich and Schmidtbleichher 1996; Sale 2002; Gossen and Sale 2000). Previous studies have shown that specifics such as the individuals' training habits or type of fibril dispersion can modify their capability to prompt PAP (Güillich and Schmidtbleichher 1996; Sale 2002).

In the study, penalty kick performance increased by 5.9 percent after a WBV application. This result conveys similar qualities to the previous results where WBV applications increased the acute performance (Cochrane and Stannard 2005; Cormie et al. 2006; Issurin and Tenenbaum 1999; Jacobs and Burns 2009; McBride et al. 2010; Ronnestad 2009).

In their study, Jacobs and Burns (2009) stated that WBV applications increased the knee extension peak and average isokinetic torque in sequence of 7.7 percent and 9.6 percent, and knee flexion average isokinetic torque of 7.8 percent. In the conclusion of their study it was also stated that short-term WBV exercises were suitable for the preparation of vigorous exercises. In the conclusion of their study where McBride et al. (2010) examined the acute effects of WBV on muscle force output and motor neuron excitability, it was stated that WBV has increased by 9.4 percent after peak force exercises and 10.4 percent after 8 minutes. In their study that Cormie et al. (2006) conducted to determine the acute effects of WBV on muscle activity, strength and power, they found the jump height during the countermovement jump after vibration to be more meaningful than sham condition. At the end of their study it was stated that WBV is a potential warm up procedure, which can increase vertical jump height. Cochrane and Stannard (2005) stated that WBV training has a positive impact on arm countermovement vertical jump in female elite field hockey players.

It has been claimed that the application of vibration causes minor changes in muscle length (Bosco et al. 1999a), changes high frequency in afferent stimulants after maximal isometric contractions into neurotransmitter releases (Rittweger et al. 2003), increases the spinal excitability in the α-motor neuron pool (Issurin 2005), and additionally vibration trainings have the same effects as weightlifting training on muscle performance (Bosco et al. 1999b).

It has been argued that vibration stimulants facilitated neuromuscular conduction by increasing neurotransmitter release through mecano sensors (primer afferents in muscle fibril) as well as enabling the use of motor units that are not normally used (Rittweger et al. 2003).

CONLUSION

In conclusion, a temporary increase can be observed in muscle activities through the use of WBV applications.

It can be suggested that SBW, EB and WBV applications, which are used after low intensity aerobic jogging performed in this study increased the excitability of the target muscle and thus, can activate these units to play a major role in penalty kick performance. Furthermore, it has also been observed that SBW, EB and WBV as preconditioning activities can bring about similar physiologic results. PAP appears to be a potential field of study for forthcoming research on increasing athletic performance. Since the relationship between the potentiation method, which is required to increase the performance and its level, is highly variable, researchers, trainers and sports instructors in this area should perform applications to determine which preconditioning activities provide optimal benefits for their players.

RECOMMENDATIONS

The use of preconditioning activities such as SBW, EB and WBV to achieve success in branches of sports that require maximum power production can acutely increase the performance.

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