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EFFECT OF 8 WEEKS OF INJURY PREVENTION TRAINING OF MODIFIED FIFA 11+ ON KINETICS INDICES OF VERTICAL JUMP ON ELITE HANDBALL PLAYERS

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ABSTRACT

Introduction: Warm-up programs are one of the most common preventive programs for injury in various sports. These warm-up exercises have had a positive outcomes in reducing lower limb injuries, but it is unclear what changes have occurred in these exercises and how and by what mechanism they reduce the injury.
Methods: The participants were the available young players (n=24) and adults (n=24) of the national league, the 48 subjects divided in four groups participated in this study. They were randomly selected from each group to two groups of 12 subjects of exercises and control groups. By using force plate and the Bosco test, various kinematics indices were evaluated.
Results: The results showed that the training modified +11 made and improved Bosco, pre-stretch, balance and endurance indices in handball players. There was a significant difference at the post-test of Bosco, balance and power indices with both the pre-test scores and control groups. Pre-stretch index with pre-test score and endurance index with control group had a significant difference.
Conclusion: The implementation of 8 weeks of training modified +11 resulted in a significant improvement in these indices compared to the control group, which only had their normal exercises, could be the cause of injury reduction. Therefore, it is suggested that a modified +11 program for handball players at all skill levels and age should be implemented to prevent injuries.

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Introduction

Handball is played today in 183 countries of both sexes and among different age groups. About 31 million handball players, coaches and referees around the world are cooperating with 113,000 handball teams. Handball is one of the most extreme sports with the prevalence of high-impact and contact and non contact injuries among players [1]. Not only do these injuries threaten the health of players, but also expend millions of dollars and Euros. One of the ways to prevent injuries is warming up programs.

Warm-up programs are the most common prevention programs in various sports such as soccer. The most popular and famous warming program is FIFA 11+. FIFA Medical Research and Evaluation Center (F-MARC) in collaboration with the Oslo Sports Trauma and Research Center and the Santa Monica Sports and Orthopedic Center The orthopedics and sports medicine

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center specially designed for the prevention of lower limb injury in soccer players. Several studies have reported the effect of training program +11 on lower limb injuries [2].

The FIFA 11+ has been done in basketball and has been effective in preventing injury to Italian basketball players by an RCT study [3]. But in handball, only a few studies have been done on injury prevention program, which used different warming protocols, and all reported positive outcomes with respect to injury reduction [4,5]. Although the FIFA 11 has been designed for football, it is also effective in reducing injury in basketball and may also reduce injury in handball. Since the mechanisms of injury to handball are different from soccer, this difference should be evident in the warm-up program, and the exercises of the program should be appropriate to the mechanism of handball injuries. As previous studies have shown, about 80% of ACL injuries were non-contact injuries [6]. And some of the techniques or the implementation of some of them cause injury. Former study showed that the landing is one of the most important mechanisms of injury in handball.

The prevalence of handball injury is different in adults, young people and adolescents. The second cause of injury in young handball is the incorrect landing technique. For young people, emphasis on strength training and landing techniques is also recommended for prevention of injury [7]. With this in mind, warming protocols should be adjusted to the extent of its prevalence and injury mechanism and, if possible, a special protocol for prevention of handball injury should be provided. Koga et al. (2010) have recommended that handball injury prevention programs focus on obtaining a proper landing technique to prevent injury by lowering the knee valgus loud and tibial rotational force [8]. Fatigue has also shown that muscle activity is reduced, which may decrease knee joint stability as a result of the possibility of knee joint injury, in addition to prestretch and practice on the muscle action preprograming reduces injury [9], in contrast, increased activity of quadriceps muscles and decreased hamstring activity during landing, increases the load on the ACL and increases the risk of injury.

Previous studies have shown that knee injury is not a contact injury in handball players, and most often when the player does not feel at risk, such as when they deceptive the opponent or performing the cutting, and is the most common cause of cutting [10]. About 55 percent of injury occurred during cutting, and deceptive movements and plant and cut occurred. In handball, movements such as three steps, hop and jump, and shoot and landing occur on a large scale. On the other hand, hoping has also been suggested in studies as a practice to prevent knee injury [11]. Therefore, handball warming exercises should include hop, cut, and correcting landing techniques, which are not available in FIFA 11+ and its need to modified according to the handball injury mechanism.

Since the FIFA 11 has been tested both for football and basketball players and has had positive outcomes in reducing lower limb injuries, the question is what changes have been made to these exercises and how and by what mechanism did they reduce the injury? It may change the technique, especially in landing, or change in terms of force, power, coordination during landing. This study was conducted to predict how this protocol may change in handball players and whether these changes reduce the incidence or severity of injury. This study initially attempted to modified FIFA 11 as a protocol and fitting it for handball and then focusing on the lower limbs and kinetics. Therefore, the mechanism is trying to check the effect of this warm-up program to prevent injury to the lower limbs of the handball, will the landing mechanic change? What changes in kinetics after these warm up training? How does kinetic force occur during a jump or repetitive jump? In this part of the study, the comprehensive changes including the Bosco index, pre-stretch index, endurance index, balance index, and power index are calculated to address all aspects of the causes and mechanisms of injury.

Methods

Among the volunteer youth (n = 24) and adults (n = 24) players of the Yazd Pishgaman team which present in the national league, purposefully and available subject selected. Each groups divided randomly in two equal groups of exercise and control. Players who had lower limb injuries or history of surgery were excluded. After signing inform constant, the subjects in the intervention group performed modified FIFA 11+ training for 8 weeks, while the control group was asked to maintain their traditional warm-up method throughout the season. Before the intervention, the instructors of the intervention group were fully trained by the researcher. Also, a syllable containing a training video with exercises poster as well as a Persian guide to the exercises was provided to the instructors.

Bosco Test: Kinetic data was collected using the Quattro Jump force plate, model 9290AD made in Switzerland and the Bosco test [12]. This test, also known as the repetitive jump, includes various types of jumps, such as jumping from standing (CMJ), Squat jump starting from knees bent at 90 degrees (SJ) and continues jumps (CJ). The number of jumps between 3 and 5 jumps, and for repetitive jumps, 15 to 60 second jumping were used (table 1).

Table 1. The Quattro Jump Bosco Protocol

The Bosco Protocol evaluates 6 different jump types and calculates a variety of parameters

	Jump type	**Description**
SJ	Squat Jump	Single jump starting from knees bent at 90 degrees
SJbw	Squat Jump + Body Weight	Squat jump with an additional load of up to one body weight
CMJ	Countermovement Jump	Single jump starting with straight legs with a natural flexion before takeoff
CJbref	Continuous Jump Bent Legs	Series of 5 jumps with bent knees, used as reference to compare with CJb (15..60s)
CJs	Cont. Jump straight leg	Series of 5 jumps with straight knees
CJb	Cont. Jump Bent Legs	Series of 15..60s jumping with knees bent

The normal distribution of data was checked by Shapiro-Wilk test. To compare the groups and the effect of intervention, ANOVA repeated measures as well as pair t-test was used. Data were analyzed by SPSS software version 22 and at the significance level of 0.05.

Results

Comparison of demographic characteristics between control and exercise groups showed that there was no significant difference in pre-test in age, height, weight and body mass index (Table 2) (P <0.05).

Table 2. Subjects characteristics including age, weight, height and body mass index in control and exercise groups

Groups		**Age (years)**		**Weight (kg)**		**Height (cm)**		**BMI**	
	N	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Youth control	12	15.25	0.62	72.77	16.15	175.78	175.78	23.60	5.26
Youth exercise	12	16.17	1.03	67.08	12.27	177.38	177.38	21.22	2.90
Adults control	12	19.67	3.03	67.17	9.50	178.21	178.21	21.08	2.24
Adults exercise	12	20.00	1.71	69.33	4.05	178.82	178.82	21.71	1.45
Control	24	17.46	3.11	69.85	13.11	177.05	4.95	22.29	4.09
Exercise	24	18.08	2.39	68.21	9.01	178.10	5.84	21.47	2.26

Comparison of the pretest results in the two groups showed that there was no significant difference between the control group and the intervention group in the Bosco repetitive jump indices (P >0.05). Measured indices in Bosco jump test are Bosco index, pre-stretch index, balance index, endurance index and power index.

After 2 months training of FIFA 11+, these indices had a significant change compared to the pre-test, and this difference was significant with the control group as well.

Indices and various factors were evaluated in each of the four groups, which are presented in Table 2. Some factors did not differ significantly between control and exercise groups in youth or adult, but the indices that obtained from multi-factor computations showed significant changes.

ANOVA showed that in the post-test of Bosco index, a total of 24 people in both exercise groups of youth and adults in the post test were significantly increased (P <0.001) and this increase was significantly different ($F_{1, 46} = 4.87$, P = 0.032) with the control groups (Fig. 1).

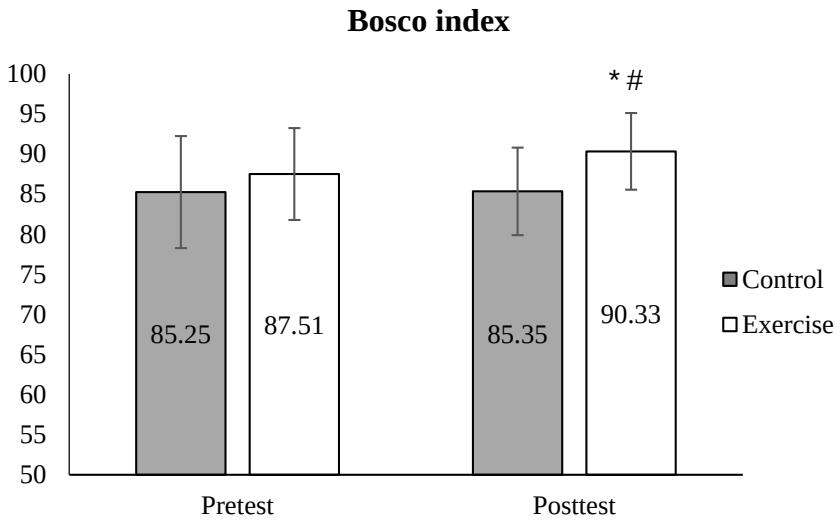

Figure 1. Bosco index in control group (n = 24) and practice (n = 24) in pre-test and post-test
* Significant difference with pre-test
# Significant difference with control group

Table 3. Mean and standard deviation of variables and indices in different groups, and paired t-test between pre-test and post-test

		Pre-test		Post-test		Pair t-test		
groups		**mean**	**SD**	**mean**	**SD**	**t**	**df**	**P**
Youth control	Squat jump height	58.2	7.8	60.1	7.5	-0.76	11	0.463
	Squat jump + body weight	53.4	8.8	54.4	8.9	-169.78	11	0.000
	Bosco index	85.7	7.4	86.4	6.0	-1.12	11	0.287
	Pre-stretch index	-26.4	7.5	-26.5	4.9	0.02	11	0.982
	% Fast Twitch Fibers	34.7	9.3	34.9	9.4	-2.57	11	0.026
	Balance index	1.4	0.2	1.3	0.1	2.13	11	0.056
	Endurance index	86.9	6.1	87.7	5.1	-0.31	11	0.761
	Power index	21.0	2.3	21.9	2.2	-1.84	11	0.093
Youth exercise	Squat jump height	61.8	8.0	65.0	7.9	-7.98	11	0.000
	Squat jump + body weight	56.3	8.5	58.0	8.6	-87.32	11	0.000
	Bosco index	88.9	6.5	91.4	4.5	-5.65	11	0.000
	Pre-stretch index	-25.1	5.2	-29.5	4.3	3.91	11	0.002
	% Fast Twitch Fibers	36.2	6.6	36.4	5.8	-0.22	11	0.833
	Balance index	1.5	0.2	1.6	0.2	-4.50	11	0.001
	Endurance index	88.6	8.4	90.6	5.0	-1.34	11	0.207
	Power index	21.8	2.4	24.3	2.1	-3.20	11	0.008
Adult control	Squat jump height	59.2	9.6	60.0	5.9	-2.17	11	0.053
	Squat jump + body weight	52.9	7.7	53.9	7.8	-187.26	11	0.000
	Bosco index	84.8	6.8	84.3	5.0	51.0	11	0.620
	Pre-stretch index	-24.8	7.6	-24.5	4.5	-0.35	11	0.731
	% Fast Twitch Fibers	34.3	10.0	34.2	10.2	0.35	11	0.736
	Balance index	1.4	0.3	1.3	0.3	1.59	11	0.141
	Endurance index	84.0	2.5	86.4	2.4	2.18	11	0.052
	Power index	20.3	2.8	21.1	2.2	-1.28	11	0.227
Adult exercise	Squat jump height	58.9	7.5	62.4	7.1	-9.82	11	0.000
	Squat jump + body weight	56.0	8.4	57.7	8.5	-89.18	11	0.000
	Bosco index	86.1	5.8	89.3	5.0	-8.11	11	0.000
	Pre-stretch index	-25.8	4.8	-29.3	4.7	2.12	11	0.057
	% Fast Twitch Fibers	34.9	8.9	36.5	9.0	-42.17	11	0.000
	Balance index	1.5	0.1	1.9	0.5	-2.73	11	0.019
	Endurance index	88.3	0.5	90.0	2.8	-1.04	11	0.322
	Power index	21.1	2.6	24.0	2.7	-4.22	11	0.001

Pre-stretch index in youth and adults, from pretest to posttest was not significantly different in control groups, while in exercise groups, these changes were significant ($t_{11} = 3.91$, $P = 0.002$) or borderline not significant ($P = 0.057$).

Totally in combined groups, pre-stretch index in control group did not change at the post test, while in the exercise group, these changes were significantly deferent ($P < 0.001$). Although ANOVA showed no significant difference in posttest between groups (Figure 2).

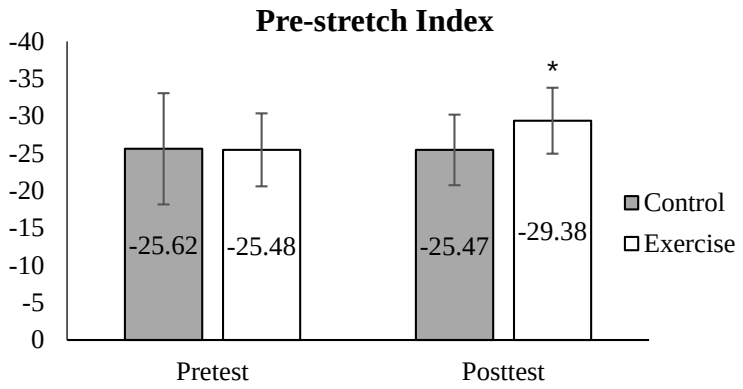

Figure 2. Pre-stretch index in the control and exercise group in pre-test and post-test
* Significant difference with pre-test

In terms of endurance index, both exercise groups increased, but not significantly (Table 3). ANOVA showed that the difference in exercise and control group was not significant (P <0.05). As shown in Figure 3, in total both groups, (two groups of exercise and two groups of control) endurance index were significantly different in the post-test (P = 0.049).

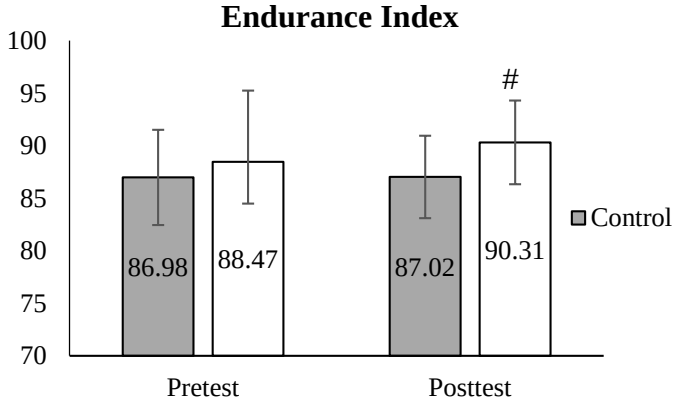

Figure 3. Endurance index in control and exercise groups in pre-test and post-test
Significant difference with control group

T-test showed (Table 3) a significant increase in post-test of balance index in both groups of youth (t_{11} = 4.5, P = 0.001) and adults (t_{11} = 2.73, P = 0.019).
ANOVA showed that the balance index in both groups of youth and adults in the post test was significantly increased (P = 0.007), and this increase was significantly different with the control group at post test ($F_{1, 46}$ = 14.73, P < 0.001) (Figure 4).

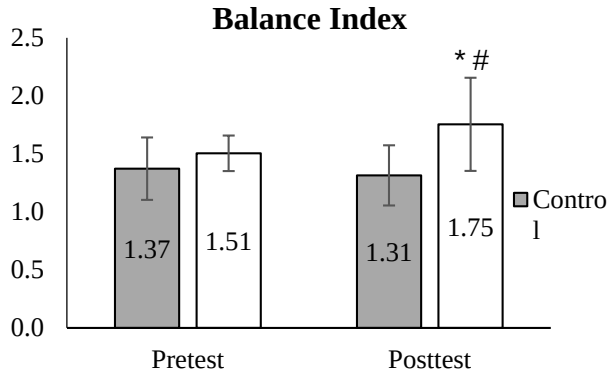

Figure 4. Balance indicator in control and practice group in pre-test and post-test
* Significant difference with pre-test
# Significant difference with control group

In terms of power index t-test showed that, the index in the youth exercise group (t_{11} =3.2, P = 0.008) and also in the adult exercise group (t_{11} = 4.22, P = 0.001) were increased significantly at posttest (Table 3).
ANOVA showed that, the power index had a significant increasing in the total score of the two exercise groups in the post test (P <0.001), and this increase was significantly different with the control groups ($F_{1, 46}$ = 7.71, P = 0.008) (Figure 5).

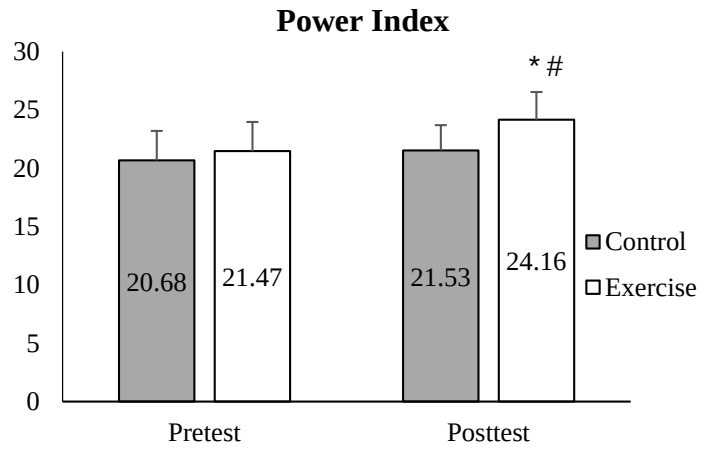

Figure 5. Power index in control and exercise group in pre-test and post-test
* Significant difference with pre-test
# Significant difference with control group

Discussion

In this study, 48 elite handball players were selected from youth and adult teams and randomly assigned to training and control groups. Exercise group after usual exercises, performed modified FIFA 11+ and the control group performed only usual exercises. Using the force plate and the Bosco jump test, the jumps factor and indices were obtained, which indices were significantly different at post test in the exercise group and also in compare with control group.

In the exercise group, the jump height increased significantly after 8 weeks compared to the control group. The reason for this is perhaps to do jumping and strength exercises in the warm-up program of FIFA 11+, which some studies have been confirmed, such as DiStefano et al. (2010), which reported a rise in the vertical jump height of players after performing of the injury prevention program [13]. Also, Kilding et al. (2008) stated that the vertical jump of soccer players has increased significantly after training of the FIFA 11+ program [14]. Noyes et al. (2013) also found that the performing of the sportsmetric injury prevention program increases the ability of the athlete to jump vertically [15].

Other studies also reported an increase in the vertical jump soccer, volleyball and basketball players following a program designed to prevent ACL injuries [16]. One of the reasons for the effectiveness of training 11+ on the vertical jump of players is the use of jumping and plyometric exercises and so on. Also, using strength training such as squat and walking lunge exercise can also increase the amount of vertical jump height. Recently, a review study has shown that the combination of squat and plyometric exercises can lead to higher vertical jump height [17].

In contrast, Vescovi and VanHeest (2010) reported that the preventive injury program had no effect on their jump height on female adolescent girls [18]. Lindblom et al. (2011) also performed neuromuscular exercises without affecting the vertical jump of female players aged 12 to 16 years [19]. Stefan et al. (2008) stated that the training program 11+ had no effect on the vertical jump height of soccer players [20]. The differences in the age and sex of the subjects in these studies may be due to the contradictions in their results compared with the present study.

Casajús (2001) did not see a change in the results of the 15-second repetitive Bosco jump test in the beginning and the end of the season for the adult Spanish players in La Liga Spain [21]. Although a slight increase of about 1.7 W / kg was observed in post test results, this study was not significant. The increase observed in the results of Bosco jump in the players in the intervention group of this study can be attributed to the FIFA 11+ training program. This training program includes a variety of strength exercises and jump exercises. One of the possible reasons for increasing the strength of the lower extremity after the FIFA + 11 program can be increased muscle strength. Brito et al reported that exercises increase the strength of the muscles around the knee. Daneshjoo et al. reported that the isokinetic strength of the knee muscles of the young male soccer players improved after performing 11+ training [22]. Agaard et al. (1994) also argued that increased muscle strength of the lower extremity could increase the anaerobic power of the lower extremity muscles of soccer players [23].

In the best of our knowledge, no study has yet been made of the results of the Bosco test on handball players. Only Bosco's index has been reported in many sports. Contreras 2007 showed strength training increase the Bosco index [24]. Fazl Ersi et al. (2016) also reported significant correlations between core stability with CMJ jump [25] and suggested that the path of

power transmission from the lateral parts to the core muscle. As the core muscle improves in the training of FIFA 11+, this maybe explains the increasing Bosco index.

For other indices we couldn't find any literature to compare but in general, the results of this study showed that training FIFA 11+ have led to the change and improvement of these indices in handball players. Although some indices were not significant in the young or adult group due to the small number of subjects, or was borderline not significant but in total, two groups of youth and adults with intervention of FIFA 11+ indices have significant improvement due to pre-test score or compare to control group.

Although selected handball players are at the elite level and are highly skilled in terms of technique and fitness, but they are less aware of basic skills such as jumping or, more importantly, landing techniques. Practice or performing 8 weeks of 11+ training, which includes these basic movements, has made a significant improvement compared to the control group, which only had their usual exercises. Therefore, it is suggested that teaching and training basic movements for players, even at high or elite levels. And it is recommended that a modified FIFA 11+ program for handball players at all skill levels and age be implemented to prevent injury.

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Competing interests

The authors declare that they have no competing interests.

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