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Effects of a comprehensive warm-up program on performance parameters of elite and sub-elite male skiers

Efectos de un programa integral de calentamiento en los parámetros de rendimiento de esquiadores masculinos de élite y sub-élite

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ABSTRACT

This study investigates the effects of a comprehensive warm-up program (FIFA 11+) on performance and injuries in ski athletes. Recent research shows that comprehensive warm-up programs can significantly affect performance and prevent injury. A total of 20 sub-elite (n:10) and elite (n:10) male ski athletes participated in the study. Inclusion criteria for the study were to be in the 18–25 age range and to have participated in international competitions for elite athletes and skiing for at least three years, as well as to be actively continuing their sports life for sub-elite athletes. A comprehensive warm-up program (FIFA 11+) was applied to the athletes three days a week, for eight weeks, before the training. Two measurements were taken from the athletes as pre-test and post-test. In this study, hexagon agility tests, high box tests, balance measurements, and proprioception measurement tests were applied. In the within-group comparisons, there was a statistically significant difference in the hexagon agility test ($p = 0.01$), proprioception test ($p = 0.01$), and high box test ($p = 0.01$). Dynamic right leg balance test ($p = 0.01$) was significant in the sub-elite athletes, and statistically significant differences were found among elite athletes in hexagon agility ($p = 0.01$), proprioception test ($p = 0.01$), high box test ($p = 0.01$), and the dynamic right leg balance test ($p = 0.02$). The effects of the FIFA 11+ warm-up protocol on performance parameters and proprioception did not differ between sub-elite and elite athletes.

KEYWORDS

Ski; Balance; Proprioception; Agility; Warm-Up

RESUMEN

Este estudio investiga los efectos de un programa integral de calentamiento (FIFA 11+) sobre el rendimiento y las lesiones en esquiadores. Investigaciones recientes muestran que los programas integrales de calentamiento pueden afectar significativamente el rendimiento y prevenir lesiones. Un total de 20 esquiadores masculinos de sub-élite (n: 10) y élite (n: 10) participaron en el estudio. Los criterios de inclusión en el estudio fueron estar en el rango de edad de 18 a 25 años y haber participado en competiciones internacionales para esquiadores de élite durante al menos tres años, así como continuar activamente su vida deportiva para esquiadores de sub-élite. Se aplicó un programa de calentamiento integral (FIFA 11+) a los esquiadores tres días a la semana, durante ocho semanas, antes del entrenamiento. Se tomaron dos medidas de los deportistas: pre-tests y post-tests. En este estudio se aplicaron tests de agilidad hexagonal, pruebas de caja alta, mediciones de equilibrio y pruebas de medición de propiocepción. En las comparaciones dentro de los grupos, hubo una diferencia estadísticamente significativa en el test de agilidad del hexágono ($p = 0,01$), prueba de propiocepción ($p = 0,01$) y prueba de caja alta ($p = 0,01$). El test de equilibrio dinámico de la pierna derecha ($p = 0,01$) fue significativo en los esquiadores de sub-élite, y se encontraron diferencias estadísticamente significativas entre los esquiadores de élite en agilidad hexagonal ($p = 0,01$), prueba de propiocepción ($p = 0,01$), prueba de caja alta ($p = 0,01$), y el test de equilibrio dinámico de la pierna derecha ($p = 0,02$). Los efectos del protocolo de calentamiento FIFA 11+ sobre los parámetros de rendimiento y la propiocepción no difirieron entre deportistas de élite y de sub-élite.

PALABRAS CLAVE

Esquí; Equilibrio; Propiocepción; Agilidad; Calentamiento

1. INTRODUCTION

Sports have an important place in human life, both physiologically and psychologically (Emery and Pasanen, 2019). Motoric features are one of the basic needs in sports. These include many parameters, such as coordination, agility, and aerobic/anaerobic endurance. Motoric features, balance skills, and proprioception, which have an important place in all sports branches, also form the basis of skiing (Byeon and Park, 2018). It improves parameters such as balance skills, agility, and proprioception. It has been found that good balance skills prevent injuries, such as falling and impacts, while good proprioception function reduces injuries (Raschner et al, 2017; Irrgang, Whitney and Cox, 2010).

Proprioception is thought to be related to the feeling of the movements and positions of the joints within the nervous system (Hewett, Lindenfelt and Riccobene, 1999). The sense of proprioception, which triggers the neuromuscular control response, has an important place in sports that require ability and agility (Jerosch, Brinkmann and Schneppenheim, 2003). As a result of the 10-week FIFA 11+ warm-up program applied to amateur football players, it was found that there was no improvement in the static, dynamic balance, and proprioception of athletes (Lopes et al, 2019). However, in another study, it has been found that the Fifa-11+ warm-up program, which is used as a warm-up before training, has a feature that improves balance (Gioftsidou et al, 2006).

Agility and anaerobic capacity are other motoric features that are as necessary as proprioception and balance, which are very important for alpine skiing. As it is known, agility is an indispensable element for sudden turns at the doors during rapid descents. Agility should be developed as much as an anaerobic capacity for alpine athletes competing in split seconds (Can and Polat, 2004). It is thought that the excessive load on the knee during these turns, as well as the forward and outward rotation of the knee, cause injury to the connective tissues. Therefore, agility and anaerobic capacity development affect performance, as well as proprioception and balance skills (Demirdağ, Öncan and Durak, 2004, Sulheim, Ekeland and Bahr, 2007). As seen in the study, according to traditional warm-ups, it has been determined that the FIFA 11+ warm-up program has a positive effect on agility, vertical jump and speed performances (Zarei et al, 2018). In another study, it was found that there were significant improvements in agility and long jump performance in young football players after applying the 4-week FIFA 11+ warm-up program (Trajkovic et al, 2020).

Athletes reported that extensive warm-ups before training and competition positively affected many parameters (Bishop, 2003, Göktepe and Günay, 2016). A comprehensive warm-up is a set of physical movements performed before training so that the muscles can gain elasticity. Warming up before high-intensity loads, by individuals, can improve performance while protecting the athlete from injuries (Silva et al, 2018). The fact that the elasticity and stretching ability of the muscles is high indicates that they can be put under more mechanical load, while the risk of injury will decrease (Bilgin, 2015).

As a result of the 5-week study, it has been found that the FIFA 11+ program improves jumping and speed (Patti et al, 2022). With aging, the range of motion between the joints decreases with increased muscle tone (Patti et al, 2021). In a study conducted by Bianco et al. in 2016, it was determined that athlete injuries mainly consisted of muscle and tendon injuries. This result reiterated the importance of a warm-up before training or a competition for the muscle structure in our body

(Bianco et al, 2016). As it is known, the sudden turns, speed, and environmental factors made by the athletes in alpine skiing, to control the ski, increase the possibility of injuries. In cases such as collisions or falls, it causes damage to the joints, bones, and ligaments in the athlete, as well as fractures and traumas in areas such as the head and neck. Therefore, the ability of the muscles, which gain elasticity with warming up, to flex against the external load will prevent injuries that may occur in the muscle (Yılmaz, Özen and Koç, 2018).

There are general warm-ups, special warm-ups, active warm-ups, passive warm-ups, and comprehensive warm-up programs (Ayala et al, 2016). Many programs have been designed as dynamic warm-up programs to increase the applicability of the Comprehensive Warm-up Program and to take advantage of the biomechanical advantages associated with improved joint position sense. The most important of these programs is FIFA 11+, which is a comprehensive warm-up program that actively engages the whole body in the movement sequence, rather than traditional warm-up models (Silvers-Granelli et al, 2017). In this way, it has been found to increase performance while preventing injuries (Bizzini and Dvorak, 2015).

FIFA 11+ warm-up protocol is an injury-preventive warm-up program developed by experts from sports and health institutions, such as OSTRC (Oslo Sports Trauma Research Center), SMSMF (Santa Monica Orthopedic and Sports Medicine Research Foundation), and F-MARC (FIFA Medical Assessment and Research Centre), under the leadership of the International Football Federation (FIFA). A designated club tested a comprehensive warm-up program before starting research. The movements, in this study, are done together with the partner. The study consists of six cones, with a spacing of 5 m. The first part includes active stretching and warm-ups that start at a slow pace. The second part contains an increasing difficulty level compared to the first part. This section consists of six exercises, including strength, balance, and jumping. Finally, in the third part, rapid runs are combined with sudden changes of direction and movement specific to football (Soligard et al, 2008). Although the application of the comprehensive warm-up program (FIFA 11+) is high in football players, the balance, agility, and sudden changes in the direction of the movements in the second and third sections that we have mentioned above are the movement sequences that can improve the basic motoric features of alpine skiers. Therefore, it is thought that it will have a significant impact not only on football players but also on skiers.

These days, a lot of importance is given to the warm-up programs that should be done before the training. We know that the athlete should not experience any injury for the training carried out. This means that the more time allocated to the warm-up program, the more efficient the training and

the recovery time for the next training. This study examines the effects of the FIFA 11+ comprehensive warm-up program on some performance parameters (balance, proprioception, agility, and anaerobic power) in alpine skiers.

2. METHODS

2.1. Design of the Study

At the beginning of the study, the height and body weight (BW) of each participant were measured. Then, a 10 min warm-up run was performed. Following it, the high box test measurement and the balance test measurement were taken. On the second day, a 10 min warm-up run was performed, and the hexagon agility test was applied. On the third day, proprioception measurement was taken after a 10 min warm-up run. After the preliminary tests were carried out, the FIFA 11+ warm-up program was applied to the elite and sub-elite ski athletes 3 days a week for 8 weeks. FIFA 11+ program was used as a warm-up before each training. After 8 weeks of FIFA 11+ warm-up program application, the tests were repeated.

Before data collection, Ankara University, Faculty of Medicine Clinical Research Ethics Committee approved the decision numbered 15–222 on 1 October 2020. All procedures and subjects provided written informed consent, according to the Helsinki declaration. Throughout testing, procedures adhered to standard national and international regulations regarding the use of human subjects in research.

2.2. Participants

A total of 20 male alpine skiers participated in this study. Participants were divided into two groups. While 1 group consisted of athletes who participated in international competitions, the second group consisted of athletes who had been involved in skiing for at least three years and were still actively engaged in skiing.

2.3. Procedures

2.3.1. Height Measurements (cm)

Body height was measured with an accuracy of 0.1 cm using a Holtain (England) brand stadiometer. During the height measurement, participants were asked to stand upright, and their height was recorded when the caliper touched the athlete’s head’s top (apex) point.

2.3.2. Body Weight Measurements (kg)

Participants' BW, BFR, BMI, BFM, and LBM were measured with a Tanita TBF 300 (Japan) brand bioimpedance device. All elite and sub-elite athletes were measured, while hungry, in the morning (Arslan,Engin and Yapalı, 2017).

2.3.3. Balance Measurement

Right leg, left leg, double leg static, and dynamic balance tests of both groups were performed with a kinesthetic balance device (SportKAT 4000-TS, LLC, Vista, CA, USA). For the dynamic balance test, the hydraulic pressure value of the device platform was adjusted to be 6 force per square inch (PSI). Double leg, right leg, and left leg dynamic balance tests were performed when the difficulty level of the platform was 6 PSI (Ön, Yıldız and Dündar, 2020).

2.3.4. High Box Test

Developed by Kornexl in 1977 to measure anaerobic power specific to ski athletes. The high box test used a box with a 40 cm height, a 51 cm width, and a 60 cm length. Athletes tried to reach as many reps as possible by jumping with both legs for 90 s. The total number of jumps made was recorded at the end of the test. After the first test, the athletes had a 20 min passive rest, and they were asked to repeat the test. The highest score obtained was recorded at the end of the two tests (Hewett, Lindenfelt and Riccobene, 1999).

2.3.5. Hexagon Agility Test (Sec)

The hexagon agility test measures agility, coordination, and anaerobic endurance. A hexagon with 66 cm borders was drawn on a flat surface. Each corner of the hexagon was identified from the letter A to the letter F. Each of the athletes entered in the middle of the hexagon facing the front-line A. At the activation of the stopwatch, they jumped ahead, across the line, with both feet together, and then, they backed over the same line into the middle of the hexagon. They then repeated this movement for each side of the hexagon. Each revolution was recorded as a test score after completion. The test was repeated 3 times, and the best round was used as the test score. The test was restarted in case of landing on a line, falling, or missing the jump order (Esmer,2020).

2.3.6. Proprioception Measurement

The ISOMED 2000 isokinetic test system was used to apply this test. Participants' right and left knees were passively brought to the target angles (30°, 45°, and 60° knee flexion) to memorize the 30°, 45°, and 60° target angles, while the eyes and ears of the participants were closed. Knees were held at the target angles for 5 s and then returned to the starting position at 90°. After the

participants found the target angle degree, they were asked to press the stop button. The tests were repeated three times for each target angle. Between each test attempt, the athletes were given a 30 sec rest (Daneshjoo et al, 2012).

2.3.7. FIFA 11+ Warm-Up Protocol

FIFA 11+ is a training and warm-up program prepared by the FIFA Health Board, lasting an average of 20 min to prevent injuries. Since this program includes plyometric studies, it is more accurate for athletes aged 14 and over. This warm-up program consists of three parts. In the first part, low tempo runs, combined with active stretching movements and controlled partner contacts, are performed. In the second part, there are six sets of exercises to activate the trunk and leg muscles, balance, and agility. Each set is composed of three levels with increasing difficulty. In the third part of the protocol, moderate-to-high tempo runs are combined with sudden direction changes (Daneshjoo et al, 2012).

2.3.8. Statistical Analysis

Data were analyzed using the SPSS (version 23.0, Armonk, NY, USA) statistical software package. Normality of distribution for outcome measures was tested using the Kolmogorov–Smirnov test, and it was determined that the data showed normal distribution (value). The homogeneity of the variables was evaluated with the Levene statistical method. The results of the anthropometric measurements of the participants are presented as the minimum, maximum, mean, and standard deviation values. Paired-sample *t*-test was used to compare within-group differences. To examine the differences between groups, independent samples *t*-test was used. The statistical significance level was accepted as $p < 0.05$.

3. RESULTS

Independent sample *t*-test results obtained from anthropometric measurements of elite and sub-elite athletes participating in the study are presented (Table 1). According to the results obtained, no statistically significant difference was found in height, BW, BMI, BFP, BFM, and LBM values of elite and sub-elite athletes ($p > 0.05$).

Table 1. Anthropometric characteristics of sub-elite and elite skiers.

	Sub-Elite Athletes				Elite Athletes				*p*
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	
Age	18	24	20	1.94	18	23	20.2	1.98	0.83
Height (cm)	164	187	174.8	6.54	173	195	180.9	7.03	0.6
BW (kg)	48.2	98.3	67.76	14.2	58.1	82.8	69.15	8.99	0.79
BMI (kg/m²)	17.9	30	21.92	3.31	18.8	23.4	20.91	1.69	0.40
BMR (kcal)	1417	2179	1765.2	238.04	1605	2027	1808.1	148.9	0.63
BFP (%)	5.0	19.6	8.07	5.16	4.1	12.5	7.26	2.67	0.66
BFM (kg)	2.4	19.3	6.09	5.43	2.5	10.1	5.18	2.42	0.63
LBM (kg)	45.8	79	61.43	9.25	54.7	75.6	63.95	7.39	0.51
TBW (kg)	34.6	57.8	44.87	6.83	40	55.3	46.83	5.4	0.48

**BW: Body weight, BMI: Body mass index, BMR: Basal metabolic rate, BFP: Body fat percentage, BFM: Body fat mass, LBM: Lean body mass, TBW: Total body water.*

Table 2 shows the results of the paired sample *t*-test of the proprioception test scores of elite and sub-elite athletes (Table 2). According to these results, there is no statistically significant difference between the proprioception in all pre and post-test scores of the sub-elite athletes *(p* > 0.05). According to these results, in the measurements taken before the warm-up protocol and after the warm-up protocol, there is a significant difference in the right leg at 30°, right leg at 45°, and left leg at 30° in elite athletes ($p > 0.05$).

Table 2. Within-groups comparison of proprioception pre and post-test score.

		Pre-Test	**Post-Test**	**ROC %**	***p***
		Mean ± SD	**Mean ± SD**		
Sub-elite athletes	**Right Leg 30°**	27.5 ± 5.62	26.8 ± 4.98	−2.54	0.44
	Right Leg 45°	40.5 ± 5.12	39.6 ± 3.53	−2.22	0.34
	Right Leg 60°	59.1 ± 4.74	57.6 ± 2.91	−2.53	0.10
	Left Leg 30°	26.4 ± 4.59	26.8 ± 4.82	1.51	0.68
	Left Leg 45°	40.5 ± 3.2	40.9 ± 4.38	0.98	0.71
	Left Leg 60°	54.9 ± 2.8	53.7 ± 3.09	−2.18	0.13
Elite athletes	**Right Leg 30°**	31.5 ± 2.91	33.1 ± 2.46	5.07	0.01*
	Right Leg 45°	43.1 ± 2.46	42 ± 2.16	−2.55	0.02*
	Right Leg 60°	61.1 ± 4.93	60 ± 5.03	−1.8	0.28
	Left Leg 30°	30.2 ± 4.21	32 ± 3.55	5.96	0.08
	Left Leg 45°	45.1 ± 3.44	44.9 ± 4.53	−0.44	0.83
	Left Leg 60°	57.5 ± 4.4	56.7 ± 4.94	−1.39	0.13

**ROC: Ratio of change.*

The proprioception test scores and independent-sample *t*-test statistical analysis results of sub-elite and elite athletes are presented (Table 3). According to these results, there was no statistically significant difference in the proprioception test scores for the right leg at 30°, right leg at 45°, right leg 60°and left leg at 60° for both pre-tests as well as post-test ($p > 0.05$). In addition, a significant difference was found in the left leg 30° post-test score and left leg 45° pre-test measurements applied after the warm-up protocol of the elite and sub-elite athletes ($p < 0.05$).

Table 3. Between-groups comparison of proprioception pre and post-test scores.

		Sub-Elite Athletes		Elite Athletes		*p*
		Mean	SD	Mean	SD	
Right Leg 30°	**Pre-test**	27.5	5.62	31.5	2.91	0.61
	Post-test	26.8	4.98	43.1	2.46	0.20
Right Leg 45°	**Pre-test**	40.5	5.12	43.1	2.46	0.16
	Post-test	39.6	3.53	42	2.16	0.08
Right Leg 60°	**Pre-test**	59.1	4.74	61.1	4.93	0.36
	Post-test	57.6	2.91	60	5.03	0.20
Left Leg 30°	**Pre-test**	26.4	4.59	30.2	4.21	0.07
	Post-test	26.8	4.82	32	3.55	0.01*
Left Leg 45°	**Pre-test**	40.5	3.2	45.1	3.44	0.06
	Post-test	40.9	4.38	44.9	4.53	0.06
Left Leg 60°	**Pre-test**	54.9	2.8	57.5	4.4	0.13
	Post-test	53.7	3.09	56.7	4.94	0.29

The results of high box test scores and hexagonal agility scores of sub-elite and elite athletes are given (Table 4). These results showed a statistically significant difference between the high-box test results of both the sub-elite and elite athletes' groups before and after the warm-up protocol (p = 0.01). The comparison between the groups is examined, there was no statistically significant difference in high-box test scores (p = 0.21). According to the hexagon agility test results, there was a statistically significant difference between the hexagon agility 1st round pre and post-test scores of both the sub-elite athletes and the elite groups (p = 0.01 and p = 0.05, respectively). While no statistically significant difference was found between the total test scores in both groups (p = 0.37 and p = 0.12). The analysis results showed that there was no statistically significant difference between the groups in hexagon agility 1st round pre-test as well as in post-test scores (respectively p = 0.82, p = 0.32). Similarly, the results showed no statistically significant difference between the groups in hexagon agility total pre-test as well as in post-test scores (respectively, p = 0.97, p = 0.61).

Table 4. Within-group and between-group comparison of high-box and hexagonal agility pre and post-test scores.

	Sub-Elite Athletes				Elite Athletes				Between-Group	
	Pre-Test	Post-Test	ROC	Within-Group	Pre-Test	Post-Test	ROC	Within-Group	Pre-Test	Post-Test
	Mean ± SD	Mean ± SD	%	*p*	Mean ± SD	Mean ± SD	%	*p*	*p*	*p*
HBT	84 ± 9.76	92.2 ± 10.22	9.52	0.01*	77.6 ± 12.31	93.2 ± 10.14	21.03	0.01*	0.21	0.83
HXAT / 1. round	5.59 ± 0.88	5.27 ± 0.66	−5.72	0.01*	5.69 ± 0.98	5 ± 0.49	−12.12	0.05	0.82	0.32
HXAT/ Total	11.15 ± 1.1	10.93 ± 1.17	−1.97	0.37	11.17 ± 1.09	10.69 ± 0.82	−4.29	0.12	0.97	0.61

**ROC: Ratio of change, HBT: High-box test, HXAT, Hexagonal agility test.*

Table 5 shows the results of comparing static and dynamic balance test scores within-group and between-group (Table 5). A statistically significant difference was found between the sub-elite athletes' right leg dynamic balance pre-test and post-test scores (p = 0.01). In elite athletes, a statistically significant difference was found between the right leg static balance pre and post-test values (p = 0.01) and between the right leg dynamic balance pre and post-test values (p = 0.02). There was no statistically significant difference for the right leg, left leg and double leg dynamic balance test scores between the groups in pre-test (respectively p = 0.53, p = 0.17, p = 0.52) as well as in post-test (respectively p = 0.51, p = 0.21, p = 0.95).

Table 5. Within-group and between-group comparison of static and dynamic balance test score.

		Sub-Elite Athletes				Elite Athletes				Between-Group	
		Pre-Test	Post-Test	ROC	Within-Group	Pre-Test	Post-Test	ROC	Within-Group	Pre-Test	Post-Test
		Mean ± SD	Mean ± SD	%	*p*	Mean ± SD	Mean ± SD	%	*p*	*p*	*p*
Static	RL	538 ± 245.9	496.8 ± 273.55	−7.8	0.28	494.8 ± 141.71	431.4 ± 132.23	−12.75	0.01*	0.63	0.50
	LL	570.9 ± 274.88	544.2 ± 264.16	−4.56	0.16	553.6 ± 176.29	537.3 ± 238.16	−2.89	0.56	0.87	0.95
	DL	465.3 ± 199.37	492.4 ± 236	5.8	0.36	473.2 ± 199.78	474.3 ± 184.16	0.21	0.98	0.93	0.85
Dynamic	RL	1152.3 ± 229.94	1069 ± 224.68	7.2	0.02*	1094.8 ± 166.97	1010.8 ± 157.35	−7.67	0.02*	0.53	0.51
	LL	1186.3 ± 307.08	1124 ± 259.88	−5.22	0.15	1024.5 ± 186.23	982.4 ± 235.1	−4.1	0.32	0.17	0.22
	DL	998.1 ± 232.52	1027.7 ± 276.84	2.9	0.56	1063.9 ± 223.87	1021.4 ± 217.29	−3.95	0.34	0.52	0.95

**ROC: Ratio of change, RL: Right leg, LL: Left leg, DL: Double leg.*

4. DISCUSSION

This study aimed to examine the effect of a comprehensive warm-up program (FIFA 11+) on balance, agility, anaerobic capacity, and proprioception characteristics of alpine skiers after eight weeks of training. The main findings of this study are listed as follows.

According to the comparison, there was no statistically significant difference between the anthropometric measurement values of sub-elite and elite athletes (p > 0.05) (Table 1).

Ski athletes perform their training and competitions in icy weather conditions, studies have shown that cold weather conditions increase the risk of injury. Various studies have reported that dynamic neuromuscular warm-up and FIFA 11+ warm-up programs reduce the risk of injury in many sports branches by improving the athletes' joint stability, position sense, and protective joint reflexes

(Hübscher and Refshauge,2013, Sugimoto et al, 2015). Although proprioceptive development is an essential factor for preventing injury, studies in the literature show that it also improves ski performance. In their study, Dickson et al. (2020), investigating the effects of proprioception on ski performance, reported that proprioception, developed as a result of training, positively affects the performance of elite ski athletes. Daneshjoo et al. (2012) investigated the effects of HarmoKnee and FIFA 11+ exercise programs on the proprioception of professional football players. In the tests performed after the FIFA 11+ warm-up protocol, it was determined that the proprioception error of the football players improved by 2.8% and 1.7% at 45° and 60°.

Proprioception is called the creation of responses by the central nervous system that will keep the joints, ligaments, and limbs in the safest condition [9]. As can be understood from this interpretation, keeping the limbs in the safest condition will protect the athlete when there are rapid changes in direction in alpine skiing. However, the presence of factors affecting proprioception cannot be ignored. In a study, it was found that fatigue worsens proprioception (Sandrey and Kent, 2008). In our research, we can attribute the worsening of the right leg at 45°, the right leg at 30°, and the left leg at 30° in elite athletes to the fatigue caused by the extensive warm-up program we have applied for 8 weeks, as well as the training they have done.

Alpine skiing is a sport in which anaerobic energy production is dominant because the competitions are related to speed or distance, and the duration of the competition is less than 3 min (Vitale et al, 2018). Since the high-box test includes jumps, it measures lower extremity strength, and the test score can be affected by features such as anaerobic endurance and balance (Andersen, Montgomery and Turcotte, 1990). In their study, Paoli et al. (2017) determined that resistance training increased muscle strength and endurance. Previous studies have shown a relationship between the high-box test score and alpine skiing performance (Andersen, Montgomery and Turcotte, 1990). In addition, a study found a correlation between high-box test scores and anaerobic power output on cycle ergometer scores and anaerobic running test scores on the treadmill (Paoli et al, 2017). According to the previous studies, the high box test score is an important tool to determine anaerobic power (Brown and Wilkinson, 1983).

In our study, when the high-box test scores of the elite and sub-elite skiers were examined, it was seen that there was a significant positive increase in the within-group comparisons, but there was no significant difference between groups. According to these results, it can be said that the comprehensive warm-up program positively affects the anaerobic capacity of the skiers.

It was found, in many studies, that the amount of oxygen which was carried to the muscles during high-intensity exercises affects sports performance. In this situation, it was claimed that

MaxVo2 decreases, accordingly, with the decrease in the amount of oxygen in the blood, and the time to exhaustion is prolonged with the increase in the amount of oxygen in the blood (Richards et al, 2004; Harms et al, 2000). This clarifies the importance of anaerobic capacity for alpine rock climbing at high intensity in a short time.

Pomares-Noguera et al. (2018) investigated the effects of the FIFA 11+ warm-up protocol on the physical performance of young male football players. The football players were divided into two groups, and one group carried out the FIFA 11+ warm-up protocol, while the control group applied the routine warm-up protocols two days a week for four weeks. As a result of the study, it was determined that the FIFA 11+ warm-up protocol increased the players' vertical jump and agility performances. According to the current research and the results of previous studies in different sports branches, it is seen that the FIFA 11+ warm-up program affects anaerobic performance positively.

A comparison of the pre and post-hexagon agility tests of the sub-elite and elite skiers was examined, there was a positive development between the pre and post-test first round and total test scores of the sub-elite skiers, but there was no significant difference in the total score, In the comparison between the groups, no significant difference was found in the hexagon agility test (Table 4).

It is obvious that the higher agility in alpine skiing, where there are speed and sudden changes in direction, leads to the higher performance of the skier. According to our results, it was concluded that the comprehensive warm-up program of FIFA 11+ affected the agility of alpine skiers.

Şahin et al. (2018) investigated the effects of applying for the FIFA 11+ comprehensive warm-up program on performance and injury in young basketball players, twenty young basketball players, with a mean age of 10.7 ± 0.3 years, participated in this study. While 10 of the participants in the experimental group applied the FIFA 11+ warm-up protocol, 10 of the participants in the control group carried out the branch-specific routine warm-up program, and both groups performed warm-up protocols 3 days a week for 10 weeks. As a result of the study, they concluded that the FIFA 11+ warm-up protocol had a positive effect on the agility test values of the participants. In another study, two hundred male amateur football referees (average ± SD age, 31.6 ± 4.1 years) participated. Participants were randomly divided into experimental and control groups. The experimental group performed the FIFA 11+ warm-up protocol as a warm-up at least twice a week, while the control group performed their regular warm-ups. Participants were followed for one season. As a result, the FIFA 11+ warm-up protocol effectively reduced injuries by 65% in the experimental group compared to the control group.

While there was no improvement in the pre and post-test scores of the right leg, left leg, and double leg static balance test results of the sub-elite skiers participating in the study, an improvement was observed between the right leg static balance test scores. While there were significant differences in the right leg static and right leg dynamic measurements within the group of elite athletes, there was no significant difference between the groups ($p < 0.05$). These results led us to the conclusion that the dominant legs of the skiers are the right legs.

A comprehensive warm-up program is one of the basic needs of every sport because warming up the athletes' muscles before training or competitions prevents injuries and increases performance. To protect their athletes, there are warm-up programs that conscious trainers do not give up. In addition to the general warm-up programs, many trainers follow the comprehensive warm-up program (FIFA 11+) with interest. It has been observed that the comprehensive warm-up program (FIFA 11+) improves many motoric features and prevents injuries. Therefore, it will be beneficial for trainers and athletes to use it as a warm-up program before training.

5. CONCLUSIONS

As a result, the FIFA 11+ warm-up protocol, applied three days a week for eight weeks, had positive effects on the skiers' dynamic and static balance, anaerobic power, and agility parameters. On the other hand, the FIFA 11+ warm-up protocol does not impact the proprioception sense of skiers, considering the increase in proprioception error post-test compared to the pre-test score. It has been determined that the FIFA 11+ comprehensive warm-up protocol positively affects performance. In line with these results, it is recommended that skiers apply the FIFA 11+ comprehensive warm-up protocol.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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