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The Effects of Resistance Training Applied to Elite Field Hockey Players on Some Strength Parameters

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Ethical Statement: It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited.

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Abstract

This study is intended to investigate the effects of resistance training on the muscular strength and muscular endurance of elite female and male national team field hockey players. 30 female and 30 male national field hockey players aged between 17-28 participated in the study voluntarily. Before the training program of the participants, maximum muscular strength (bench press, leg extension, leg curl, push down) and muscular endurance (30 sec sit-up and 30 sec push-up test) were determined. The training program was applied to the players for 8 weeks, 3 days a week. SPSS 23.0 package program was used for statistical analysis. As a result of the analysis, it was seen that the distributions were normal, and therefore, t-test was used in dependent groups, which is one of the parametric tests, to compare the pre-test and post-test. The significance level was accepted as 0.05. After the 8-week training program, body weight, while body mass index and body fat percentage values decreased in both female and male field hockey players ($p<0.05$), 1RM values in bench press, leg extension, leg curl and push down applications and 30 sec sit-up and 30 sec push-up values increased significantly compared to the pre-training program ($p<0.05$). As a result, it can be said that regular resistance training has a positive effect on the body composition, muscular strength and muscular endurance of male and female elite field hockey players.

Keywords: Field hockey, Resistance training, Muscular strength, Muscular endurance

Elit Çim Hokeycilere Uygulanan Direnç Antrenmanlarının Bazı Kuvvet Parametreleri Üzerine Etkileri

Özet

Bu çalışmanın amacı direnç antrenmanlarının elit düzeydeki kadın ve erkek milli takım çim hokeyi oyuncularının kas kuvveti ve kassal dayanıklılığı üzerine etkilerinin araştırılmasıdır. Araştırmaya yaşları 17-28 arasında değişen 30 kadın ve 30 erkek milli çim hokeyi sporcusu gönüllü olarak katılmıştır. Katılımcıların antrenman programı öncesinde maksimum kas kuvveti (bench press, leg extansion, leg curl, push down) ve kassal dayanıklılığı (30 sn mekik ve 30 sn şınav testi) belirlenmiştir. Sporculara antrenman programı 8 hafta süresince, haftada 3 gün uygulanmıştır. İstatistiksel analizlerde SPSS 23.0 paket programı kullanılmıştır. Analiz sonucunda

dağılımların normal olduğu görülmüş ve bu nedenle ön test ve son test karşılaştırması yapmak için parametrik testlerden biri olan bağımlı gruplarda t testi kullanılmıştır. Anlamlılık düzeyi 0,05 olarak kabul edilmiştir. 8 haftalık antrenman programı sonrası hem kadın hem de erkek çim hokeyi sporcularında vücut ağırlığı, vücut kütle indeksi ve vücut yağ yüzdesi değerleri azalırken ($p<0,05$), bench pres, leg extansion, leg curl ve push down uygulamasındaki 1TM değerleri ile 30 sn şınav ve 30 sn mekik değerleri antrenman programı öncesine göre anlamlı düzeyde artmıştır ($p<0,05$). Sonuç olarak, düzenli olarak yapılan düzenli direnç antrenmanlarının kadın ve erkek elit çim hokeycilerinin vücut kompozisyonu, kas kuvveti ve kassal dayanıklılığını olumlu yönde etkilediği söylenebilir.

Anahtar Kelimeler: Çim hokeyi, Direnç antrenmanı, Kassal kuvvet, Kassal dayanıklılık

INTRODUCTION

Field hockey is a multidimensional Olympic sport that is played by men and women both recreationally and professionally, is popular around the world, and requires the contribution of many different physical and psychological components such as strength, speed and skill for elite success (Kahn 1999, Burr et al. 2008, International Hockey Federation 2019).

The game of hockey includes all the elements of physical fitness. Hockey is a fast game that requires a high level of conditioning in competitions. A successful hockey player must have a high level of aerobic and anaerobic capacity throughout the game. Success in attacking and defending in hockey requires being fast in short and long distance. Speed is a critical factor. Instantaneous velocity is required to accelerate with the stick and ball and steal the opponent's ball. With a high aerobic capacity, each sprint effort can be sustained (Traverner 2005). In other words, performance is determined by aerobic and anaerobic energy gain, tactical and psychological factors and neuro-muscular functions such as speed, strength and technique (Astrand and Rodalh 1986). Considering the playing time and the need to play quickly and accurately in hockey, the necessity of basic motor skills is important. However, similar to all team sports, some motor features such as quick power, speed, continuity in strength and coordinative abilities come to the fore in hockey (Şahin 2008). It is known that rapid changes and instantaneous velocity in branch-specific talents cause loss of balance and affect performance. That's why top hockey players need high-level technical skills. (Reilly and Borrie 1992). Success in sports can only be achieved with scientific methods today. To be successful, the performance output of the player is aimed to be at maximum levels both physically and mentally with long-term training programs (Günaydın et al. 2002).

Although hockey is one of the three most popular branches in Olympic and 120 countries, there are limited studies on hockey players in our country. For this reason, it is thought that our research will close the gap in the field and will shed light on the studies to be done in this field. In addition, in hockey, where aerobic and anaerobic energy systems are used intensively, general and special strength development is very important in terms of high-level performance. Therefore, this study is important in terms of investigating the effects of special strength training programs on hockey players. This study is intended to investigate the effects of resistance training on the muscular strength and muscular endurance of elite female and male national team field hockey players.

MATERIAL & METHOD

Research Group

30 female and 30 male national hockey players aged between 17-28 years who have no health problems to exercise participated in the study voluntarily. The purpose and application processes of the study were explained to the participants in detail, verbally and practically. Selçuk University Faculty of Sport Sciences Non-Invasive Clinical Research Ethics Committee Decision was taken for this research.

Measurements Applied in Research

Determining Body Composition

The body weights and heights of the national team players participating in the research were measured with a TanitaSc 330 brand device. The body weight of the subjects (kg) was measured with an accuracy of 0.01 kg, and height (cm) was measured with an accuracy of 0.01 cm when they were in anatomical position, wearing sports clothes and bare feet (without shoes).

Measuring Muscular Strength

One Rep Maximum (1-RM) Strength Measurement

In the study, bench press, leg extension, leg curl and push down applications were performed with free weights and on the smith machine. Subjects warmed up with 5-10 repetitions at an estimated intensity of about 50% of 1-RM. After 1 min of rest, participants performed one repetition (~80% of estimated 1-RM). After each successful performance, the weight increased until an unsuccessful attempt. One-minute rests were given between each attempt, and 1-RM was reached in about 5 attempts (Seo et al. 2012).

Muscular Endurance Measurement Method

30 second push-up and 30 second sit-up tests were used to determine muscular endurance.

Strength Training Program

A strength training program with an intensity of 50-70% was applied to the participant group 3 days a week for 8 weeks. The intensity, number of repetitions, number of sets and frequency of exercises related to free weight exercises, core exercises and resistance band exercises of the program are shown in tables below.

Table 1. Free Weight Training

Free Weight Exercises	**Week 1-2**	**Week 3-4**	**Week 5-6**	**Week 7-8**
Bench Press	Intensity: % 50 Repetition: 12 Set: 1 Frequency: 3	Intensity: % 50 Repetition: 12 Set: 2 Frequency: 3	Intensity: % 60 Repetition: 12 Set: 2 Frequency: 3	Intensity: % 70 Repetition: 12 Set: 3 Frequency: 3
Lat Front Pull Down				
Shoulder Press Dumball				
Ower Head Squat				
Dumball Lunge				
Barbel Crul				
Push Down				
Barbel Silkme				

Table 2. Core Exercises

Core Exercises	**Week 1-2**	**Week 3-4**	**Week 5-6**	**Week 7-8**
Leg Raise	Intensity: % 50	Intensity: % 60	Intensity: % 70	Intensity: % 70
	Repetition: 12	Repetition: 15	Repetition: 20	Repetition: 20
	Set: 1	Set: 1	Set: 2	Set: 3
	Frequency: 3	Frequency: 3	Frequency: 3	Frequency: 3
Hundred	Intensity: % 50	Intensity: % 60	Intensity: % 70	Intensity: % 70
	Repetition: 50	Repetition: 75	Repetition: 90	Repetition: 100
	Set: 1	Set: 1	Set: 2	Set: 3
	Frequency: 3	Frequency: 3	Frequency: 3	Frequency: 3
Plank	Intensity: % 50	Intensity: % 60	Intensity: % 70	Intensity: % 70
	Duration: 30 sn	Duration: 40 sn	Duration: 50 sn	Duration: 60 sn
	Set: 1	Set: 1	Set: 2	Set: 3
	Frequency: 3	Frequency: 3	Frequency: 3	Frequency: 3

Table 3. Resistance Band Exercises

Resistance Band Exercises	Week 1-2	Week 3-4	Week 5-6	Week 7-8
Behind Neck Press Lat Pul Down Lateral Raise Front Raise Chest Fly Biceps Curl Triceps	Intensity: % 50 Repetition: 12 Set: 1 Frequency: 3	Intensity: % 50 Repetition: 15 Set: 2 Frequency: 3	Intensity: % 60 Repetition: 20 Set: 2 Frequency: 3	Intensity: % 70 Repetition: 20 Set: 3 Frequency: 3

Statistical analysis

The mean and standard error mean of all values obtained from the participants are given. To see the effect of training, t-test was applied to independent groups.

RESULTS

The mean age of the female and male participants, the mean age of the player, the mean height and body weight are given in the table.

Table 4. Distribution of physical feature parameters by gender

Variables	Gender	n	Mean	Standard Deviation
Age (year)	Female	30	20,03	3,56
	Male	30	20,97	3,24
Player Age (year)	Female	30	7,23	2,54
	Male	30	7,87	2,88
Height (cm)	Female	30	164,70	0,05
	Male	30	177,03	0,06
Weight (kg)	Female	30	56,23	5,42
	Male	30	72,80	13,12

Table 5. Comparison of pre-test and post-test values of male players' body composition variables.

Variables	Training	Mean	Standard Deviation	t	p
Weight (kg)	Pre test	72,80	13,12	0,647	0,00
	Post Test	72,50	12,20		
Body fat percentage (%)	Pre Test	12,58	4,65	2,922	0,00
	Post Test	12,20	3,88		
Body Mass Index	Pre Test	23,07	3,33	0,576	0,00
	Post Test	23,02	3,00		

$p<0,05$

It was determined that there was a statistically significant difference between the body weight, body fat percentage and body mass index pre-test and post-test values of male players ($p<0,05$).

Table 6. Comparison of pre-test and post-test values of male players regarding maximal strength measurements.

Variables	Training	Mean	Standard Deviation	t	p
Leg extansion	Pre test	91,29	11,18	-14,66	0,00
	Post test	102,42	13,53		
Bench press	Pre test	71,94	8,13	-9,61	0,00
	Post test	78,81	8,97		
Leg curl	Pre test	112,42	20,81	-9,81	0,00
	Post test	123,77	20,89		
Push down	Pre test	62,10	7,39	-10,49	0,00
	Post test	68,71	6,95		
p<0,05					

It is seen that there is a significant difference between the pre-test and post-test values of male players for leg extension, bench press, leg curl and push down movements (p<0.05).

Table 7. Comparison of pre test and post test values of male players for 30 sec push up and 30 sec sit up tests.

Variables	Training	Mean	Standard Deviation	t	p
30 sec push up	Pre test	25,68	7,42	-10,05	0,00
	Post test	30,06	6,38		
30 sec sit up	Pre test	24,87	3,03	-9,20	0,00
	Post test	27,55	2,55		
p<0,05					

After the 8-week strength training program for male hockey players, it was determined that there was a significant difference between the pre-test and post-test values in both the 30-second push-up and 30-second sit-up tests (p<0.05).

Table 8. Comparison of pre test and post test values of body composition variables of female players.

Variable	Training	Mean	Standard Deviation	t	p
Weight (kg)	Ön Test	56,23	5,42	2,648	0,00
	Son Test	55,99	4,92		
body fat percentage (%)	Ön Test	20,36	3,94	4,870	0,00
	Son Test	19,34	4,11		
Body Mass Index	Ön Test	21,20	2,01	2,630	0,00
	Son Test	21,04	1,98		
p<0,05					

It was determined that there was a statistically significant difference between the body weight, body fat percentage and body mass index pre-test and post-test values of female players (p<0,05).

Table 9. Comparison of pre-test and post-test values of female players regarding maximal strength measurements.

Variables	Training	Mean	Standard Deviation	t	p
Leg extansion	Pre test	49,13	8,74	-29,43	0,00
	Post test	60,43	8,72		
Bench press	Pre test	34,93	5,85	-15,58	0,00
	Post test	43,70	6,61		
Leg curl	Pre test	69,67	10,42	-16,09	0,00
	Post test	80,23	11,48		
Push down	Pre test	34,00	8,749	-18,94	0,00
	Post test	46,60	7,38		
p<0,05					

It is seen that there is a significant difference between the pre-test and post-test values of female players for leg extension, bench press, leg curl and push down movements (p<0.05).

Table 10. Comparison of pre test and post test values of female players for 30 sec push up and 30 sec sit up tests.

Variables	Training	Mean	Standard Deviation	t	p
30 sec push up	Ön test	17,27	5,79	-9,40	0,00
	Son test	23,73	5,53		
30 sec sit up	Ön test	24,40	3,64	-5,72	0,00
	Son test	26,77	3,30		

p<0,05

After the 8-week strength training program for female hockey players, it was determined that there was a significant difference between the pre-test and post-test values in both the 30-second push-up and 30-second sit-up tests ($p<0.05$).

DISCUSSION

The aim of this study is to investigate the effect of resistance training applied for eight weeks on the muscular strength and muscular endurance of elite level female and male national team field hockey players. As a result of the research, resistance training significantly increased the muscular strength and muscular endurance of both male and female players.

Body composition has a significant impact on combined specific tests that can help sports scientists and conditioners adjust training programs better and optimize the performance of elite hockey players (Chiarlitti et al. 2018). In a study in which professional hockey players were followed for a long time, it was reported that when compared to players in the 1920s and 1930s, the current players have increased 17 kg in body weight, 10 cm in height, and 2.3 kg/m2 in their average body mass index. Researchers have reported that this increase in body mass index is not due to increased fat mass, because body fat percentage has remained unchanged over the past 22 years (Montgomery 2006). In a study in which hockey players were evaluated according to their positions, it was stated that defenders were taller and heavier, strikers were younger, and goalkeepers were shorter with less body mass and higher skinfold thickness (Quinney et al. 2008). Similarly, Vescovi et al (2006) found that while defenders are heavier and taller than goalkeepers and strikers, goalkeepers have a higher body fat percentage than strikers. Another study found no significant differences between defensive and forward hockey players in anthropometric or body composition measurements. Triplett et al (2018), on the other hand, found that ice hockey defenders were taller than strikers, and there was no significant difference in body fat percentage and body weights in terms of positions.

In the research conducted on the ice hockey players of the university school team, the average body fat percentage was 9.3% and the total skinfold was 57.7 mm (Brayne 1985). It was reported that the body fat percentage of hockey players who competed in the National Hockey League between 1980-1991 was between 10.7% and 14% (Cox et al. 1995). In several studies on elite male junior and adult ice hockey players, body fat percentages ranged from 8.6% to 16.1% (Green et al. 2006, Burr et al. 2008, Peyer et al. 2011, Runner et al. 2016, Chiarlitti et al. 2018). In a study examining the relationships between laboratory tests and skating performance on skating on ice in men's ice hockey players, the body fat percentage of hockey players was found to be 12%, and it was concluded that skating times were moderately associated with body fat percentages, and thus higher body fat percentage was related to slower skating speed (Potteiger 2010). Body fat percentages of elite female field hockey players were reported to be between 16% and 26% (Reilly and Borrie 1992). In our current study, body fat percentages of elite field hockey players were determined as 12.2% for men and 19.3% for women, and it was concluded that these values were similar to most of elite field hockey players in other studies. In addition, resistance exercises decreased body weight, body mass index and body fat percentage values in both genders. The differences in body fat percentages of hockey players can be explained by the size of the sample, age, nationality, etc., or it can be said that it may result from the differences in playing style.

Muscular strength and muscular endurance have important functions in hockey (Cox and ark 1995). High levels of lean tissue mass were reported to support the performance of men's hockey players, particularly in tests measuring the strength and power. The relationship between lean tissue mass and various combined physical fitness tests demonstrates the importance of developing and maintaining lean tissue mass in

providing improvements in muscular strength and power, which are critical components for optimum performance on ice (Chiarlitti et al. 2018). In a study evaluating the performance of elite ice hockey players in terms of positions, it was found that goalkeepers had lower upper body strength and anaerobic capacity than strikers and defenders (Vescovi et al. 2006). Toong et al (2018) found that the grip strength of young ice hockey players is higher than Canadian pediatric norms, grip strength increases with age in both genders, and boys and girls perform similarly until the age of 12, and boys, after this age, have more grip strength values than girls. In a different study investigating the effects of training applied for twelve weeks (5 days a week, 4 hours a day) on some parameters of field hockey players of different age groups after the training program, while significant increases were observed in lean body mass, grip strength and back strength of players especially under 16, 19 and 23 years old, significant decreases were found in body fat. When compared according to age groups, field hockey players under the age of 23 and in the senior category were reported to have higher lean body mass and strength, and lower body fat than players under the age of 16 and 19. In addition, the researchers stated that the unique profiles of age-related changes should be taken into account when training players, and this provides an opportunity for coaches to evaluate a player's current status and degree of training compliance and modify the training program accordingly to achieve the desired performance (Manna et al. 2011). Cordingley et al. (2019) followed the physical and physiological development of male young hockey players for 3 consecutive years, and at the end of the study, while height and body mass increased each year, there was no change in body fat percentage. In addition, pull-ups, long jump and grip strength improved with age, however, push-up performance increased only between 13 and 14 years of age, while maximum plank time decreased between 14 and 15 years of age. In a different study in which professional hockey players were followed for a long time, upper body strength was evaluated using a bench press test and the maximum 1 rep (1 RM) value for the 17-19 age group was determined as 107.0 kg, and for the 25-29 age group it was 128.1 kg. These gains in body mass were associated with increases in upper body strength (Montgomery 2006). Behm et al. (2005) measured the 1 RM leg press values of ice hockey players aged 16-25 (age 5-13 years in sports) as 133.9 kg. The researchers found low correlations between leg strength and skid speed and they emphasized the need for players to train to perform high-intensity contractions under relatively unstable conditions. Johansson et al. (1989), on the other hand, in their study investigating the quadriceps isokinetic muscle performance in elite ice hockey players, suggested individual programs for leg muscle training in ice hockey players due to large differences in individual muscle performance and different responses to similar training.

The results show that good body structure is important for women's skating performance in ice hockey. To improve women's skating performance in ice hockey, players need to increase quadriceps muscle strength, oxygen uptake and related muscle mass. Differences in body composition between men and women, when these values are given relative to lean body mass, result in large differences on ice, despite similar oxygen uptake and quadriceps muscular strength. This also suggests that there should be differences in training arrangement for men and women, as women are more dependent on quadriceps muscular strength for ice skating performance relative to body weight (Gilenstam et al. 2011).

Similar results were obtained in studies conducted on non-athletes. Gürbüz (2013) reported that 6-week maximal strength training resulted in significant increases in 1 RM bench press, shoulder press, biceps curl, squat, biceps in flexion and biceps values in extension. In a different study in which a weight training program was applied for eight weeks, four days a week, for two hours a day, a statistical increase was found in bench press, squat, arm curl, deadlift and shoulder press movements compared to the weights lifted at the beginning of the work out (Büyükipekçi 2015). Chilibeck et al (1998) reported significant increases in bench press and arm curl exercises at the end of 20 weeks in their study to determine the effect of resistance training applied to young women on strength and muscle mass. There are many studies examining the relationship between resistance training and performance in different sports branches. In our current study, at the end of the eight-week resistance exercise program, the 1RM values of both female and male field hockey players in bench press, leg extension, leg curl and push down applications, and the 30-second push-up and 30-second sit-up values, which are indicators of muscular endurance, increased significantly. Barjaste and Mirzaei (2018) examined the effect of resistance training on football players. The results of the study showed that muscular strength and explosive performance in players with little experience in resistance training can be significantly improved upon completion of the general phase of resistance training periodization using moderate loads. McKinlay et

al. (2018) stated that eight-week free weight resistance training and plyometric training provided significant improvements in muscular strength and jump performance in elite young football players, and both methods resulted in similar muscle hypertrophy. Similarly, the performance improved in both the hip thrust exercise group and the squat exercise group after seven weeks of resistance training in young female football players (González et al. 2019). At the end of the whole body and regional body training program (twenty weeks, two days a week, at 75-90% intensity, 6-12 repetitions) in female players, while there was a significant difference in maximal strength bench press, lat pulldown, arm curl, triceps extension, leg extension and leg curl exercises, no difference was observed between the groups (Calder et al. 1994). Barbalho et al. (2020) compared the effects of twelve weeks of squat and hip thrust exercises on muscle strength and hypertrophy in well-trained women. Researchers found that training increased hip extensor muscle size and 1RM hip thrust values in both groups. They also stated that the increase in quadriceps femoris and gluteus maximus muscle size and in 1RM squat values was higher in the squat group than in the hip thrust group.

Our study has some limitations. First, the training program is limited to eight weeks. Second, the tests were determined by the field method only.

As a result, it can be said that the resistance exercise program applied for eight weeks positively affects the maximum muscular strength and muscular endurance of both female and male field hockey players.

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