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Effects of a Strength Training Program on Basic Basketball Skills in Wheelchair Basketball Players

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Abstract

The aim of this study is to investigate the effects of an upper extremity strength training program on basic basketball skills in wheelchair basketball players. The study consisted of a total of 27 wheelchair basketball players (15 in the training group and 12 in the control group). The basic basketball skills were assessed at the beginning and end of the training program with a slalom test, slalom with ball test, layup test, zone shot test, two-point shot test, and pass for accuracy test. The warm-up part of the strength training included the use of wheelchair and passing exercises with a basketball. The special strength program was applied to the training group three times a week for eight weeks. The control group continued with the routine education program. While there was a statistically significant difference in the slalom, slalom with ball, zone shot, and four-meter and eight-meter pass for accuracy tests in the training group ($p<0.05$), there was no significant difference in terms of layup and two-point shot tests ($p>0.05$). There was no difference in the basic basketball skills test of the control group ($p>0.05$). At the conclusion this research, it was determined that the upper extremity strength training program planned for wheelchair basketball players for eight weeks positively affected their basic basketball skills. It may be recommended to include this program in the warm-up session of the training program in order to improve sportive performance.

Keywords: Wheelchair Basketball, Disability, Antrenman, Upper Extremity, Basketball Skill Test

Tekerlekli Sandalye Basketbol Oyuncularında Kuvvet Antrenman Programının Temel Basketbol Becerileri Üzerine Etkileri

Öz

Bu çalışmanın amacı, üst ekstremite kuvvet antrenman programının tekerlekli sandalye basketbol oyuncularının temel basketbol becerileri üzerindeki etkilerini araştırmaktır. Çalışmaya toplam 27 tekerlekli sandalye basketbol oyuncusu (antrenman grubunda 15 ve kontrol grubunda 12 kişi) katıldı. Temel basketbol becerileri antrenman programının başında ve sonunda slalom testi, topla slalom testi, turnike testi, alan atış testi, iki sayılık şut isabet testi ve isabetli pas testi ile değerlendirildi. Kuvvet antrenmanının ısınma bölümünde tekerlekli sandalye kullanımı ve basketbol topuyla pas çalışmaları yer aldı. Özel kuvvet programı eğitim grubuna sekiz hafta boyunca haftada üç kez uygulandı. Kontrol grubu olağan eğitim programına devam ettirildi. Eğitim grubunda slalom, topla slalom, alan atışı, dört metre ve sekiz metre isabetli pas testlerinde istatistiksel olarak anlamlı bir fark varken ($p<0.05$), turnike ve iki sayılık şut isabet testleri açısından anlamlı bir fark yoktu ($p>0.05$). Kontrol grubunun temel basketbol becerileri testinde ise fark olmadığı tespit edildi ($p>0.05$). Bu araştırma sonucunda, tekerlekli sandalye basketbol oyuncularına sekiz hafta boyunca uygulanan üst ekstremite kuvvet antrenman programının temel basketbol becerilerini olumlu yönde etkilediği belirlendi. Sportif performansı artırmak için bu programın antrenman programının ısınma seansına dahil edilmesi önerilebilir.

Anahtar Kelimeler: Tekerlekli Sandalye Basketbolu, Engellilik, Antrenman, Üst Ekstremite, Basketbol Beceri Testi

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Introduction

Wheelchair basketball (WB) has become one of the most popular sports for individuals with disabilities in recent years (Soylu et al., 2021; Yüksel & Sevindi, 2018). It has been a part of the Paralympic Games since the 1960's (Hollander et al., 2020), and the use of sport-specific wheelchair and ball handling forms the basis of the game (Marszałek et al., 2019; Soylu et al., 2021). Since it is a high-intensity intermittent/interval sport, athletes need to have physical skills, such as speed, agility, strength, power, and endurance, and technical skills, such as pushing, turning, hitting, dribbling, throwing, passing, and catching the ball (Ferreira da Silva et al., 2022).

WB players, as in the other wheelchair sports, have to use their arms above their heads very often during games. Also, wheelchair users have shoulder problems due to repetitive movements such as quick wheel spinning and reaching overhead combined with poor shoulder mechanics and overuse. Apart from these repetitive movements in sports, the increase in the load on the upper extremity with the use of wheelchair in daily life may cause the risk to increase even more (Wilroy & Hibberd, 2018). In addition to athletes using wheelchair, amputee athletes who use crutches experience the same problems in different ways. Crutches transmit forces to the wrists and shoulders and can cause injury to the user (Aytar et al., 2015). Shoulder strengthening programs that provide muscle strength balance are important in wheelchair athletes to both reduce the risk of possible injury and improve sportive performance (Soo Hoo, 2019). The strength programs focusing on adductors, external rotators, and scapular retractors are recommended to keep shoulder muscles well-balanced in wheelchair athletes (García-Gómez et al., 2019). Strength training in WB players is likely to improve sports performance in addition to preventing sports injuries (Ozmen et al., 2014).

Parameters, such as upper extremity muscle strength, endurance, and speed in WB players are very vital both in performing sports-specific activities (shooting, passing, rebounding) and in controlling the wheelchair (Cömert et al., 2010; Soylu et al., 2021). In WB, the direct effects of upper extremity muscle strength on chair usage skills, such as pushing, accelerating, decelerating, or changing direction, are also reflected in sportive performance (Romarate et al., 2021). Various studies have emphasized the need to increase upper extremity muscle strength in wheelchair players due to its relationship with WB performance (Akınoğlu & Kocahan, 2017; Romarate et al., 2021; Turbanski & Schmidtbleicher, 2010). We consider that exercise

programs that will increase upper extremity muscle strength and endurance are critical to increase athletic performance in WB players.

Sportive skill tests are frequently used for determining regular training strategies to improve the performance of athletes and to evaluate these skills. They are also important in terms of making quick tactical decisions during matches (Ferreira da Silva et al., 2022). In WB, tests such as slalom, layup, accurate shot - pass are common both in training and for evaluation purposes. Although there are some studies in the literature on the investigation of the effectiveness of strength training in WB players, no research into the effect of upper extremity-specific strength training on basketball skills in WB players has been found. Therefore, this study was conducted to investigate the effect of an eight-week strength training program on basic basketball skills in WB players.

Methods

Participants

The study was carried out in TAF Rehabilitation Center Sports Facilities and Keçiören Taha Akgül Sports Facilities. Licensed athletes classified and have been playing basketball for at least two years in WB leagues within the body of the Turkish Physically Handicapped Sports Federation were included in the study. In addition, participants were required to have used wheelchair for at least one year and at least one year of competitive experience.

The additional criterion for athletes (amputee, poliomyelitis…) who did not constantly use wheelchair in their daily lives but used prostheses and canes included using wheelchair for WB training at least 6 hours a week (García-Gómez et al., 2022). Those who had pain in their shoulder in the last 6 weeks, had a shoulder injury or history of surgery in the upper extremity, playing WB players for less than two years, and did not agree to participate in the study were not included. A total of 33 athletes who met the inclusion criteria were contacted. The study was initiated with 30 individuals who agreed to participate. Since the athletes had to train in their clubs after the first evaluation, they were divided into the training group (n=15) and control group (n=15) non-randomly. Three individuals from the control group quit for various reasons; therefore, the study was completed with 15 athletes in the training group and 12 athletes in the control group. The flow chart of the study is shown in Figure 1.

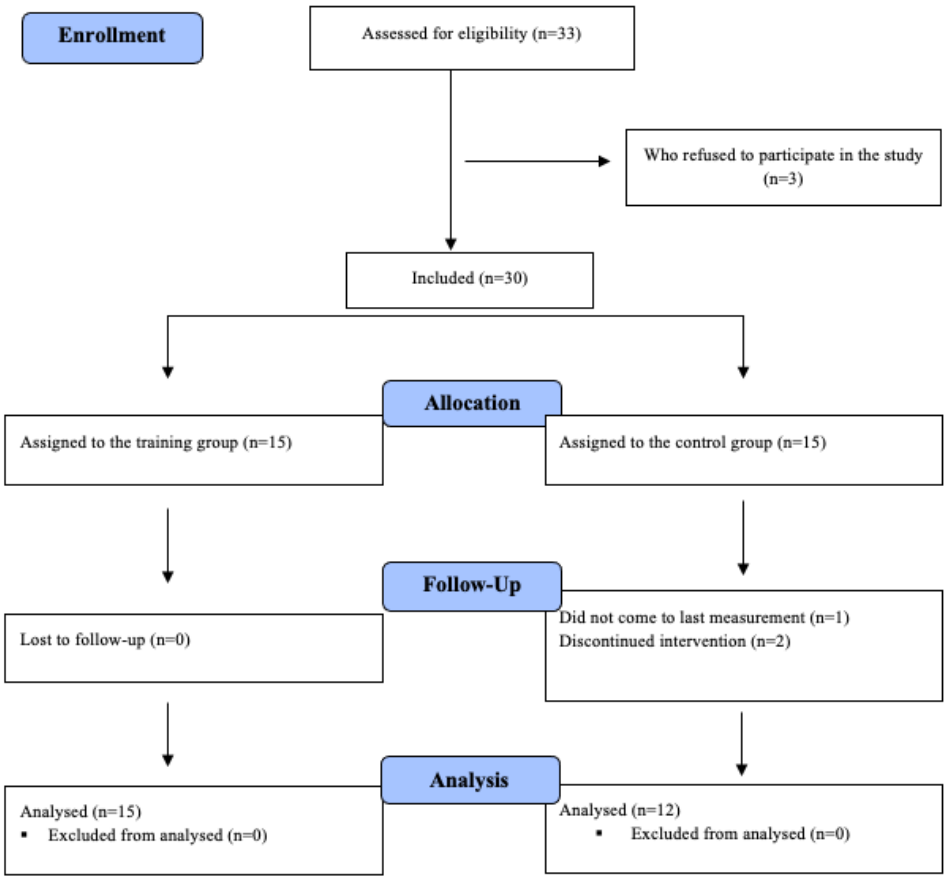


Figure 1: Flow chart of study

Procedures

Basic basketball skill tests were applied to WB players before and after the eight-week special strength training program. The strength training program was implemented under the supervision of WB players just before the training. Measurements were made before starting and end of the training. Approval of Gazi University Ethics Committee (Number: E-77082166-302.08.01-351945, Date: 19.04.2022) was obtained. WB players were informed about the study, and then they signed an "informed voluntary consent form for participants," which meant that they agreed to participate in the study. Before the assessment was initiated, the athletes' age, body weight, height, body mass index (BMI), dominant side, classification score, disability, experience in sports, and the aids they used in their daily life were questioned. The dominant side was determined by asking the athletes which arm they usually use or prefer to throw the ball (Kara et al., 2024).

Outcome Measures

Basketball skill tests included; a slalom test, slalom with ball test, layup test, zone shot test, two-point shot test, and pass for accuracy test. The tests were applied following the usual warm-up activities of the team, consisted of low to moderate-intensity wheelchair propulsion, acceleration and agility drills, shot, passing, and stretching exercises, which were done with and without a ball. Each athlete used their own wheelchair during the tests and was given two minutes of rest between tests.

Slalom test: This test was conducted to measure wheelchair usage skills, five cones were placed on the field, starting 1.5 meters from the starting line, each 1.5 meters apart. Athletes were positioned at the starting line, with the front bar of the wheelchair behind the line. Then, they were asked to move as fast as possible first straight then slalom between these cones, and to return from the last cone and slalom in the same way and complete the course by crossing the starting line. The completion times of the test were recorded in seconds (Molik et al., 2010; Soylu et al., 2021; Yüksel & Sevindi, 2018).

Slalom with ball test*:* This test was conducted to evaluate the athletes' wheelchair use and dribbling skills. Cones were placed as in the slalom test. Athletes were asked to slalom dribble following the rules set by the International Wheelchair Basketball Federation. The completion times of the test were recorded in seconds (Molik et al., 2010; Yüksel & Sevindi, 2018).

Layup Test*:* This test was conducted to evaluate the layup skills of the athletes, two cones were placed on the projections of the free throw line on the three-point line. With the start signal, the athletes were asked to perform a layup from the side of the first cone, get their own rebounds, and then go around the cone on the other side and perform the layup again. After getting the rebound, the athletes were asked to turn from the inside of the cone and perform the layup again. At the end of two minutes, the accurate shots were assigned two points and the missed shots one point, and the total score was recorded (Ergun et al., 2008).

Zone Shot Test*:* This test was conducted to assess the athletes shooting skills. They were asked to start shooting at the free-throw line following a start signal. At the end of the two minutes, accurate shots were assigned two points, the misses were assigned one point, and the total score was recorded (Yüksel & Sevindi, 2018).

Two-point Shot Test*:* This test was implemented to measure the athletes' two-point shooting performance, cones were placed in five regions at a distance of five meters

from the projection of the center of the hook to the floor. The athletes were asked to shoot from five regions beginning from the right bottom line following a start signal. At the end of 60 seconds, accurate shots were assigned two points, the misses were assigned one point, and the total score was recorded (Pojskić et al., 2011).

Pass For Accuracy Test*:* This test was conducted to assess the athletes' skills to pass the ball from different distances accurately. To do this, a 30x30 square with a center height of 120 cm from the ground was drawn on the wall, and the athletes were asked to pass the ball from 4 and 8 meters distances, respectively. For two minutes, the accurate passes by the athletes from a distance of 8meters were assigned two points, and the accurate passes from a distance of 4 meters were assigned one point, and the total score was recorded. During the test, the athletes were informed that they could use a chest pass, overhead pass, or throw the ball with one hand but that bounce pass was not alllowed (Ergun et al., 2008; Yüksel & Sevindi, 2018).

Training Program

A special training program involving exercises appropriate for WB players was created by choosing among those that are included in the FIFA 11+ Shoulder and Thrower's Ten Exercise Programs, have international validity in the literature, strengthen the shoulder girdle muscles, and also have an effect on preventing shoulder injuries. The exercises were applied in the warm-up part of the training and lasted approximately 20-25 minutes. In the first part warm-up session of this two-part program, the athletes exercised the use of wheelchair (forward, backward, change of direction, stop) and basketball passing drills. The second part included exercises to improve the strength and balance of the muscles around the shoulder, elbow, wrist, and scapula by using a resistance band (theraband) and a medicine ball (Figure 2).

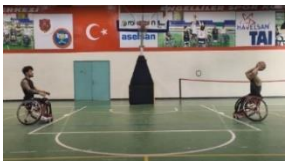
The special strength training was applied to the training group as a single set with 12 repetitions three times a week for eight weeks. A 30-second resting time was given between sets. For the first four weeks, the program was implemented using a green-color theraband (light-medium, strength-elongation relationship: 2.3 kg) and a two-kg medicine ball. In the second four weeks, theraband resistance was increased. Accordingly, a blue-color theraband (medium, strength-elongation relationship: 3.2 kg) was used, and the weight of the medicine ball was increased to 2.5 kg. All of this special strength training was carried out in the gym where the athletes trained and on the wheelchair they used in competitions. After the warm-up session of the training program was implemented, the team continued with the normal training.

Part I – Warm-up exercises

1- Wheelchair movements: forward and backward driving, changing direction, stopping, sprinting, jog. (5 min.)

2- Chest pass (1 min.)

3- Overhead Pass (1 min.)



Part 2- Shoulder, Elbow, Arm, Wrist Exercises with Theraband and Medicine Ball

1- Shoulder Abduction

2- Overhead Band Pull

3- Shoulder External Rotation

4- Shoulder Internal Rotation

5- External Rotation at 90° Abduction

6- Internal Rotation at 90°Abduction

7 – Shoulder Flexion

8- Scaption

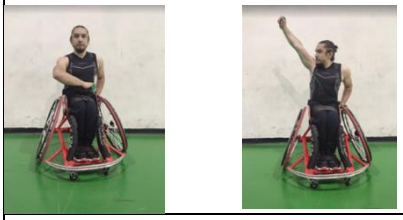
9- Biceps Curl

10- Triceps Extension

11- Wrist Curl

12- Wrist Extension

13- Diagonal Pattern Forward Flexion



14- Overhead Pass with Medicine Ball

15- Chest Pass with Medicine Ball

Figure 2: The training program

Statistical analysis

Statistical analyses of the study were performed on the Statistical Package for Social Sciences (SPSS) software version 21 (SPSS Inc. Chicago, IL, USA). The normal distribution of the variables was determined by histograms, probability charts, and the Shapiro-Wilk test, and descriptive statistics were expressed as median and interquartile range (IQR) values due to non-normal distribution. The difference between the groups in terms of categorical variables was compared by using Chi-Square or Fisher's tests. Mann-Whitney U Test was used to make an intergroup comparison of baseline values. Wilcoxon test was implemented to make an intragroup comparison of baseline values and the values obtained after eight weeks. The significance level for all analyses was determined as $p<0.05$. Effect sizes were analyzed using Cohen's d standards. The effect size results were interpreted as small (≥0.2), medium (≥0.5), or large (≥0.8) according to the guidelines (Cohen, 2013).

Results

The study was completed with 15 training groups and 12 control groups. The post hoc power analysis of the study was calculated using G*Power 3.1.9.6 programme. As a result of the calculation performed using the research data with a total sample size of 27, the effect size value of the research was found to be 0.60. With a 5% error rate (a = 0.05), the power of the study (1- β) was calculated as 0.99. There was no statistically significant difference between the groups in terms of age, height, body weight, BMI, duration of engagement in sports and dominance ($p>0.05$, Table 1). The two groups showed similar characteristics in terms of these parameters.

Table 1: The participants's demographic information

		Training Group (n=15)	Control Group (n=12)	p
		Mean ± SD	**Mean ± SD**	
Age (year)		34 ± 10.8	37.5 ± 9.78	0.562
Body Mass (kg)		70,93 ± 14.49	73.33 ± 18.46	0.337
Height (cm)		175.2 ± 9.17	177.17 ± 9.7	0.583
BMI (kg/m^2)		22.88 ± 3.08	23.11 ± 3.77	0.373
Experience in Sport (year)		12.53 ± 8.57	15.17 ± 7.36	0.408
		(n (%))	**(n (%))**	
Dominance	**Right**	14 (%93.3)	12 (%100)	0.362
	Left	1 (%6.7)	0 (%0)	

BMI: Body Mass Index, n: Number, SD: Standard Deviation

The descriptive characteristics of the participants in the groups, such as classification score, disability, and aids they used to mobilize in daily life, are given in Table 2. There was no statistical difference between the groups in terms of classification point (p = 0.516), disability type (p = 0.136) and device used in daily life (p = 0.072). The groups showed similar distribution in terms of these parameters.

Table 2: Descriptive features of the participants

		Training Group (n=15) (n (%))	Control Group (n=12) (n (%))
Classification Point	**1**	5 (%33.3)	2 (%16.6)
	1.5	2 (%13.3)	3 (%25)
	2	1 (%6.6)	3 (%25)
	2.5	1 (%6.6)	1 (%8.3)
	3	2 (%13.3)	0 (%0)
	3.5	0 (%0)	0 (%0)
	4	3 (%20)	3 (%25)
	4.5	1 (%6.66)	0 (%0)
Disability	**Polyomyelitis**	1 (%6.7)	3 (%25)
	Amputation	4 (%26.7)	2 (%16.7)
	Spinal Cord Injury	10 (%66.7)	5 (%41.6)
	Spina Bifida	0 (%0)	2 (%16.7)
Device used in Daily Life	**(N/A)**	2 (%13.3)	0 (%0)
	Prosthesis	3 (%20)	2 (%16.7)
	Canedian	0 (%0)	4 (%33.3)
	Wheel Chair	10 (%66.7)	6 (%50)

The intergroup comparison of baseline values indicated that the values of the two groups were similar in all tests (p>0.05, Table 3). When the intragroup results of the training group were examined, a statistically significant difference was found in the slalom, slalom with ball, shot, and four and eight-meter pass for accuracy tests (p<0.05, Table 3). After eight weeks of training, the duration of the slalom and slalom with ball scores of the training group decreased, and the shot test and four and eight-meter pass for accuracy test scores increased. No statistically significant difference was found in the layup and two-point shot tests (p>0.05, Table 3). When the pretest-posttest scores of the control group were compared, it was observed that there was no difference in any of the tests (p>0.05, Table 3).

Table 3: Comparison of basketball basic tests within and between groups

		Pre-test Median (IQR)	p (between groups)	post-test median (IQR)	Change Median (IQR)	p (within group)	Effect size
Slalom Test	**Training Group**	12.06 (10.81 / 12.66)	0.510	11.51 (10.32 / 11.88)	-0.59 (-0.7 / -0.4)	**0.001***	1.92
	Control Group	12.01 (11.66 / 12.47)		11.89 (11.81 / 12.16)	-0.16 (-0.46 / 0.54)	0.937	0.05
Slalom with Ball Test	**Training Group**	13.3 (11.61 / 14.06)	0.164	12.54 (11.26 / 13.21)	-0.65 (-0.8 / -0.11)	**0.003***	1.14
	Control Group	13.79 (13.41 / 13.97)		13.74 (13.59 / 14.05)	-0.11 (-0.36 / 0.6)	0.875	0.07
Layup Test	**Training Group**	23 (20 / 26)	0.270	24 (20 / 26)	0 (-2 / 3)	0.231	0.26
	Control Group	22 (19.5 / 24)		21 (18 / 22.5)	-2 (-2.5 / 0)	0.122	0.46
Zone Shot Test	**Training Group**	52 (46 / 60)	0.406	59 (48 / 62)	5 (0 / 7)	**0.047***	0.62
	Control Group	46.5 (41.5 / 54.5)		48.5 (43.5 / 54)	2 (-4 / 6.5)	0.555	0.16
Two-point Shot Test	**Training Group**	16 (13 / 18)	0.403	17 (15 / 19)	1 (-1 / 3)	0.078	0.48
	Control Group	14.5 (12.5 / 17)		14 (13 / 16)	-1 (-2 / 1)	0.318	0.31
4 m Pass For Accuracy Test	**Training Group**	40 (26 / 46)	0.241	46 (40 / 57)	8 (6 / 12)	**0.001***	1.56
	Control Group	42.5 (33 / 49)		43 (33.5 / 47)	-3.5 (-6 / 4.5)	0.529	0.18
8 m Pass For Accuracy Test	**Training Group**	18 (14 / 22)	0.238	24 (12 / 30)	6 (-2 / 8)	**0.015***	0.73
	Control Group	14 (8 / 20)		12 (8 / 17)	0 (-5 / 4)	0.635	0.23

IQR: Intequartiile Range. *$p < 0.05$ between two groups for baseline values (Mann Whitney U Test) and within the group after 8 weeks (Wilcoxon test)

Discussion

This study was carried out to determine whether the special strength training program had an effect on basic basketball skills in WB players. A review of the literature has shown that there are no studies on the investigation of the effect of strength training on basic basketball skills in WB players. It was found that the eight-week upper extremity-specific strength training program provided improvement in wheelchair use, dribbling, shooting skills, and pass accuracy values.

There are some studies on the investigation of the effect of strength training programs created for WB players on different parameters. For example, Özmen et al., who investigated the effect of an explosive strength program on speed and agility in WB players, implemented a program in addition to the routine program for WB players. It was stated that speed and agility performance increased significantly at the end of the training (Ozmen et al., 2014). In a study with WB and wheelchair rugby players, Turbanski and Schmidtbleicher stated that an eight-week weightlifting resistance training program showed improvement in the strength and power parameters of the athletes (Turbanski & Schmidtbleicher, 2010). There are also studies in the literature on the investigation of the effectiveness of shoulder injury prevention programs on strengthening the shoulder and shoulder girdle muscles in WB players (García-Gómez et al., 2022; García-Gómez et al., 2019; García-Gómez et al., 2017; Wilroy & Hibberd, 2018). For example, Wilroy and Hibberd applied a five-minute injury prevention program that included shoulder stretching and strengthening exercises with therapeutic bands to WB players. As a result, they found that there was an improvement in the external rotation and internal rotation range of motion of the dominant side, but that there was no improvement in the strength of the shoulder external rotator, internal rotator, and scapular retractor muscles (Wilroy & Hibberd, 2018). As a result of the shoulder home-based exercises (SHBE) program applied to WB players, which was intended to provide active mobility of the shoulder joint and included strengthening and stretching exercises, it was determined that there was a statistically insignificant decrease in shoulder pain but that there was no difference in other shoulder ranges of motion except the decrease in extension range of motion (García-Gómez et al., 2019). In another study in which the SHBE program was applied to WB players, it was reported that while shoulder pain decreased, no improvement was observed in shoulder range of motion and impingement special tests (García-

Gómez et al., 2022). Pérez-Tejero and Garcia-Gomez stated that the SHBE program was useful for protecting shoulder health in WB players preparing for competitions (Pérez-Tejero & García-Gómez, 2020). There are studies on the investigation of the effectiveness of the strength training program in the other wheelchair branches and manual wheelchair users, except for WB players. For example, Pereira et al. found that the strength training program applied to wheelchair handball players with elastic bands resulted in significant improvements in strength, speed, and aerobic endurance (Pereira et al., 2017). In a study that included individuals who used manual wheelchair and had paraplegia due to spinal cord injury, it was revealed that exercises performed with theraband to improve upper extremity strength were superior to mat exercises in terms of 15-meter sprint test and wheelchair propulsion speed tests (Satyavanshi et al., 2017). Although there are studies investigating the effectiveness of strength training programs on various parameters in the literature, there is no study on the effect of the strength training program specially created for WB players on basic basketball skills. It has been stated in previous studies that improving wheelchair skills, such as wheeling around, transferring, and popping wheelies, will increase mobility and performance in athletes (Phang et al., 2012; Wilroy & Hibberd, 2018). In our study, we investigated the effect of a special strength training program, which was created by selecting exercises suitable for WB players from FIFA 11+ Shoulder and Thrower's Ten Exercise programs, which are frequently used in shoulder injury prevention programs, on basic basketball skills. According to the results of our study, it was determined that this eight-week strength training program developed basic basketball skills, such as slalom, slalom with ball, shooting, and four and eight-meter pass accuracy. Although there are no specific exercises for the body in the strength training program, we consider that especially the diagonal exercises with theraband and the pass exercises with the medicine ball may have increased the body control. In other words, the exercises applied in the study may have improved both upper extremity strength and body control and positively affected basic basketball skills. In case where wheelchair use, dribbling, and shooting skills needed to be improved, coaches and physiotherapists can add specially created strength exercises for the upper extremity to their training programs.

This research has several limitations. For instance, it included only male WB players, and only basic basketball skills were evaluated. The range of motion and strength of upper extremity muscles could not be evaluated. In addition, the study was

non-randomized since it was possible to have the separate team players do the strength training. However, we consider that the homogeneity of the groups in terms of demographic characteristics and the duration of engagement in sports, and the availability of routine training programs with very similar durations and content reduced the disadvantage of non-randomization. Future studies are needed to evaluate the effect of such exercise programs on parameters such as injury prevention, shoulder range of motion and strength in WB.

Conclusion

The aim of this study is to investigate the effects of an upper extremity strength training program on basic basketball skills in WB players. In conclusion, it was determined that the special strength training program applied for eight weeks in WB players improved the basic basketball skills of slalom, slalom with ball, shooting performance, and four and eight-meter pass accuracy. We think that the data we obtained in this study are important in terms of showing that the addition of upper extremity strengthening exercises to the routine exercises performed in warm-up programs will be beneficial and increase their sportive performance. It is recommended for coaches and trainers to include upper extremity strengthening exercises as an addition to routine warm-up programs to increase basic basketball skills in WB players.

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