INVESTIGATING THE RELATIONSHIP BETWEEN SOME PERFORMANCE PARAMETERS AND ONE REPETITION MAXIMAL STRENGTH IN TRAINED ATHLETES[2]

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ABSTRACT

The purpose of this study was to investigate the relationship between some performance parameters and one repetition maximal strength in trained athletes. In accordance with this purpose, thirty four amateur athletes competed in football, volleyball, wrestling and kickboxing sport branches (age: 22,0 ± 3,03 years; height: 179,2 ± 0,06 cm; weight: 75,2 ± 8,9 kg; training experince: 9,0 ± 2,82 years) have participated voluntarily in this study. Repeated sprint test, agility test, standing long jump test, vertical jump test and one repetition maximal (1RM) tests were applied to subjects. To assessment of data, descriptive statistics and Pearson Correlation analysis methods were used to determine whether there was a relationship between some performance parameters and 1RM strength values in full back squat (SQ) exercise. According to the analysis results, it was obtained that there wasn't statistically significant relationship between standing long jump (r = ,157) and agility (r = - ,207) performances with 1RM strength values in full back SQ exercise of research group (p > 0,05). On the other hand, there was a positive, statistically significant relationship (p < 0,05) between 1RM strength value in full back SQ and vertical jump performance (r = ,415). Accordingly, the more 1RM strength increases the more vertical jump distance increases in vertical jump test. In addition there weren't any statistically significant (p > 0,05) relationships between 1RM strength values with total test duration (r = ,038) and fatigue index (r = ,142) in repeated sprint test.

Keywords: Strength, Jump, Repeated Sprint, Agility, Performance

ANTRENMANLI SPORCULARDA BİR TEKRARLI MAKSİMAL KUVVET VE BAZI PERFORMANS PARAMETRELERİ ARASINDAKİ İLİŞKİNİN ARAŞTIRILMASI

ÖZ

Bu çalışmanın amacı, antrenmanlı sporcularda bir tekrarlı maksimal kuvvet ve bazı performans parametreleri arasındaki ilişkinin araştırılmasıdır. Bu amaç doğrultusunda; futbol, voleybol, bilek güreşi ve kickboks spor branşlarında mücadele eden 34 amatör sporcu (yaş: 22,0 ± 3,03 yıl; boy: 179,2 ± 0,06 cm; kilo: 75,2 ± 8,9 kg; antrenman yılı: 9,0 ± 2,82 yıl) çalışmaya gönüllü olarak katıldı. Deneklere tekrarlı sprint testi, çeviklik testi, durarak uzun atlama testi, dikey sıçrama testi ve bir tekrarlı maksimal (1TM) kuvvet testi uygulandı. Verilerin değerlendirilmesinde tanımlayıcı istatistik ve tam squat (SQ) hareketindeki 1TM kuvvet ile bazı performans parametreleri arasında ilişki olup olmadığının belirlenmesi için Pearson korelasyon analiz yöntemi kullanıldı. Analiz sonuçlarına göre; araştırma grubunun tam SQ hareketindeki 1TM kuvvet değeri ile çeviklik (r = - ,207) ve durarak uzun atlama (r = ,157) performansları arasında istatistiksel olarak anlamlı bir ilişkinin olmadığı elde edilmiştir (p > 0,05). Buna karşılık tam SQ hareketindeki 1TM kuvvet değeri ve dikey sıçrama performansı (r = ,415) arasında pozitif ve istatistiksel olarak anlamlı bir ilişki elde edilmiştir (p < 0,05). Buna göre 1TM kuvvet değeri arttıkça, sporcuların dikey sıçrama testindeki sıçrama mesafeleri de artmaktadır. Ayrıca tam SQ hareketindeki 1TM değeri ile tekrarlı sprint testindeki toplam test zamanı (r = ,038) ve yorgunluk indeksi (r = ,142) arasında istatistiksel olarak anlamlı bir ilişki olmadığı elde edilmiştir (p > 0,05).

Anahtar Kelimeler: Kuvvet, Sıçrama, Tekrarlı Sprint, Çeviklik, Performans

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INTRODUCTION

Strength, one of the important components of muscular fitness (50), was often equated with muscular force and defined as maximal strength amount of a muscle or groups of muscle to produce in a single voluntary contraction against an external resistance during a specific movement pattern in specific contraction velocity (58). According to this definition it can be suggest that muscular strength lies along a continuum from zero (no force generated) to maximal force production (maximal muscular strength). That is, strength is not an absolute value and always tends to change. Also, force is an agent that cause to change in the movement of an external resistance (49). In strength ability, the body to apply a force against a resistance and during sporting activity, this resistance may vary. Whilst running, the resistance that you are working against is your own body weight; a swimmer applies force to the water and a shot putter obviously must apply force to the shot which is acting as the resistance (69). In other words, external resistance to be countered, not only provided through body weight but also includes jump movements, upwind and hill runnings, arm - leg throws made in various areas and weights lifted (2). Maximal strength defined as the highest force that can be performed in a muscle or muscle groups by the neuromuscular system during one maximum voluntary contraction, without any time restriction (42, 52). Also, it was refer to one repetition maximal (1RM) or 100 % of maximal and indicate the highest force which an athlete can lift (15).

One of the most important parameters of success in sports are the contribution of strength to vertical jump performance (32, 45). Jumping ability which athlete can horizontally jump far as possible and vertically high as possible is one of the important indicators of lower body muscle power (35, 57, 73). Jumping is a ability which involves complicated movement series and based on jump ability and flexibility of muscles joined in jumping movement, explosive strength and power of leg muscles. In addition, jumping ability is an important performance indicator for several sports like basketball, football, and volleyball (40). Jump tests are commonly used to as a general measure of lower body power in sport branches such as football that require high levels of lower body muscle power or to measure improvements in jump performance for sport branches such as handball, basketball, and volleyball where jump ability assists performance (34).

In some studies, strong relationships were shown between strength and jumping performance and it was stated that strength have an effect on vertical jump performance. On young female volleyball players, it was found that there was a significant correlation between vertical jump and 1RM performance in full squat (SQ) exercise both before and after the training protocol (5). Similarly, Wisloff *et al.,* (71) reported that there was a strong relationship between jump performance and 1RM strength value in SQ exercise of soccer players.

Agility which occurs by coordination, speed, balance, and strength combination has not a common definition (26, 56). Anyways, it can be defined as control and coordination skill which provides joints and body to be in the right place for changing direction rapidly in space (67,76). In performance sports, it is defined with rapid changes in direction skill it means the whole body changes place through a stimulant (61). Fast change ability of direction is observed in two ways; one of them is to pass opponent and other one is showing reaction to movement made with ball (74). For this reason, agility is an important ability in sports such as football, basketball and handball (36). Because players who competed in such sports have many sudden change of direction in games (46). In a study conducted on professional basketball players by Alemdaroğlu (4), it was obtained that there were no statistically a significant

correlation between agility performances and strength values of players. Conversely, it was suggested that maximal strength measured as squat performance can be associated with agility performance of players who competed in team sports (19).

Short duration sprints applied with short recovery period are widely used in many sports (12). Therefore, recovery ability between sprints and regenerating performance for the next sprint (activities include full recovery or medium or lower intensity activities) is an important fitness requirement for performing repeatedly to maximal or near maximal effort interspersed with short recovery periods (including full recovery or medium and low density activities) over a broad time period of athletes who compete in many sports and this characteristics is named as repeated sprint ability (RSA) (8, 25).
When considered as physiologically, RSA is a complex ability believed to be in relation with both neuromuscular (determine the maximal sprint speed as neural impuls or motor unit activation) and metabolic factors (associated with the RSA such as oxidative capaity for regeneration creatine phosphate) (30, 63). While RSA is often equated with a low fatique index (i.e. decrease in performance from the first to the last sprint), it is important to note that a good RSA is better described by a high average sprint performance, with or without a low fatique (e.g. a marathon runner with a low average sprint performance, but a very low fatique index, would not be classified as having good repeated sprint ability) (29). Newman *et al.,* (51) reported that there wasn't any significant relationship between RSA and strength cahracteristic.

In many sports, to demonstrate a successful performance, players should have not only better technical - tactical features but also strength, jump and repeated sprint skills. Determining some performance parameters of athletes and revealing the relationships between each other, may contribute to train these characteristics. Therefore, the purpose of this study is to investigate the relationship between some performance parameters and 1RM strength in trained athletes.

METHOD

Subjects

34 amateur certified athletes competed in football (n=12), volleyball (n=8), wrestling (n=6) and kickboxing (n=6) sport branches (age: 22,0 ± 3,03 years; height: 179,2 ± 0,06 cm; weight: 75,2 ± 8,9 kg; training experience: 9,0 ± 2,82 years) voluntarily participated in this study.

Data Collection Tools

Subject's height and body weight values were determined using a Seca 769 electronic measurement device (Seca Corporation Hamburg Germany). One repetition maximal (1RM) values in full back SQ exercise of subjects were obtained using smith machine (Esjim, Eskisehir, Turkey) which a stable vertical plane. Free weights (1, 1.25, 2.5, 5, 10, 15 and 20 kg) which controlled weights with a electronic device was used to determine 1RM strength values in full back SQ exercise using smith machine. To determining agility and RSA times of subjects, A portable photocell system (Newtest Powertimer, Model 300s, Oy Finland) was used. In addition, tape measure was used for measure to vertical jump height.

Data Collection Process

Data collection process of this study was carried in two different periods. At first period, physical characteristic and 1RM values in full SQ exercise of subjects were determined. At second period, performances in agility, repeted sprint and jump tests were determined. Subjects were applied the vertical jump test in a indoor sports hall, 1RM full SQ measurements in a fitness center, agility and RSA tests in an artificial soccer field. Information about how data collected

during the study are described as detail in case of subtitles.

One Repetition Maximal Strength Test in Full Back Squat Exercise

Subjects were performed to full back squat exercise using a prosedure which designed by Earle and Beachle (24). Subjects were informed about how to apply this procedure before taking 1RM values in full SQ exercise. In this procedure the subject grasped the barbell with a closed, pronated grip slightly wider than shoulder width and the barbell was placed above the posterior deltoids (high bar position). The feet should be slightly wider than shoulder width and indicated slightly outward when the subject begins the descent. The subject reached the lowest point in the descent when the top of the thighs are parallel to the ground, and the barbell lifted in a continuously motion without assistance. For safety, at least two observers were stood on either side of the barbell and followed the bar during the descent and ascent. It was emphasized that subjects should breathe out when lifting the barbell and breathe in when lowering the barbell during implementing of the full back SQ exercise. 1RM strength values in the full back squat exercise of subjects were obtained with test procedure designed by Beachle, Early and Wathen (10). Processes applied in this test procedure was detailedly explained as below.

1. After a 10 minutes warm-up, the subjects warms up by performing repetitions with a load that allows 5 to 10 repetitions,
2. One minute rest was given,
3. Estimate a warm-up load that allows the subject to complete three to five repetitions by adding a load between 14 to 18 kg, or 10 to 20 %, to the load used in step 1,
4. Two minutes rest was given,
5. Estimate a near maximal load that will allow the subject to complete two or three repetitions by adding a load between 14 to 18 kg, or 10 to 20 %, to the load used in step 3.
6. Two to four minutes rest was given,
7. The subject performs a 1RM attempt by increasing the load used in step 5 by 14 to 18 kg, or 10 to 20 %,
8. Two to four minutes rest was given,
9. If subject succeed in lifting the load in step 7, the load has been resumed increasing in proper proportions. But, if the subject fails the 1RM attempt, decrease the load by removing 7 to 9 kg, or 5 to 10 %, and have the subject perform one repetition,
10. Two to four minutes rest was given,
11. Continue increasing or decreasing the load until the subject can complete one repetition with appropiate technique. The subject's 1RM value was maximally obtained within five attemps.

Agility Test

Illinois agility test designed by Getchell (28) were applied in order to determine subject's direction change, acceleration and agility characteristics. Test field with 10 meter length and 5 meter width was marked with 4 cones (start, finish and two turning points). There were 4 more cones in the middle of the field each had 3.3 meter distance. A photocell was placed for start and finish points (Figure 1). Test consists of 180º turnings at each 10 meter, 40 meter straight running, and slalom (zigzag) running between cones along 20 meter (41). Before starting the test, athletes were allowed to try out to get used to test field. When subjects feel ready, they lay face down on the floor and hands are in line with shoulders contacted on ground, test was started and tried to finish as soon as possible. To reach the best result, test were applied 2 times with 3-4 minutes resting intervals and best result was recorded as second.

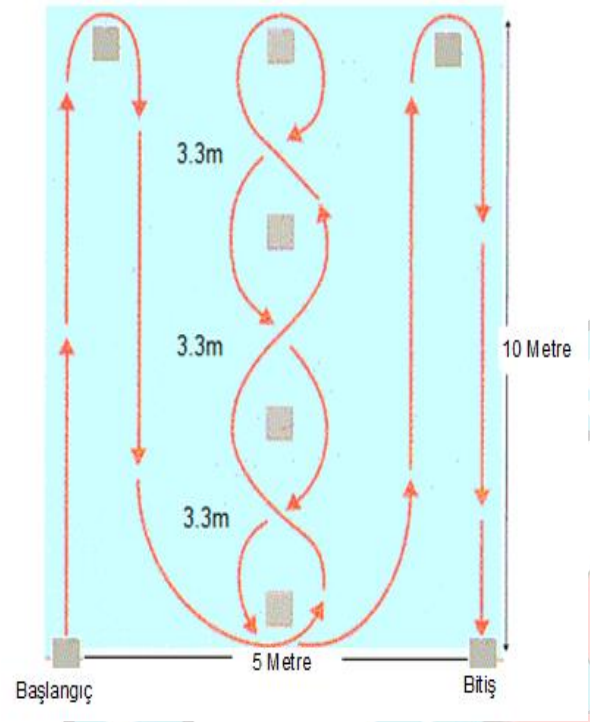

Figure 1. Illinois Agility Test Field (41)

Repeated Sprint Test

Repeated sprint ability (RSA) of subjects were obtained by using repeated sprint test development by Bangsbo (9). This test contain 7 sprints performed at maximal speed in 34,2 meter test field (Figure 2). After every running tour, a rest period of 25 seconds was given to athletes (1). Before repeated sprint test, subjects were asked to running in a low intensity for 10 minutes and warm up for 5 minutes. After that, in order to familiarise to test procedure, sprints were performed with passive resting. Full resting time were given to athletes to recover and measurements were made when they were ready. Repeated sprint test were applied two times for obtaining the best result, and best results were recorded for statistical analysis. Each sprint value was recorded through a photocell placed on start and finish. Fatigue index values of subjects were obtained according to formula below (54).

Formula: % YI = (TT - IT) / IT x 100

Ideal Time (IT): S_{EZ} x 7
Total Time (TT): S1 + S2 + S3 + S4 + S5+ S6 + S7
S_{BS}: Best Score (Time)
S: Sprint

Vertical Jump Test

After general a warm up activity of ten minutes, athletes were applied the vertical jump test in a indoor sports hall. Firstly, in front of the test platform was determined to standart arm lenght of athletes and then it was dictated that jumps as high as possible, but should fall on the ground without bending his knees after the jump. The end of the test, it was determined to difference between player's arm length with vertical jump height and vertical jump height was recorded as centimeters (41). Athletes were performed two times vertical jump tests by giving adequate rest periods and the best vertical jump height were reported for statistical analysis.

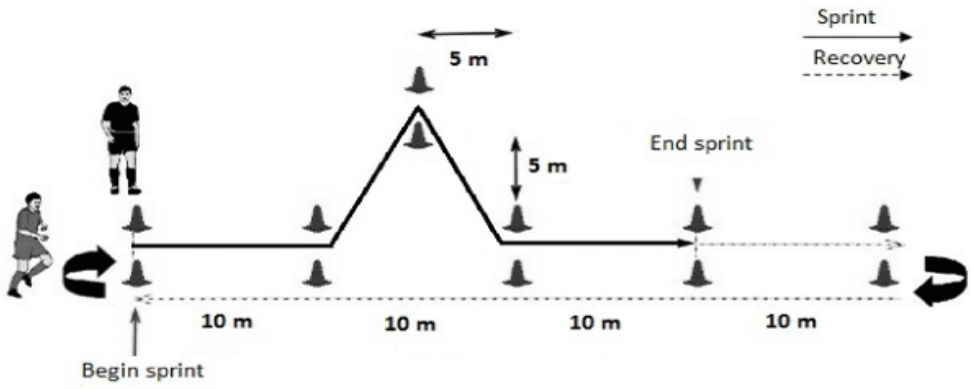

Figure 2. Repeated Sprint Test Field (64)

Standing Long Jump Test

After 10 minutes warm-up period, in order to determine explosive leg power of subjects, standing long jump test were applied. In this test, subjects were asked to open their legs in line with shoulders, and jump forward on toe tips from the back of line. Distance were calculated between toe at start point and feet heel at landing point and recorded as centimeter (41). Standing long jump test were applied two times by giving adequate time to have a rest to athletes and best scores were recorded for statistical analysis.

Statistical Analysis

In order to assessment of data, descriptive statistics and Pearson Correlation analysis method were used to determine whether there was a relationship between some performance parameters and 1RM strength values in full squat exercise. Significance level was accepted as $p < 0.05$ in all statistical analysis.

RESULTS

Table 1. Physical Characteristics of Subjects

Variables	n	Minimal	Maximal	Mean (sd)
Age (year)	34	18,00	28,00	22,0 (± 3,03)
Height (cm)	34	1,67	1,89	179,2 (± ,06)
Weight (kg)	34	60,00	92,00	75,2 (± 8,98)
Training History (year)	34	5,00	13,00	9,0 (± 2,82)

Table 2. Agility, Jumping and Strength Values of Subjects

Variables	n	Minimal	Maximal	Mean (sd)
Illinois Agility Test (sec)	34	14,73	17,33	16,1 (± ,74)
Standing Long Jump Test (cm)	34	216,00	274,00	248,9 (± 17,4)
Vertical Jump Test (cm)	34	40,00	62,00	53,8 (± 5,7)
1RM Strength in Squat (kg)	34	80,00	150,00	118,6 (± 19,0)

Table 3. Repeated Sprint Test Performance of Subjects

Variables	n	Minimal	Maximal	Mean (sd)
RST1	34	6,76	7,74	7,30 (± ,31)
RST2	34	6,78	8,03	7,48 (± ,34)
RST3	34	7,01	8,16	7,50 (± ,33)
RST4	34	7,14	8,16	7,65 (± ,28)
RST5	34	7,23	8,67	7,74 (± ,38)
RST6	34	7,29	8,28	7,78 (± ,31)
RST7	34	7,38	8,58	7,83 (± ,37)
Total Time (sec)	34	50,80	56,48	53,30 (± 1,19)
Fatigue Index (%)	34	1,02	8,59	5,30 (± 2,13)

RST: Repeated Sprint Test

Table 4. Pearson Corelation Analysis Results Between Agility Times and One Repetition Maximal Strength Value in Full Back Squat Exercise

		1RM Strength in Squat	Illinois Agility Test
1RM Strength in Squat	Pearson Correlation	1	-,207
	Sig. (2-tailed)		,239
	n	34	34
Illinois Agility Test	Pearson Correlation	-,207	1
	Sig. (2-tailed)	,239	
	n	34	34

$p > 0.05$

When examining table 4, it can be seen that there wasn't any statistically significant relationship between agility times and 1RM strength value in full back SQ exercise ($r = -,207$; $p > 0.05$).

Table 5. Pearson Corelation Analysis Results Between Jumping Distance and One Repetition Maximal Strength Value in Full Back Squat Exercise

		1RM Value in Squat	Standing Long Jump Test	Vertical Jump Test
1RM Value in Squat	Pearson Correlation	1	,157	,415*
	Sig. (2-tailed)		,374	,015
	n	34	34	34
Standing Long Jump Test	Pearson Correlation	,157	1	,609**
	Sig. (2-tailed)	,374		,000
	n	34	34	34
Vertical Jump Test	Pearson Correlation	,415*	,609**	1
	Sig. (2-tailed)	,015	,000	
	n	34	34	34

* $p < 0.05$ ** $p < 0.01$

When examining table 5, while there wasn't any statistical significant relationship between standing long jump test and 1RM strength value in full back SQ exercise ($r = ,157$; $p > 0.05$); it can be seen that there was average level, positive and a statistically significant relationship with vertical jump test ($r = ,415$; $p < 0.05$). For this reason as 1RM maximal strength value increases, vertical jump test performance increases.

Table 6. Pearson Corelation Analysis Results Between Fatigue Index and Total Test Time in Repeated Sprint Test and One Repetition Maximal Strength Value in Full Back Squat Exercise

		1RM Value in Squat	Total Time in RST	Fatigue Index in RST
1RM Value in Squat	Pearson Correlation	1	,038	,142
	Sig. (2-tailed)		,829	,423
	n	34	34	34
Total Time in RST	Pearson Correlation	,038	1	,127
	Sig. (2-tailed)	,829		,475
	n	34	34	34
Fatigue Index in RST	Pearson Correlation	,142	,127	1
	Sig. (2-tailed)	,423	,475	
	n	34	34	34

When examining table 6, it can be seen that there wasn't any statistically significant relationships between fatigue index (r = ,142; p > 0.05) and total test time in repeated sprint test (r = ,038; p > 0.05) with 1RM strength value in full back SQ exercise.

DISCUSSION

One repetition maximal (1RM) strength is defined as maximal strength that an individual can produce at once in a specific exercise (17). In this study, full back squat exercise was applied for determining 1RM values of subjects and subject's 1RM values were, on average, obtained as 118.6 (± 19,0 kg). Similarly, in a study related to elite soccer players by requena *et al.,* (59), average 1RM values in full SQ exercise was obtained as 119.5 kg. In addition, 1RM values in full SQ exercise of NCAA 1st league soccer players were reported as 121 (± 22.5 kg) (65). This results is in line with results obtained in the current study. Conversely, in studies carried out by Garcia-Pallares *et al.,* (27) and Sanchez - Medina *et al.,* (60) obtained that 1RM values in full SQ exercise of subjects who are doing strength training was, on average, 100.4 (±21.8 kg) and 102 (±22 kg), respectively. Parejo-Blanco *et al.,* (55) found that 1RM values in full SQ exercise of professional soccer players which they divided the players in two groups who have 15 and 30 % average speed loss as 93.3 kg for 15 % group and 98.1 kg for 30 % group. 1RM value obtained from this studies seem to have quite lower values than values obtained in this study. Though, when considering participant groups, while expecting 1RM values to be higher, these values seem to be lower. This may result from test procedure. That is, 1RM strength values in mentioned studies were determined according to lift velocity (velocity factor). In this study, 1RM strength values in full squat exercise was obtained by using traditional method.

Unlike the results obtained in this study, while Alcaraz *et al.,* (3) obtained that 1RM values in full SQ exercise of sprinters who had at least 6 years of sprint training and 2 years of strength training experience as 199.7 (± 59.1 kg); Zink *et al.,* (77) obtained 1RM values in full SQ exercise of participants who had 2 years of strength training experience as 175.1 (± 30.6 kg), on the average. In studies carried out by Cotterman, Darby and Skelly (21) and Masamoto *et al.,* (44), it was found that 1RM values of healthy males were as 171.5 (± 35.7 kg) and 139 (± 29.3 kg), respectively. In studies on soccer players, while average 1RM values in full squat exercise of elit soccer players were found as 171.7 (± 11.4 kg) (71), 1RM values of players in Celtic U17 soccer club were found as 129.1 (47). In a study carried out by Cormie, McBride and McCaulley (20) obtained that 1RM values in full SQ exercise of 1st league soccer players, on average, were as 170 (± 21.7 kg). In study of Iglesias-Soler ve *et al.,* (37) 1RM values in SQ exercise of judo athletes who had at least 18 months strength training experience were found as 129.8 (± 19.4 kg). Izquierdo *et al.,* (38) reported that average 1RM values in squat exercise was obtained as 157 (± 18 kg) for weight lifters and 134 (± 18 kg) for bicyclers. As can be seen, the results obtained from mentioned studies are higher than results in current study. This difference may result from the procedures applied or the differences between individuals in studies. That is, participants in this study are amateur athletes and full back SQ exercise were applied as procedure. In mentioned studies, participants were applied half SQ exercise and participants consisted of athletes or elite athletes who have been training for long time.

One of the most important parameters of success in sports are the contribution of strength to vertical jump performance (32, 45). Vertical jump performance is based on conractile characteristics of muscles as well as increase occured in concentric

exercise due to stretch-shortening cycle (39). Some studies in literature; while expressing that there was a strong relationship between strength level and vertical jump distance and strength was effected vertical jump performance in positive way, in some studies it was reported that there was a very low or no relationship between strength and vertical jump performance. These differences reported by different researchers may result from participant groups and mesaurement methods. In addition, it was stated that the relationship between muscle strength and body weight may be a significant factor for vertical jump (23). In a study, it was reported that there was a positive correlation between vertical jump performance and muscle strength when the maximal strength value are expressed relative to body weight (72).

In a study carried out on young female volleyball players by Augustsson (5) was found that there was a statistically significant relationship between vertical jump performance and 1RM strength value in full SQ exercise both before and after the training protocol. Similar results were also obtained by Wisloff *et al.,* (71). In related study, it was stated that there was a strong relationship ($r = 0.78$; $p < ,02$) between jump performances and 1RM strength value in half squat exercise of football players. Conversely, in a study carried out by Bonnette *et al.,* (16) obtained that there was a lower relationship ($r = 0.09$; $p > ,05$) between 1RM values in full SQ exercise and vertical jump performances of young football players. Similarly, it was reported that there were no any significant relationships between 1RM value in half squat exercise and squat jump performance (59) and between 3TM value in half squat exercise and vertical jump performance (22). Results obtained from this study, are in parallel with study of Augustsson (5) and Wisloff *et al.,* (71).

Besides athletic activities such as jumping, or sprinting, most of the team and racket sports require frequent performance of quick change of direction maneuvers, like zigzag runs, sidestepping, crossover cutting, and shuttle runs (48, 66). Change direction rapidly or start and stop quickly movements generally define a complex motor quality which named as agility (14, 31). There are not too much information in sports sciences literature about physiologic and muscular process of agility for a successful performance (66).

In current study, there was no any statistically significant relationship between 1RM value in full back SQ exercise and agility characteristic ($r = - ,207$; $p > 0.05$). Similarly, in a study conducted in professional basketball players by Alemdaroğlu (4), it was obtained that there were no statistically a significant correlation between strength and agility performances of players. In addition similar results were reported by different authors. In a study, it was reported that there was no any statistically significant difference between agility characteristic and 1RM strength values in squat exercise performed by using free weights of Women Softball players (53). In a study conducted on hockey players by Behm *et al.,* (11) reported that there were no any significant differences between agility and leg press values.

On the other hand, in some biomechanical studies it was stated that there can be a relationship between muscle strength and agility characteristics. Especially, performance of most agility tasks consist rapid deceleration phase in which leg extensor muscle operate eccentirically, followed by a rapid acceleration phase, in which leg extensor muscle operate concentrically (43, 62). In order to produce a rapidly change of direction, one should achieve a relatively short ground time, and therefore generate force in a short period of time (75). It was suggested that maximal strength measured as squat performance can be in relation with agility performance of athletes competed in team sports (19). In a study conducted by using three different agility tests on physical education and sport students were

obtained that there was a weak and negative relationship between both isoninertial (a constant external load) 1RM squat strength obtained in smith machine, and isometric 1RM squat strength where squat circle stabled on the ground on a power platform with three different agility tests (43).

Short duration sprints applied with short recovery period are widely used in many sports (12). Therefore, recovery ability between sprints and regenerating performance for the next sprint (activities include full recovery or medium or lower intensity activities) is an important fitness requirement for performing repeatedly to maximal or near maximal effort interspersed with short recovery periods (including full recovery or medium and low density activities) over a broad time period of athletes who compete in many sports and this characteristics is named as repeated sprint ability (RSA) (8, 25). In studies, repeated sprint ability are in relationship with aerobic contributions like both maximal oxygen uptake and anaerobic contributions like buffering capacity and decreasing of phospocreatine (6, 13, 68).

When looking on literature, except for study carried out by Newman, Tarpenning and Marino (51), there was no any study related to relationships between repeated sprint skill an done repetition maximal strength; and in addition to this in studies it can be seen that there were studies related to single sprint running performance and strength characteristic. In aforementioned study, it was reported that there was no significant relationship between strength characteristic and repeated sprint ability. These results seem parallel with results in our study. In this study it can be seen that there is no a statistically significant relationship between fatigue index, and total test time in repeated sprint test with 1RM strength value in full back SQ exercise. On the other hand, when looking on studies where relationship between single sprint running and one repetition maximal strength are researched; in study of Wisloff *et al.,* (71) reported that there was a statistically significant relationship between 10 and 30 meters sprint times with 1RM strength value in half squat exercise applied by using free weigths. Can (18) obtained that there was a significant relationship between 1RM value in full back squat exercise and 5 meter sprint times; and no significant relationship with 30 m sprint time. In studies carried out by Harris *et al.,* (33) and Wilson, Murphy and Walshe (70), it was reported that there were no any statistically significant relationships between 1RM strength value in half squat exercise and 40 meter sprint times. It was reported that there were no any significant relationship between both 40 meters (7) and 30 meters (22) sprint times and 3RM strength values in half squat exercise. Briefly, It can be suggested that 1RM maximal strength is generally associated with short sprint runnings, and as running distance increases this relationship decreases. Because of running distance is 34.2 meter in repeated sprint test, it can be suggested that there cannot be any significant relationship between 1RM maximal strength and repeated sprint test.

In literature review, while obtaining a statistically significant relationship between 1RM strength value and vertical jump performance in some papers, this relationship were not seen in some other papers. When considering results obtained from this study, it can be suggested that jumping ability is important for sportive success and athletes dealing with soccer, basketball, volleyball and handball need to do strength training towards lower extremity in order to improve their jump abilities.

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