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CHAPTER 1

PERFORMANCE INDICATORS THAT DISTINGUISH WINNER AND LOSER FENCERS IN MEN'S FOIL WORLD CHAMPIONSHIP

Sercin KOSOVA[1], Merve KOCA KOSOVA[2]

1 Dr., Dokuz Eylül University, Necat Hepkon Faculty of Sport Sciences, İzmir, Turkey, sercin.kosova@gmail.com http://orcid.org/0000-0003-1005-3387
2 Dr., Dokuz Eylül University, Necat Hepkon Faculty of Sport Sciences, İzmir, Turkey, merve.koca@deu.edu.tr http://orcid.org/0000-0003-0454-2790

INTRODUCTION

All fencing branches are asymmetric and quickness is a critical feature for these branches (Sorel et al., 2019). More complex technical movements can be performed in foil because only thrusting movements are used in this arena and the foil is a much lighter weapon compared with epee. It is necessary to perform smaller weapon movements more precisely to achieve accuracy in foil because the target area is narrow.

Fencing World Championships are played in individual and team competitions. Group bouts placed in order of classification (pools) are played first in individual competitions. The top 16 world-class fencers are not included in these bouts, they compete directly in the main tableau. After pool bouts are completed, a general ranking is created and pre-qualifying bouts are played according to the method of the competition. The top 16 fencers from pool bouts are placed in the main tableau. The remaining fencers play pre-qualifying to rise to the main tableau. According to the results of the pre-qualifying bouts, all players of the main tableau (Tableau 64) are determined (*Rules For Competitions, Book 2. Organisation Rules*, 2016).

In addition to having an improved physical condition in fencing, technique and tactics also play an important role (Kalkan, 2020). To plan the tactical approach correctly, bout analysis and interpretation are required for fencers and trainers. There are a limited number of studies in the literature on fencing bout analysis. One of these studies was designed to compare the performance of top epee fencers in individual and team competitions and the majority of fencers were better in individual competitions (Zadorozhna et al., 2021). In another study conducted with bout analysis, researchers reported that female foil fencers could train with an analogous program for five touch (pool), fifteen touch (direct elemination), and team bouts (Wylde et al., 2013). Borysiuk (2005) investigated the performance determinants of sabre fencers with various performance tests after electronic scoring apparatus was included. Roi and Bianchedi (2008) stated the effective fight time, which includes these movement patterns for male foil fencers, as between 17-34 minutes. To perform these actions and more, fencers primarily must have strength (Turner et al., 2013), muscular power (Chang et al., 2019), accuracy (Tsolakis et al., 2010), and good change of direction performance (Kosova & Kosova, 2021).

The Men's Foil World Championship in 2019, the last World Championship before the Tokyo Olympic Games, is very important for athletes to evaluate themselves and their opponents. The fact that all top-level athletes take part in this championship can be stated as the reason why this competition was chosen for the study. The aim of this study was

to determine the differences between the key performance parameters of the winners and losers among the athletes who have the right to compete in the main Tableau in the World Championship, the largest tournament of the whole season.

MATERIALS and METHODS

An observational study was used to describe performance indicators in male foil fencers. In this study, Tableau 64, Tableau 32, Tableau 16, and the finals at the Men's Foil World Championship in 2019 were analyzed retrospectively. All bout records were accessed from the official website and YouTube channel (https://www.youtube.com/watch?v=vE7sHH0HBJA / last access date: march 09, 2021) of the International Fencing Federation (FIE). The notational analysis was conducted in terms of winners and losers by an operator with a fencer and referee background at international competitions. To reduce operator error, the bouts were monitored by a single operator and each action was analyzed twice. Independent observers analyzed 61 bouts because one bout was not played in Tableau 64 and Tableau 16.

Analyzed Parameters

Attack: It is the general name given to all offensive actions (Barth & Barth, 2003). Actions considered as attacks in the study:

Attack Total (AT): Attack valid + Attack not valid

Attack Valid (AV): Points earned with attack actions

Attack Not Valid (ANV): A touch to off-target on the fencer with attack actions.

Lunge: The lunge is the fundamental footwork technique used with all three fencing weapons. Actions considered as lunges in the study:

Lunge Total (LT): Points earned with lunge + Touch with lunge not valid + Lunge

Points Earned With Lunge (PEL): Earn points by making a lunge

Touch With Lunge Not Valid (TLNV): A touch to off-target on the fencer with a lunge.

Lunge (L): Lunge without touch

Parry: Defensive actions done with a weapon to block an opponent's attack (Barth & Beck, 2007). Actions considered as parries in the study:

Parry Total (PT): Points earned with parry + Touch with parry not valid + Parry

Points Earned With Parry (PEP): Earn points by making a parry

Touch With Parry Not Valid (TPNV): A touch to off-target on the fencer with parry

Parry (P): Parry without touch

Counter-Attacks: Counter-attacks actions taken during the opponent's offensive action (Barth & Beck, 2007). Actions considered as counter-attacks in the study:

Counter-Attack Total (CT): Counter-attack valid + Touch with counter-attack not valid

Counter-Attack Valid (CV): Earn points by making counter-attack actions.

Touch With Counter-Attack Not Valid (TCNV): A touch to off-target on the fencer with counter-attack.

Actions in 4 m: The number of actions scored between the starting lines (total number in Tableau 64 and following bouts)

The Simultaneous: Actions started and completed at the same time by two fencers (*International Fencing Federation Technical Rules*, 2021) (total number in Tableau 64 and following bouts).

Penalty Points: Red card or penalty for leaving the last meter on the playing field (total number in Tableau 64 and following bouts). All these parameters are presented in Figure 1.

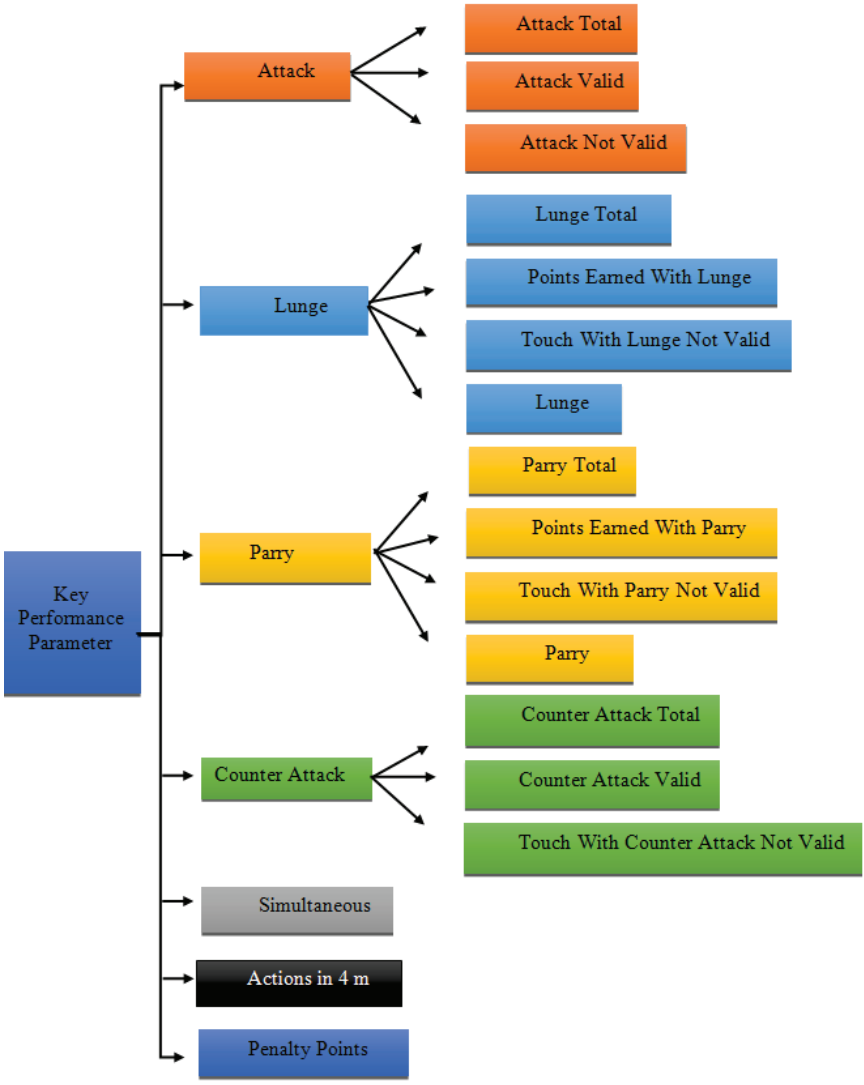

Figure 1. Notational Analysis Parameters

SPSS Statistics 20 software package (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY) was preffered. The significance level was determined as $p < 0.05$. The results of the research were expressed as mean and standard deviation. The Mann-Whitney U test was used to compare the winners and losers of all bouts in Tableau 64, Tableau 32, Tableau 16, and the finals.

RESULTS

The average age of the athletes who qualified in the main tableau in the 2019 Men's Foil Fencing Championship was 26.30 ± 4.74 (min 18.64 -

max 37.51) years. Some 35.9% of the athletes in the main tableau were left-handed and 64.1% were right-handed. Descriptive data on the performance parameters of the fencers in the main tableau and the following bouts are presented in Table 1.

Table 1: Descriptive data on the performance parameters of the fencers in the main tableau (T 64) and the following bouts in the Men's Foil World Championship

	Parameters	n	Mean±SD	Min- Max
Attack	Attack total (AT)	122	11.52±4.51	3-23
	Attack valid (eraned point) (AV)	122	7.49±3.10	1-14
	Attack not valid (ANV)	122	3.99±2.97	0-16
Lunge	Lunge total (LT)	122	29.07±9.65	11-57
	Points earned with lunge (PEL)	122	6.67±2.81	1-13
	Touch with lunge not valid (TLNV)	122	3.29±2.84	0-15
	Lunge (L)	122	19.07±7.96	5-45
Parry	Parry total (PT)	122	15.29±6.55	4-38
	Points earned with parry (PEP)	122	2.26±1.64	0-8
	Touch with parry not valid (TPNV)	122	1.27±1.42	0-7
	Parry (P)	122	11.76±5.85	3-28
Counter-Attack	Counter attack total (CT)	122	3.37±2.51	0-13
	Counter attack valid (CV)	122	2.47±2.02	0-13
	Touch with counter-attack not valid (TCNV)	122	0.90±1.09	0-4
Action in 4-m		61	4.10±2.20	0-11
Simultaneous		61	0.28±0.65	0-4
Penalty points		122	0.13±0.34	0-1

There were statistically significant differences between the analyzed parameters in the comparison of the winner and loser groups. Comparisons of the mean values of Tableau 64 are presented in Figure 2.

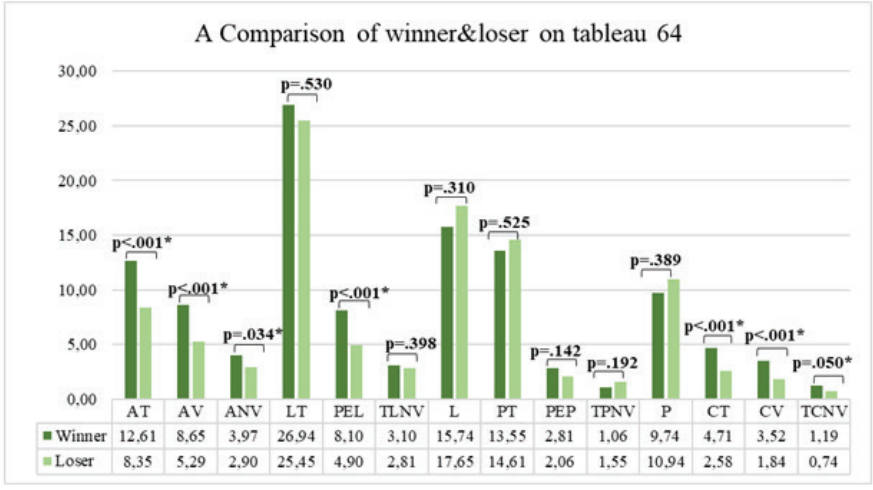

Figure 2. A Comparison of Winner&Loser on Tableau 64

AT: Attack total, AV: Attack valid, ANV: Attack not valid, LT: Lunge total, PEL: Points earned with lunge, TLNV: Touch with lunge not valid, L: Lunge, PT: Parry total, PEP: Point earned with parry, TPNV: Touch with parry not valid, P: Parry, CT: Counter-attack total, CV: Counter-attack valid, TCNV: Touch with counter-attack not valid.

When the data of the winners and losers in Tableau 64 were compared, AT (*U=166.500, Z=-4.436*), AV (*U=163.500, Z=-4.492*), ANV (U=332.500, Z=-2.121), PEL (*U=170.500, Z=-4.396*), CT *(U=221.500, Z=-3.683*), CV (*U=226.000, Z=-3.645)*, TCNV (*U=349.500, Z=-1.956*) of the winners were found to be significantly higher than the losers**.** Comparisons of winner's and loser's mean values of Tableau 32 are presented in Figure 3.

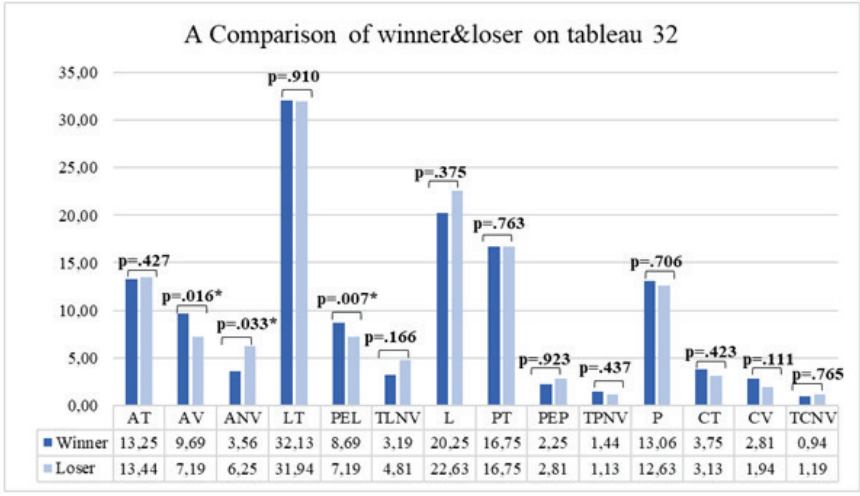

Figure 3. A Comparison of Winner&Loser on Tableau 32

AT: Attack total, AV: Attack valid, ANV: Attack not valid, LT: Lunge total, PEL: Points earned with lunge, TLNV: Touch with lunge not valid, L: Lunge, PT: Parry total, PEP: Point earned with parry, TPNV: Touch with parry not valid, P: Parry, CT: Counter-attack total, CV: Counter-attack valid, TCNV: Touch with counter-attack not valid.

When bouts of Tablaeu 32 were evaluated, AV (*U=64.500, Z=-2.413*) and PEL (U=56.500, Z=-2.713) of the winners were found to be significantly higher than the losers, ANV (*U=71.500, Z=-2.137*) of the losers were found to be higher than the winners. Comparisons of winner's and loser's mean values of Tableau 16 are presented in Figure 4.

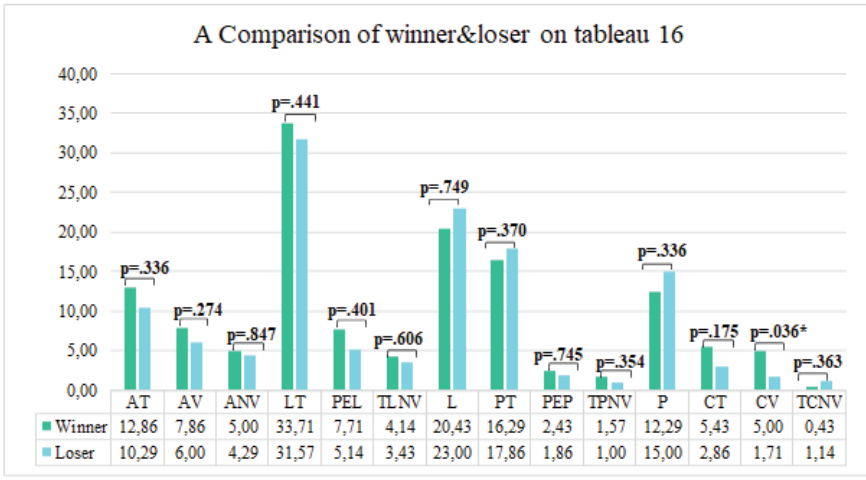

Figure 4. A Comparison of Winner&Loser on Tableau 16

AT: Attack total, AV: Attack valid, ANV: Attack not valid, LT: Lunge total, PEL: Points earned with lunge, TLNV: Touch with lunge not valid, L: Lunge, PT: Parry total, PEP: Point earned with parry, TPNV: Touch with parry not valid, P: Parry, CT: Counter-attack total, CV: Counter-attack valid, TCNV: Touch with counter-attack not valid.

When the data of the winners and losers in Tableau 16 were compared, the CV (*U=8.500, Z=-2.096*) of the winners were found to be significantly higher than the losers. Comparisons of the winner's and loser's mean values of the finals are presented in Figure 5.

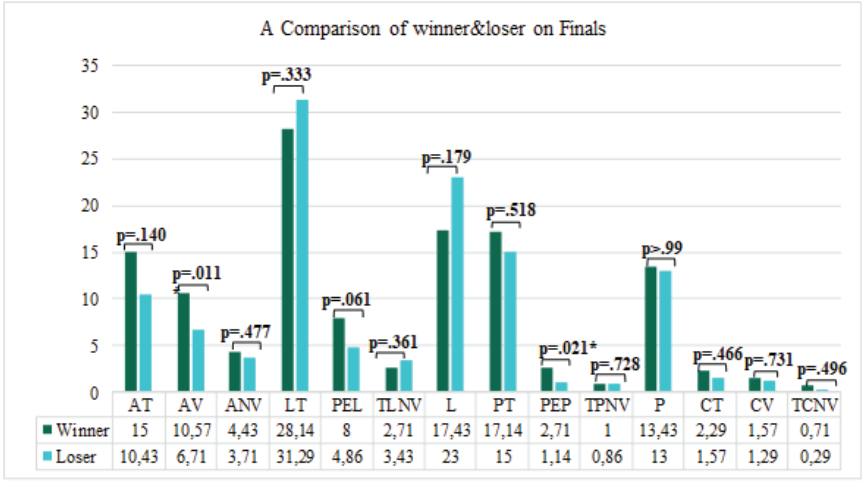

Figure 5. A Comparison of Winner&Loser on Finals

AT: Attack total, AV: Attack valid, ANV: Attack not valid, LT: Lunge total, PEL: Points earned with lunge, TLNV: Touch with lunge not valid, L: Lunge, PT: Parry total, PEP: Point earned with parry, TPNV: Touch with parry not valid, P: Parry, CT: Counter-attack total, CV: Counter-attack valid, TCNV: Touch with counter-attack not valid.

When bouts of the finals were evaluated, the AV (*U=5.000, Z=-2.537*) and PEP (*U=7.000, Z=-2.306*) of the winners were found to be significantly higher than the losers.

DISCUSSION

In this study, it was aimed to investigate the differences between the performance determinants of winners and losers in top-level fencing. Although there are limited studies in the literature on fencing bout analysis, to our knowledge, no studies have analyzed the Championship in terms of winners and losers. The main finding of the study is that although there are significant differences in seven parameters between the key performance parameters of the winners and losers in Tableau 64, the number of parameters with differences decreased in the rest of the tournament. In this case, it can be said that the quality of the fencers' game becomes closer to each other as they approach qualifying for the finals.

In Tableau 64, winners in each parameter of attack and counter-attack, as well as PEL, had significantly higher results than losers. In a study that performed performance analysis in sabre, the number of offensive actions in men during the bout was found to be more than twice the defensive actions (Aquili et al., 2013). In the current study, it was seen that the winning group in Tableau 64 displayed a more aggressive attack game, and in connection with this, both AV and ANV were found higher in the winning group. The high number of AV can be attributed to the high success rate in attacks, as well as the higher number of AT in the winning group. Likewise, the high number of ANV may be due to the higher number of AT in the winning group. Although there is no significant difference in LT, it can be said that winners complete the lunges that they execute, with more successful results than the losers. The lunge is the most preferred attack method in fencing, (Turner et al., 2014) and it is important to make a strong lunge for the attack to be accomplished (Sinclair et al., 2013). In the lunge, which is used as the basic foot movement in most of the point-scoring actions, both the lower extremity power is involved and the fencer should make the right decision at what distance the lunge must be performed tactically. Counter-attack games require the fencer to perceive a high level of concentration and tactical approach because it is necessary to take a position and react at the right time against an attack or preparation of the attack of the opponent, and even to use esquive (body displacement) at some positions. All these abilities require high reaction time performance (Kosova et al., 2020).

However, if fencers encounter uncertainty, the reaction and movement time increases (Gutiérrez-Dávila et al., 2014). Similarly, if a target change happens in the later stages of the action series, reaction and movement times increase and the style of lunge alters in foil fencers (Gutiérrez-Cruz et al., 2016). In this study, the winning group in Tableau 64 was able to fight all these factors more successfully than their opponents. The counter-attack preferences and performances of the Table 64 participants may be decisive in qualifying for the next tableau.

In Tableau 32, the winner's AV, ANV, and PEL results were significantly different from the losers. However, the counter-attack parameters did not differ in Tableau 32, unlike in Tableau 64. There were no differences in AT, so it can be said that both winners and losers adopt a more controlled offensive game approach, similar to each other. However, winners are more able to conclude their attacks with points than losers. The high ANV of the losers can be explained by the fact that they are behind the winners in terms of finding the valid target technique and the winner's effective performance in defence. In Tableau 16, only CV values differed between winners and losers. This shows the winning group's ability to take advantage of the opponent's gap while in the offensive action, and their ability to take risks. As for Tableau 16, there were no statistical differences in most of the actions that earned points. This indicates that the rivalry is very high, as there are no major differences between Tableau 16 and the following fencers competing. It can be thought that most of the features that make a difference at this level are aerobic endurance capacity (Witkowski et al., 2019), anaerobic energy capacity (Milia et al., 2014), the adoption of tactical approaches specific to the opponent, and the ability to keep the stress of the bout at an optimal level. Lastly, in the finals, the winner's AV and PEP results were higher than the losers. The best eight fencers of the world are competing at this level. The importance of the touches that are taken offensively and defensively is seen, but still, it is obvious that more touches are taken in an offensive way.

CONCLUSION

These findings suggest that in general, firstly AV, then PEL and CV were key performance indicators of winning in Men's Foil World Championship in 2019. In line with these results, the attack game is dominant to win in high-level foil fencing. For this reason, senior coaches are recommended to focus on training plans that can make the attacking game dominant, taking into account the individual characteristics of the opponent. As Curtis Armstrong said: 'Without a plan, there is no attack. Without an attack, there is no victory.' Finally, for more comprehensive information, future research should concentrate on the investigation of analysis of women foil fencers and other fencing branches in terms of winners and losers.

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CHAPTER 2

THE EFFECTS OF EXERCISE ON SERUM MMP9 AND ITS INHIBITOR, TIMP1: THE ROLE OF MMP9 -1562 C/T AND TIMP1 372 T/C POLYMORPHISMS[1]

Merve Koca KOSOVA[2], Faruk TURGAY[3], Oya YIGITTÜRK[4], Semih AŞIKOVALI[5], Sercin KOSOVA[6], Aykut Eren CANÜZMEZ[7], Burak DURMAZ[8]

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2 Araş.Gör. Dr., Department of Physical Education and Sports Teaching, Necat Hepkon Faculty of Sport Sciences, Dokuz Eylül University, İzmir, Turkey https://orcid.org/0000-0003-0454-2790

3 Doç. Dr., Department of Coaching Education, Faculty of Sport Sciences, Ege University, İzmir, Turkey https://orcid.org/0000-0003-2759-1544

4 Dr., https://orcid.org/0000-0003-1930-498X

5 Araş. Gör., Department of Medical Genetics, Faculty of Medicine, Ege University, İzmir, Turkey https://orcid.org/0000-0002-6589-3239

6 Araş. Gör. Dr., Department of Physical Education and Sports Teaching, Necat Hepkon Faculty of Sport Sciences, Dokuz Eylül University, İzmir, Turkey https://orcid.org/0000-0003-1005-3387

7 Öğr. Gör. Dr., Department of Coaching Education, Faculty of Sport Sciences, Ege University, İzmir, Turkey https://orcid.org/0000-0002-2908-2850

8 Doç. Dr., Department of Medical Genetics, Faculty of Medicine, Ege University, İzmir, Turkey https://orcid.org/0000-0002-6971-7996

Introduction

Matrix metalloproteinases (MMPs) and their inhibitors [tissue inhibitor of metalloproteinase (TIMPs)] are involved in exercise adaptations and atherosclerosis (AS) (Presti, Hopps, & Caimi, 2017; Visse & Nagase, 2003). MMPs are heterogeneous family of zinc-dependent endopeptidases and they degrading other ECM substances. Among the 23 different MMPs found in humans (Visse & Nagase, 2003), MMP2 and MMP9 have more vital roles in muscle and vascular cell repair and regeneration and inflammatory reactions (Kim & Lee, 2016; Presti et al., 2017; Wu et al., 2008). MMPs and TIMPs work together. Four TIMPs in humans are endogenous inhibitors of MMPs and all TIMPs have some specificities for their inhibition function. TIMPs are effective in cellular behaviour, tissue remodelling, and the regulation of ECM turnover (Brew & Nagase, 2010). TIMP1 is the inhibitor of MMP9, and MMPs interact with TIMPs by forming 1:1 complexes (Murphy, 2011).

MMPs have major functions in the recruitment of inflammatory and myogenic cells into the damaged site as well as ECM degradation, which can lead to inflammation. The levels MMPs are generaly low in normal adult tissues, but their expressions increase in some pathologic conditions or certain physiologic processes (Ferretti, Bacchetti, Banach, Simental-Mendia, & Sahebkar, 2017; Presti et al., 2017). For example, it was shown that exercise led to muscle damage and inflammation due to injury caused by the mechanical and physiologic stress of exercise (Kim & Lee, 2020; Madden, Byrnes, Lebin, Batliner, & Allen, 2011; Presti et al., 2017). MMP9 in particular is largely attendant in the degradation of type IV collagen and many other types of collagen. Type IV collagen is the main ingredient of the basal lamina, which is a thin layer separating the epithelium from connective tissue (Presti et al., 2017). Therefore, exercise can affect the synthesis and degradation of collagen, which is found in large amounts in the human body (Mackey, Donnelly, Swanton, Murray, & Turpeenniemi-Hujanen, 2006). Thus, MMPs have a vital role, especially in training adaptations because synthesis and secretion of matrix-degrading metalloproteases can be performed by human skeletal muscle satellite cells, which can also lead to hypertrophy and angiogenesis causing an increase in sports performance (Guérin & Holland, 1995). MMP-induced ECM degradation is inhibited by TIMPs to sustain homeostasis (Presti et al., 2017; Visse & Nagase, 2003). MMP9 and TIMP1 activity are regulated together (Gumpenberger et al., 2020; Zaidi et al., 2019) because both are released together (Rahimi, Sayad, Moslemi, Ghafouri-Fard, & Taheri, 2017). Therefore, the regulation of MMP activity is mainly performed by TIMPs (Presti et al., 2017). A balance in the operation of MMPs and TIMPs is required for ECM function (Kim & Lee, 2016), especially after

situations that can cause muscle damage, such as exercise. However, if it breaks down in balancing between MMPs and TIMPs, it may cause sports injuries (Presti et al., 2017).

Besides the mentioned functions, MMPs also have different considerable missions. Some of these missions are to the release of growth factors, and activation of different MMPs. In this way molecular and cellular transactions are also modulated during atherogenesis and cardiac remodeling. The transcription of MMPs is regulated by growth factors and cytokines, including interleukin 6 (IL-6) (Ferretti et al., 2017; Presti et al., 2017). Therefore, MMPs are also involved in some pathologic processes of some inflammatory diseases such as arterial hypertension, metabolic diseases, and coronary heart disease (CHD) (Buraczynska, Kurzepa, Ksiazek, Buraczynska, & Rejdak, 2015; Ferroni et al., 2003; Lorente et al., 2013; Wu et al., 2008). Therefore, it was reported that MMP9 was a risk factor for CHD (Ferretti et al., 2017; Presti et al., 2017). It is known that regular exercise improves muscle performance by neoangiogenesis in patients with arterial hypertension and metabolic diseases (Hansen, Nielsen, Saltin, & Hellsten, 2010). In addition, it has been reported that the MMP9 -1562 C/T polymorphism (rs3918242) (Zhang et al., 1999) and the TIMP1 372 T/C (rs4898) polymorphism, which are common among populations (Hinterseher et al., 2007; Zhang et al., 1999), were associated with the levels of these proteins and some inflammatory diseases (Buraczynska et al., 2015; Lorente et al., 2013; Presti et al., 2017).

The MMP9 -1562 C/T polymorphism (rs3918242) (MMP9P) is a single nucleotide polymorphism (SNP) at position-1562, caused by the replacement of cytosine (C) with thymine (T) (Zhang et al., 1999) and the TIMP1 372 T/C (rs4898) polymorphism is an SNP at position 372, the replacement of C with T (Hinterseher et al., 2007). For example, in a study by Buraczynska et al. (2015), it was shown that the MMP9 -1562 C/T polymorphism was associated with a risk of stroke in patients with and without Type 2 diabets. Also, the frequencies of T allele and T carriers (CT + TT) genotype were higher than the controls in ndividuals with Type 2 diabets patients groups. In another study (Lorente et al., 2013), it was shown that patients with sepsis with the T allele of the TIMP1 372 T/C polymorphism had higher serum TIMP1 levels and lower survival rates. As seen, the incidence of inflammatory diseases appears to be higher in people with the T allele, which indicates the role of MMP9 and TIMP1 polymorphism on both the mentioned disease and in the differences between the studies. Furthermore, it was shown that these mentioned polymorphisms were related to the blood lipds and lipoproteins (BLLPs) which accepted as the classic CHD risk factor (Mazzotti et al., 2014). In addition, it was reported that T allele of MMP9 -1562 C/T polymorphism was a risk factor for early-onset

coronary artery disease (Saedi et al., 2012). Therefore, the mentioned polymorphisms may also modify the effects of exercise on blood MMP9 and TIMP1 levels and BBLPs. It is known that acute and chronic exercise affect serum MMP9 and TIMP1 levels (Koskinen et al., 2001; Reihmane, Jurka, Tretjakovs, & Dela, 2013; Welsh, Allen, & Byrnes, 2014). However, in the literature there is not any study regarding the roles of the mentioned polymorhisms on possible exercise effects.

Knowing the role of these specified polymorphisms in the responses to acute and chronic anaerobic exercise in athletes and sedentary individuals can provide an important tool in the treatment of inflammatory diseases such as CHD by exercise and the prevention of sports injuries, as well as new modern training methods according to phenotypic characteristics. In addition, the results of the present study can provide phenotypic information about whether athletes who have been doing chronic anaerobic training have any risk in terms of the mentioned risk factors.

Therefore, the present study investigated the effects of acute maximal exercise (Yo-Yo intermittent recovery test, level 1) and chronic anaerobic exercise on serum MMP9, its inhibitor TIMP1, as well as BLLPs, and the role of the MMP9 -1562 C/T and TIMP1 372 T/C polymorphisms on these effects.

Methods

There were athletic and sedentary groups in the study. The athletic group (AG) included 43 healthy male basketball, volleyball, and handball players, and the sedentary group (SG) included 43 healthy men. The AG consisted of individuals aged 18-35 years who had been training for minumum 3 months. The SG consisted of healthy individuals with similar physical characteristics to the athletes and the same age range, but who had not performed regular exercise for at least 3 months.

The criteria for inclusion in the present study were that the participants were not obese [body mass index (BMI) <30 kg/m2] and did not use tobacco-related products, alcohol, drugs, and antioxidants. All athletes were instructed to stop training 2 days before the measurements. All participants were instructed to continue their usual nutrition habits and to attend for measurements with 4 hours of fasting. The research was approved by Ege University Faculty of Medicine Clinical Research Ethics Committee (Approval number: 18-7.1/49). All participants were informed about the study and written informed consent was obtained before taking the measurements.

The Yo-Yo IR1 was applied to all participants as an acute maximal exercise after a standard warm-up. It is a standard test that includes running

periods (20 x 2 = 40 m) with gradually increasing speeds. The Yo-Yo IR1 lasts 10-20 minutes depending on the ability level of the participants (Bangsbo, Iaia, & Krustrup, 2008). The test was continued until the participants were exhausted. The distance at which they could not continue and their heart rate at this time was recorded. If the participants could not complete the 40 m distance despite the auditory signal and this situation occurred twice consecutively, the test was ended for these participants by the researchers. Indirect VO2max values were calculated using the following formula according to Yo-Yo IR1 results: VO2max= 36.4 + (0.0084 x distance run).

A blood sample was taken 20-25 minutes before and 10 minutes after the Yo-Yo IR1. MMP9, TIMP1, MMP9/TIMP1 ratio, blood lipids and lipoproteins [total cholesterol (TC), high and low-density lipoprotein cholesterol (HDL-C and LDL-C)] and indicators of muscle damage [creatine kinase (CK), alanine aminotransferase (ALT), aspartate aminotransferase (AST)]; and C-reactive protein (CRP) and IL-6 levels as inflammation markers were determined from postprandial venous blood samples. Blood samples were protected at room temperature for 20 minutes, then centrifuged at 2000 g for 15 minutes and their serums were separated. Serum samples were stored at -82°C until required for further analysis. CK, AST, and ALT activities, TC, HDL-C, LDL-C and CRP were assessed using standard enzymatic-colorimetric methods with an autoanalyzer (Roche Cobas 8000, Switzerland). Serum MMP9, TIMP1 and IL-6 levels were determined using enzyme-linked immunosorbent assay (ELISA) by measuring at 450 nm on a microplate reader (Dialab ELx800, Austria). Commercial kits (Human ELISA Kit Elabscience, USA) were used for these procedures. The MMP9/TIMP1 ratio was calculated using the molecular weight of MMP9 (92kDa) and TIMP1 (28kDa). Plasma volume change was determined according to Dill and Costill's (1974) method (Dill & Costill, 1974).

MMP9 -1562 C/T and TIMP1 372 T/C polymorphisms were determined from DNA samples isolated from peripheral blood (leukocytes) using standard techniques according to the manufacturer's (QIAGEN®-Hilden, Germany) instructions. Polymerase chain reaction (PCR) and restriction fragment length polymorphism (RFLP) was used for the determination of genotypes. The primers used were 5'-GCCTGGCACATAGTAGGCCC-3' (forward) and 5'-CTTCCTAGCCAGCCGGCATC-3' (reverse) for the MMP9 gene; 5'-GCACATCACTACCTGCAGTC-3' (forward) and 5'-GAAACAAGCCCACGATTTAG-3' (reverse) for the TIMP1 gene. PCR components used per sample were as follows: 11.5 µL of DdH2O, 2.5 µL of 10X PCR buffer, 1 µL of dNTP mix, 2 µL of MgCl2, 1.25 µL of forward primer, 1.25 µL of reverse primer, 0.5 µL of

Taq polymerase, 5 μL of DNA, 25 μL in total. The reaction conditions for amplification were as follows: 95°C for 5 min; 30 cycles of 95°C for 45 s, primer annealing for 45 s, and 72°C for 45 s; and a final extension at 72°C for 5 min. The primer annealing temperature was set to be 61°C for the MMP gene and 54.5°C for the TIMP1 gene. Following amplification, the PCR products (MMP9's 436 bp, TIMP1's 175 bp) were digested with the restriction endonuclease (MMP9- SphI, TIMP1- BssSI). Fragments were separated through electrophoresis in 6% agarose gel at 100 V for 120 min and visualized using ultraviolet transillumination after ethidium bromide staining. A single band at 436 bp represented C homozygous, two bands at 194-242 represented T homozygous, and three bands at 294-242-436 bp represented heterozygous for MMP gene. For the TIMP1 gene, a single band at 175 bp represented T hemizygous, and two bands at 20-155 bp represented C hemizygous. Additionally, 10% of the samples were sequenced using a next-generation system (Nextseq) to confirm the genotyping results. In the present study, the homozygous TT genotype group was no created because none of the participants had the TT genotype for the MMP9 -1562 C/T polymorphism.

Statistical analyses were performed with the SPSS software package (IBM SPSS Statistics for Windows, version 24.0. Armonk, NY). Results are presented as mean ± standard deviation except in the tables, and $p<0.05$ was considered for significant statistical difference. According to the results of the normality test (Shapiro-Wilk test), comparisons of physical and physiologic characteristics and comparisons of the measurements of the groups before acute exercise were performed using the Mann-Whitney U test. Comparisons of the measurements before and after the acute exercise in the same group were performed using the Wilcoxon test. Genotype and allele frequencies were calculated using the Hardy-Weinberg equation. Comparisons of genotype frequencies of the sedentary and athletic groups were performed using Pearson's Chi-square test. Comparison of the pre- and post-exercise measurements of the sedentary and athletic groups according to MMP9 -1562 C/T and TIMP1 372 T/C polymorphism genotypes was performed using three-way repeated-measures analysis of variance (ANOVA) [exercise (pre/post Yo-Yo IR1) x group (sedentary/athlete) x polymorphism genotype/allele group]. This study was planned by considering the power analysis results of a study with a similar number of participants in the literature (Whitehead, Schilling, Farney, & Bloomer, 2012).

Results and Discussion

General Evaluation

The BMI results of both groups were found within normal values. In the present study, CK, AST, ALT, IL-6 and CRP parameters, used as muscle damage and inflammation indicators (Koskinen et al., 2001; Presti et al., 2017), increased significantly in both the athletic and sedentary groups ($p<0.05$) independent of the specific polymorphisms. In the present study, the VO2max levels of all athletes were significantly higher than those of the sedentary individuals, indicating that chronic anaerobic training improved the endurance levels of the athletes due to the training adaptations. No statistically significant difference was found between the polymorphism and allelic frequencies of the sedentary and athletic groups ($p>0.05$) (Table 1). Because the plasma volume change found in the present study was less than 1%, no correction was made on the data (Table 2 and 3).

Table 1 The comparison of genotype and allele frequencies of MMP9 -1562 C/T and TIMP1 372 T/C polymorphisms

MMP9 -1562 C/T	Sedentary		Athlete		Total		$\chi 2$	p
	n	%	n	%	n	%		
Genotype								
CC	34	79.07	30	69.77	64	74.42	0.977	0.323
CT	9	20.93	13	30.23	22	25.58		
Allele								
C	77	89.53	73	84.88	150	87.21	0.834	0.361
T	9	10.47	13	15.12	22	12.79		
TIMP1 372 T/C Allele								
C	14	32.56	18	41.86	32	37.21	0.796	0.372
T	29	67.44	25	58.14	54	62.79		

Table 2 The comparison of hematocrit, erythrocyte and hemoglobin of the sedentary and athletic groups before and after the exercise belonging to MMP9 -1562 C/T polymorphism genotype groups

			Pre-exercise		Post-exercise					
			+sem	95% CI	+sem	95% CI	Effect	F	p	η2
Hct (%)	Sed.	CC	45.84±0.49	44.86-46.82	47.18±0.61	45.97-48.39	E	13.433	0.000*	0.141
		CT	46.02±0.95	44.12-47.92	47.34±1.18	44.99-49.7	G	1.438	0.234	0.017
							M	0.600	0.441	0.007
	Ath.	CC	44.89±0.52	43.85-45.93	45.56±0.65	44.27-46.85	E*G	0.215	0.644	0.003
		CT	45.5±0.79	43.92-47.08	46.89±0.98	44.93-48.85	E*M	0.300	0.585	0.004
							M*G	0.293	0.590	0.004
							E*G*M	0.564	0.455	0.007
RBC (10^6/µL)	Sed.	CC	5.34±0.08	5.19-5.5	5.4±0.08	5.24-5.56	E	33.312	0.000*	0.289
		CT	5.31±0.15	5.01-5.61	5.47±0.16	5.16-5.78	G	0.729	0.396	0.009
							M	0.002	0.969	0.000
	Ath.	CC	5.25±0.08	5.08-5.41	5.33±0.09	5.16-5.5	E*G	0.201	0.655	0.002
		CT	5.22±0.13	4.97-5.48	5.33±0.13	5.07-5.59	E*M	2.957	0.089	0.035
							M*G	0.018	0.894	0.000
							E*G*M	1.083	0.301	0.013
Hb (g/dL)	Sed.	CC	15.55±15.73	0.19-0.19	15.16±15.34	15.93-16.12	E	28.970	0.000*	0.261
		CT	15.54±15.97	0.37-0.38	14.8±15.21	16.29-16.72	G	0.835	0.363	0.010
							M	0.121	0.729	0.001
	Ath.	CC	15.3±15.51	0.2-0.21	14.89±15.1	15.71-15.92	E*G	0.503	0.480	0.006
		CT	15.35±15.61	0.31-0.31	14.74±14.98	15.97-16.23	E*M	2.043	0.157	0.024
							M*G	0.006	0.941	0.000
							E*G*M	0.975	0.326	0.012

*Sed.: sedentary, Ath.: athletic, sem: standard error of means *p<0,05 E: exercise, G: group, M: MMP9-1562 C/T polymorphism genotype group*

Table 3 The comparison of hematocrit, erythrocyte and hemoglobin of the sedentary and athletic groups before and after the exercise belonging to TIMP1 372 T/C polymorphism genotype groups

			Pre-exercise		Post-exercise		Effect			
			+sem	95% CI	+sem	95% CI		F	p	η2
Hct (%)		C	46.19±0.77	44.67-47.72	46.99±0.95	45.09-48.88	E	13.453	0.000*	0.141
	Sed.	T	45.73±0.53	44.67-46.79	47.32±0.66	46.01-48.64	G	2.195	0.142	0.026
							T	0.311	0.578	0.004
		C	45.36±0.68	44.02-46.7	46.46±0.84	44.79-48.13	E*G	0.231	0.632	0.003
	Ath.	T	44.86±0.57	43.73-46	45.6±0.71	44.18-47.02	E*T	0.146	0.704	0.002
							T*G	0.214	0.645	0.003
							E*G*T	1.027	0.314	0.012
RBC (10^6/µL)	Sed.	C	5.38±0.12	5.14-5.62	5.44±0.12	5.19-5.68	E	27.607	0.000*	0.252
		T	5.31±0.08	5.15-5.48	5.41±0.09	5.24-5.58	G	0.613	0.436	0.007
							T	2.099	0.151	0.025
	Ath.	C	5.37±0.11	5.16-5.58	5.49±0.11	5.27-5.7	E*G	0.314	0.577	0.004
		T	5.15±0.09	4.97-5.33	5.22±0.09	5.04-5.4	E*T	0.026	0.871	0.000
							T*G	0.911	0.343	0.011
							E*G*T	1.687	0.198	0.020

Hb (g/dL)	Sed.	C	15.81±0.3	15.22-16.4	15.9±0.3	15.3-16.5	**E**	23.083	0.000*	0.220
		T	15.42±0.21	15.01-15.83	15.72±0.21	15.3-16.14	**G**	1.141	0.289	0.014
							T	1.130	0.291	0.014
	Ath.	C	15.43±0.26	14.91-15.95	15.71±0.27	15.18-16.24	**E*G**	0.144	0.705	0.002
		T	15.23±0.22	14.79-15.67	15.42±0.23	14.97-15.87	**E*T**	0.479	0.491	0.006
							T*G	0.006	0.937	0.000
							E*G*T	2.693	0.105	0.032

*Sed.: sedentary. Ath.: athletic. *p<0.05 E: exercise. G: group. T: TIMP1 372 T/C polymorphism allele group*

Acute exercise effect on MMP9 and TIMP1

In the SG, serum MMP9 levels were higher after acute exercise (pre-exercise: 1771.15±862.17 pg/mL, 95% confidence interval (CI): [1505.81-2036.48; post-exercise: 2172.18±680.93 pg/mL, 95% CI: [1962.62-2381.74]; p<0.001. Serum TIMP1 levels were higher after acute exercise (pre-exercise: 4.63±3.99 ng/mL, 95% CI: [3.41-5.86], post-exercise: 5.3±3.51 ng/mL, 95% CI: [4.22-6.38]; p=0.005). For the MMP9/TIMP1 ratio, no differences were found in pre-exercise and post-execise levels (p>0.05).

In the AG, serum MMP9 levels were higher after acute exercise (pre-exercise: 1373.57±705.16 pg/mL, 95% CI: [1156.55-1590.58], post-exercise: 1723.72±733.88 pg/mL, 95% CI: [1497.87-1949.58]; p<0.001). Serum TIMP1 levels were higher after acute exercise (pre-exercise: 3.26±2.34 ng/mL, 95% CI: [2.54-3.98], post-exercise: 3.59±1.99 ng/mL, 95% CI: [2.98-4.21]; p=0.005). Regarding the MMP9/TIMP1 ratio, no differences were found in pre-exercise and post-execise levels (p>0.05).

Chronic exercise effect on MMP9 and TIMP1

Serum pre-exercise MMP9 levels of the SG were significantly higher than in the AG (p=0.046). Serum TIMP1 levels and MMP9/TIMP1 ratios were not statistically different between the SG and AG (p>0.05).

Evaluations according to MMP9 -1562 C/T polymorphism genotype groups

For the MMP9 -1562 C/T polymorphism, it was determined that genotype and any interaction with genotype had no statistically significant effect on the MMP9 and TIMP1 levels (p>0.05). It was determined that the effect of exercise, group, and genotype interaction on AST was statistically significant. The increase in post-exercise AST levels was higher in athletes with the CT genotype than that of sedentary individuals with the CT genotype. The comparison of all parameters of sedentary and the athletic genotype groups before and after the exercise belonging to the MMP9 -1562

C/T polymorphism are presented in Table 4.

Table 4 The comparison of parameters of the sedentary and athletic groups before and after the exercise belonging to MMP9 -1562 C/T polymorphism genotype groups

			Pre-exercise		Post-exercise		Effect			
			+sem	95% CI	+sem	95% CI		F	p	η2
MMP9 (pg/mL)	Sed.	CC	1778.1±136.61	1506.35-2049.85	2174.59±122.5	1930.9-2418.27	E	42.232	<0.001*	0.340
		CT	1744.87±265.51	1216.68-2273.06	2163.08±238.09	1689.44-2636.71	G	5.212	0.025*	0.060
							M	0.003	0.959	0.000
	Ath.	CC	1400.04±145.43	1110.73-1689.34	1672.68±130.41	1413.26-1932.1	E*G	0.003	0.958	0.000
		CT	1312.48±220.92	873-1751.96	1841.52±198.1	1447.43-2235.61	E*M	1.250	0.267	0.015
							M*G	0.031	0.861	0.000
							E*G*M	0.890	0.348	0.011
TIMP1 (ng/mL)	Sed.	CC	4.47±0.57	3.35-5.6	5.08±0.49	4.1-6.06	E	5.623	0.020*	0.064
		CT	5.24±1.1	3.05-7.43	6.12±0.95	4.22-8.01	G	5.925	0.017*	0.067
							M	0.285	0.595	0.003
	Ath.	CC	3.17±0.6	1.97-4.37	3.74±0.52	2.7-4.78	E*G	2.037	0.157	0.024
		CT	3.45±0.92	1.63-5.27	3.25±0.79	1.67-4.83	E*M	0.414	0.522	0.005
							M*G	0.450	0.504	0.005
							E*G*M	1.753	0.189	0.021
MMP9/TIMP1 (ng/mL)	Sed.	CC	1.36±0.26	0.85-1.87	1.38±0.2	0.98-1.79	E	0.167	0.684	0.002
		CT	1.24±0.5	0.26-2.23	1.05±0.39	0.27-1.83	G	0.023	0.881	0.000
							M	0.008	0.928	0.000
	Ath.	CC	1.23±0.27	0.69-1.77	1.1±0.22	0.68-1.53	E*G	0.637	0.427	0.008
		CT	1.39±0.41	0.57-2.21	1.51±0.33	0.86-2.16	E*M	0.008	0.931	0.000
							M*G	0.637	0.427	0.008
							E*G*M	1.276	0.262	0.015
AST (U/L)	Sed.	CC	21.06±1.3	18.47-23.65	23.71±1.4	20.92-26.49	E	112.887	<0.001*	0.579
		CT	17.56±2.53	12.52-22.59	18.89±2.72	13.47-24.31	G	0.447	0.506	0.005
							M	0.395	0.531	0.005
	Ath.	CC	19.63±1.39	16.88-22.39	21.9±1.49	18.93-24.87	E*G	3.397	0.069	0.040
		CT	20.77±2.1	16.58-24.96	24.15±2.27	19.64-28.66	E*M	0.047	0.830	0.001
							M*G	2.227	0.139	0.026
							E*G*M	7.195	0.009*	0.081

ALT (U/L)	Sed.	CC	21.35±2.13	17.11-25.59	23.2±2.34	18.54-27.86	**E**	34.209	<0.001*	0.294
		CT	14.22±4.14	5.99-22.46	17±4.55	7.94-26.06	**G**	0.530	0.469	0.006
							M	0.681	0.412	0.008
	Ath.	CC	19.4±2.27	14.89-23.91	21.9±2.49	16.94-26.86	**E*G**	0.062	0.804	0.001
		CT	20.69±3.44	13.84-27.54	23.23±3.79	15.69-30.77	**E*M**	0.337	0.563	0.004
							M*G	1.514	0.222	0.018
							E*G*M	0.289	0.592	0.004
CK (IU/L)	Sed.	CC	205.09±25.34	154.68-255.5	237.24±28.97	179.6-294.87	**E**	69.920	<0.001*	0.460
		CT	186.78±49.25	88.8-284.76	208.78±56.31	96.76-320.8	**G**	1.083	0.301	0.013
							M	0.591	0.444	0.007
	Ath.	CC	254.3±26.98	200.63-307.97	284.53±30.84	223.18-345.89	**E*G**	0.280	0.598	0.003
		CT	216.31±40.98	134.78-297.83	247.54±46.85	154.33-340.74	**E*M**	0.438	0.510	0.005
							M*G	0.032	0.859	0.000
							E*G*M	0.650	0.423	0.008
TC (mg/dL)	Sed.	CC	158.06±6.2	145.73-170.38	162.56±6.87	148.89-176.23	**E**	21.358	<0.001*	0.207
		CT	164.44±12.04	140.49-188.4	167.67±13.36	141.09-194.24	**G**	0.348	0.557	0.004
							M	1.071	0.304	0.013
	Ath.	CC	148.93±6.6	135.81-162.05	152.33±7.32	137.78-166.89	**E*G**	1.067	0.305	0.013
		CT	160.15±10.02	140.22-180.09	168.92±11.12	146.81-191.04	**E*M**	0.904	0.345	0.011
							M*G	0.185	0.669	0.002
							E*G*M	2.385	0.126	0.028
HDL-C (mg/dL)	Sed.	CC	47.09±1.8	43.51-50.67	50.24±1.83	46.59-53.88	**E**	98.075	<0.001*	0.545
		CT	49.11±3.5	42.15-56.07	52.67±3.56	45.58-59.76	**G**	0.148	0.701	0.002
							M	0.023	0.879	0.000
	Ath.	CC	50.23±1.92	46.42-54.04	52.77±1.95	48.88-56.65	**E*G**	0.379	0.540	0.005
		CT	48.38±2.91	42.6-54.17	51.77±2.97	45.87-57.67	**E*M**	0.977	0.326	0.012
							M*G	0.480	0.490	0.006
							E*G*M	0.121	0.729	0.001
LDL-C (mg/dL)	Sed.	CC	87.235±4.45	78.383-96.087	90.147±4.497	81.202-99.092	**E**	15.266	<0.001*	0.157
		CT	86.333±8.649	69.128-103.54	89.778±8.74	72.391-107.16	**G**	2.879	0.094	0.034
							M	0.092	0.762	0.001
	Ath.	CC	77.933±4.737	68.51-87.357	80.133±4.787	70.61-89.656	**E*G**	0.005	0.945	0.000
		CT	73.538±7.196	59.223-87.854	77.923±7.272	63.457-92.389	**E*M**	0.673	0.414	0.008
							M*G	0.042	0.837	0.001
							E*G*M	0.249	0.619	0.003

CRP (mg/L)	Sed.	CC	0.97±0.28	0.41-1.53	1.01±0.3	0.4-1.61	**E**	7.821	0.006*	0.087
		CT	2.24±0.55	1.15-3.33	2.38±0.59	1.2-3.56	**G**	1.413	0.238	0.017
							M	2.538	0.115	0.030
	Ath.	CC	1.1±0.3	0.5-1.7	1.14±0.32	0.5-1.78	**E*G**	1.651	0.202	0.020
		CT	1.15±0.46	0.24-2.06	1.17±0.49	0.2-2.15	**E*M**	1.057	0.307	0.013
							M*G	2.241	0.138	0.027
							E*G*M	1.927	0.169	0.023
IL-6 (pg/mL)	Sed.	CC	14.64±1.74	11.17-18.11	16.01±1.82	12.38-19.63	**E**	13.501	0.000*	0.143
		CT	18.14±3.39	11.39-24.89	19.75±3.54	12.7-26.79	**G**	1.307	0.256	0.016
							M	0.744	0.391	0.009
	Ath.	CC	18.74±1.89	14.98-22.49	20.59±1.97	16.67-24.52	**E*G**	0.421	0.518	0.005
		CT	19.27±2.82	13.65-24.88	21.66±2.95	15.8-27.53	**E*M**	0.158	0.692	0.002
							M*G	0.302	0.584	0.004
							E*G*M	0.024	0.878	0.000

*Sed.: sedentary, Ath.: athletic, sem: standard error of means *p<0,05 E: exercise, G: group, M: MMP9-1562 C/T*

Evaluations according to TIMP1 372 T/C polymorphism genotype groups

For the TIMP1 372 T/C polymorphism, it was determined that the allele and any interaction with the allele had no statistically significant effect on MMP9 and TIMP1 levels ($p>0.05$). The TIMP1 372 T/C polymorphism had a significant effect on TC and LDL-C levels and the individuals with C alleles had higher TC and LDL-C levels than those of individuals with the T alleles. The effect of exercise and allele interaction on LDL-C was found statistically significant. The amount of increase of LDL-C was higher in individuals with C alleles than that of individuals with T alleles. The LDL-C values of the SG were found to be higher than in the AG. IL-6 levels were found to be lower in the SG compared with the athletes. The comparison of parameters of the sedentary individuals and athletes before and after the exercise belonging to the TIMP1 372 T/C polymorphism allele groups are shown in Table 5.

Table 5 The comparison of parameters of sedentary and athletic groups before and after the exercise belonging to TIMP1 372 T/C polymorphism allele groups

			Pre-exercise		Post-exercise		Effect	F	p	η2
			$\bar{x}$+sem	95% CI	$\bar{x}$+sem	95% CI				
MMP9 (pg/mL)	Sed.	C	1834.83±208.38	1420.3-2249.36	2308.83±185.84	1939.12-2678.53	E	46.725	<0.001*	0.363
		T	1740.4±144.78	1452.38-2028.42	2106.21±129.13	1849.34-2363.08	G	9.698	0.003*	0.106
							T	0.932	0.337	0.011
	Ath.	C	1108.65±183.77	743.06-1474.23	1466±163.9	1139.95-1792.05	E*G	0.371	0.544	0.005
		T	1564.31±155.94	1254.1-1874.51	1909.29±139.07	1632.63-2185.95	E*T	0.286	0.595	0.003
							T*G	3.678	0.059	0.043
							E*G*T	0.180	0.672	0.002
TIMP1 (ng/mL)	Sed.	C	4.07±0.88	2.32-5.82	4.76±0.77	3.24-6.29	E	8.376	0.005*	0.093
		T	4.9±0.61	3.69-6.12	5.56±0.53	4.5-6.62	G	4.566	0.036*	0.053
							T	0.832	0.364	0.010
	Ath.	C	2.95±0.78	1.41-4.5	3.42±0.68	2.08-4.77	E*G	0.797	0.375	0.010
		T	3.48±0.66	2.17-4.79	3.72±0.57	2.58-4.86	E*T	0.145	0.704	0.002
							T*G	0.090	0.765	0.001
							E*G*T	0.072	0.789	0.001
MMP9/TIMP1 (ng/ mL)	Sed.	C	1.53±0.4	0.74-2.32	1.43±0.32	0.8-2.06	E	0.511	0.477	0.006
		T	1.25±0.28	0.7-1.79	1.26±0.22	0.82-1.7	G	0.181	0.672	0.002
							T	0.044	0.834	0.001
	Ath.	C	1.36±0.35	0.66-2.05	1.02±0.28	0.47-1.58	E*G	0.067	0.797	0.001
		T	1.22±0.3	0.63-1.81	1.37±0.24	0.9-1.85	E*T	2.703	0.104	0.032
							T*G	0.337	0.563	0.004
							E*G*T	1.096	0.298	0.013
AST (U/L)	Sed.	C	21.64±2.04	17.58-25.7	23.86±2.22	19.44-28.27	E	137.038	<0.001*	0.626
		T	19.69±1.42	16.87-22.51	22.14±1.54	19.07-25.21	G	0.115	0.735	0.001
							T	0.116	0.734	0.001
	Ath.	C	19.56±1.8	15.98-23.14	22.28±1.96	18.38-26.17	E*G	0.469	0.495	0.006
		T	20.28±1.53	17.24-23.32	22.8±1.66	19.5-26.1	E*T	0.001	0.970	0.000
							T*G	0.478	0.491	0.006
							E*G*T	0.266	0.608	0.003
ALT(U/L)	Sed.	C	18.07±19.93	3.36-3.67	11.39±12.62	24.75-27.23	E	40.190	<0.001*	0.329
		T	20.72±22.86	2.33-2.55	16.08±17.78	25.36-27.93	G	0.059	0.808	0.001
							T	0.117	0.733	0.001
	Ath.	C	19.78±23.22	2.96-3.24	13.88±16.78	25.67-29.67	E*G	0.780	0.380	0.009
		T	19.80±21.64	2.51-2.75	14.79±16.17	24.8-27.11	Z*T	0.812	0.370	0.010
							T*G	0.371	0.544	0.005

							E*G*T	1.650	0.203	0.020
CK (IU/L)	**Sed.**	C	176±39.49	97.45-254.55	198.5±45.1	108.78-288.22	**E**	91.989	<0.001*	0.529
		T	213.45±27.44	158.87-268.03	247.1±31.34	184.77-309.44	**G**	1.854	0.177	0.022
							T	0.617	0.435	0.007
	Ath.	C	233.83±34.82	164.56-303.11	267.61±39.77	188.49-346.73	**E*G**	0.223	0.638	0.003
		T	249.28±29.55	190.5-308.06	277.48±33.75	210.34-344.62	**E*T**	0.205	0.652	0.002
							T*G	0.183	0.670	0.002
							E*G*T	1.846	0.178	0.022
TC (mg/dL)	**Sed.**	C	174.36±9.41	155.64-193.08	179.86±10.51	158.95-200.76	**E**	23.729	<0.001*	0.224
		T	152.17±6.54	139.17-165.18	155.79±7.3	141.27-170.32	**G**	1.316	0.255	0.016
							T	5.068	0.027*	0.058
	Ath.	C	160.67±8.3	144.16-177.18	165.67±9.27	147.23-184.1	**E*G**	0.055	0.816	0.001
		T	146.32±7.04	132.31-160.33	151.36±7.86	135.72-167	**E*T**	0.219	0.641	0.003
							T*G	0.280	0.598	0.003
							E*G*T	0.238	0.627	0.003
HDL-C (mg/dL)	**Sed.**	C	50.79±2.77	45.28-56.29	53.93±2.82	48.32-59.53	**E**	112.220	<0.001*	0.578
		T	45.93±1.92	42.1-49.76	49.21±1.96	45.31-53.1	**G**	0.326	0.569	0.004
							T	2.618	0.109	0.031
	Ath.	C	51.06±2.44	46.2-55.91	54.28±2.49	49.33-59.22	**E*G**	0.392	0.533	0.005
		T	48.68±2.07	44.56-52.8	51.16±2.11	46.97-55.35	**E*T**	0.283	0.596	0.003
							T*G	0.192	0.662	0.002
							E*G*T	0.585	0.447	0.007
LDL-C (mg/dL)	**Sed.**	C	97.71±6.63	84.52-110.91	102±6.55	88.97-115.03	**E**	20.939	<0.001*	0.203
		T	81.9±4.61	72.73-91.06	84.31±6.55	75.26-93.36	**G**	4.779	0.032*	0.055
							T	9.918	0.002*	0.108
	Ath.	C	85.61±5.85	73.97-97.25	91.17±5.77	79.68-102.65	**E*G**	0.006	0.938	0.000
		T	70.12±4.96	60.24-79.99	71.04±4.90	61.29-80.79	**E*T**	5.108	0.026*	0.059
							T*G	0.009	0.924	0.000
							E*G*T	0.921	0.340	0.011
CRP (mg/L)	**Sed.**	C	0.64±0.44	-0.24-1.52	0.63±0.48	-0.32-1.58	**E**	4.243	0.043*	0.049
		T	1.53±0.31	0.91-2.14	1.61±0.33	0.95-2.27	**G**	0.005	0.946	0.000
							T	1.623	0.206	0.019
	Ath.	C	1.08±0.39	0.3-1.85	1.13±0.42	0.29-1.97	**E*G**	0.008	0.928	0.000
		T	1.14±0.33	0.48-1.8	1.17±0.36	0.46-1.88	**E*T**	0.704	0.404	0.009
							T*G	1.293	0.259	0.016
							E*G*T	2.476	0.119	0.029

IL-6 (pg/mL)	Sed.	C	12.92±2.67	7.6-18.23	14.16±2.81	8.57-19.75	E	13.998	0.000*	0.147
		T	16.56±1.86	12.86-20.25	18.06±1.95	14.18-21.94	G	4.669	0.034*	0.055
							T	0.029	0.865	0.000
	Ath.	C	21.88±2.42	17.05-26.7	23.36±2.55	18.29-28.43	E*G	0.405	0.527	0.005
		T	16.88±2	12.9-20.85	19.27±2.1	15.09-23.45	E*T	0.433	0.512	0.005
							T*G	3.332	0.072	0.040
							E*G*T	0.136	0.714	0.002

*Sed.: sedentary. Ath.: athletic. *p<0.05 E: exercise. G: group. T: TIMP1 372 T/C polymorphism allele group*

The main findings of the present study were that serum MMP9 and TIMP1 levels increased after the acute exercise (Yo-Yo IR1) in both the sedentary and athletic genotype groups (including the CG and AG) in line with our hypothesis, but which was independent of the MMP9 -1562 C/T (MMP9P) and TIMP1 372 T/C polymorphisms (TIMP1P) (unlike our hypothesis). Chronic anaerobic training decreased MMP9 levels in the athletes, but not TIMP1. In addition, the individuals with C alleles had a higher increase in LDL-C compared with those with T alleles, and the athletic genotype CT group had a higher increase in AST activity according to the sedentary CT group after acute exercise.

In the present study, acute exercise significantly increased MMP9 and TIMP1 levels together with serum CK, AST, and ALT activities, as well as CRP and IL-6 parameters used as indicators of muscle damage and inflammation markers, respectively (Koskinen et al., 2001; Presti et al., 2017), in both the athletic and sedentary groups (including the genotype groups) ($p<0.05$), like the literature (Kim & Lee, 2020; Koskinen et al., 2001; Presti et al., 2017).

Similarly, it was also shown that acute exercise significantly increased MMP9 and TIMP1 levels in skeletal muscle (Astill et al., 2017; Mackey, Donnelly, Turpeenniemi-Hujanen, & Roper, 2004). Furthermore, in a study involving short- and long-distance elite runners, participants were given a progressive step test that continued until exhaustion before and after 6-month intensive training periods. Although not statistically significant, MMP9 levels were higher in the initial period in the short-distance group. Also, MMP9 levels were found significantly higher immediately after acute exercise in the final period, like in the present study (Suhr, Rosenwick, Vassiliadis, Bloch, & Brixius, 2010). An increase in MMP9 were observed during the early inflammatory phase (Koskinen et al., 2001), thus the increase in MMP9 together with the above-mentioned inflammation markers confirm that inflammation occurred after the acute exercise. These data indicate that although the exercise duration in the present study was

shorter than in previous studies, acute intense exercise has an inflammatory effect similar to the mentioned exercises in the present study. Taken together, the present study's findings demonstrate that acute exercise increased serum concentrations of serum MMP9 and TIMP1 in response to the physiologic stress due to possible skeletal muscle damage and extracellular matrix regeneration. It is reported that intense exercise can induce muscle damage, cell membrane disruption, infiltration of inflammatory cells such as neutrophils and macrophages into the injury site, and degradation of the ECM by MMPs (Jacob et al., 2001; Madden et al., 2011; Presti et al., 2017), which can cause inflammation. ECM degradation following muscle damage can also reduce force transmission (Presti et al., 2017). However, it also facilitates the movement and regeneration of satellite cells (Chen & Li, 2009), which can lead to hypertrophy due to the result of training adaptations.

When the chronic effects of exercise are considered in the present study, the AG's serum basal MMP9 levels were significantly lower than the SG. This finding can show that chronic anaerobic training also improves the inflammatory response, similar to endurance training (Presti et al., 2017). Similarly, it was shown that after 12 weeks of training included aerobic, resistance, and balance exercises, MMP9 enzyme activity and the MMP9/TIMP1 ratio decreased (no difference in the present study) and TIMP1 enzyme activity increased significantly (Filipović et al., 2020). The difference between the studies in terms of the MMP9/TIMP1 ratio may be due to training methods. In another study, it was reported that endurance exercise increased MMP9 and TIMP1 levels and their activities in human skeletal muscle (Rullman et al., 2009).

However, unlike the above studies, Buyukyazi et al. (Buyukyazi et al., 2008) found no significant effect of 8-week walking (with approximately 62% maximum heart rate reserve) on MMP9 and TIMP1 levels and the MMP9/TIMP1 ratio in healthy postmenopausal women (unlike the present study) despite the participants' increased fitness levels. In this work, no significant relationship was found between serum MMP9 and TIMP1 levels and VO2max levels, thus it does not seem possible that the improved fitness levels in athletes may lead to lower MMP9 levels compared with sedentary individuals. It was reported that regular exercise generally led to lower MMP9 levels (Filipović et al., 2020; Suhr et al., 2010). These results are consistent with the present study. In studies investigating the chronic effects of exercise, factors such as the exercise history of the participants, the duration and intensity of the applied chronic exercise, and using the exercise protocol and nutrition habits of participants may cause inconsistent results. However, in the present study, the decrease observed in serum MMP9 levels in athletes compared with sedentary individuals

can be estimated as explained below. Acute intense exercise has an inflammatory effect, the reaction caused by this effect causes an increase in circulating MMP9. However, it was shown that regular aerobic training could provide anti-inflammatory responses and a decrease MMP9 (Presti et al., 2017). In the present study, positive correlations were found between MMP9 and TIMP1 in both pre-exercise and post-exercise values of sedentary individuals ($p<0.05$), but not in athletes. When the MMP9 values of sedentary individuals increase, TIMP1 values can also increase in response to inflammation. MMP9 activity is regulated by TIMPs (Kim & Lee, 2016; Presti et al., 2017), thus MMP9 activity can be inhibited by TIMP1 (Presti et al., 2017) because TIMP1 suppresses the substrate-degrading function of MMP-9 due to training adaptations (Alameddine, 2012). That is, maximal training sessions and regular training can cause training adaptations in athletes, but these adaptations can not be mentioned in sedentary individuals. Therefore, these interactions between MMP9 and TIMP1 parameters may have been reflected more clearly in sedentary individuals. The higher MMP9 values of athletes than in sedentary individuals may indicate that this balance is disrupted in favor of less muscle damage due to increased TIMP1 inhibition during chronic training. Therefore, these mentioned relationships confirm that chronic anaerobic training can improve MMP9 levels and its possible activity.

MMPs are produced by inflammatory cells and another cells considered as mediators of inflammation and they have a role in the pathophysiology of many inflammatory diseases such as CHD (Presti et al., 2017) as is characterized by increased circulating pro-inflammatory substances such as MMP9 and IL-6 and reduced anti-inflammatory substances such as TIMP1. The difference between these two factors shifting to the chronic inflammatory side paves the way for CHD (Ferroni et al., 2003; Presti et al., 2017). As is known, blood lipid and lipoprotein levels are also considered to be classic risk factors for CHD.

In the present study, it was found that individuals with the C allele of the TIMP1 372 T/C (rs4898) polymorphism had higher serum TC and LDL-C compared with the T allele group and a higher LDL-C increase after acute exercise. This cannot be discussed further because there is no study in the literature examining the relationship between the polymorphism mentioned and BLLPs. These findings are the first in the literature. In a study (Lorente et al., 2013), it was shown that patients with sepsis with the T allele of the TIMP1 372 T/C polymorphism had higher serum TIMP-1 levels and lower survival rates. In another study it was shown that the 372 T>C polymorphism (in the TIMP-1 gene) was not associated with CHD susceptibility and prognosis (Polina et al., 2018). In the same study the genotype and allelic frequencies of the TIMP1 372 T/C polymorphism

were not found to be different in patients with hearth failure compared with a healthy group. Likewise, over a 5.5-year period, there wasn't difference in deaths between patients with or without the T allele. As a result, the individuals with the C allele of the TIMP1 372 T/C (rs4898) polymorphism may be more genetically susceptible to CHD.

When MMP9 (rs3918242) is considered it is interpreted that the T allele of the MMP9 -1562 C/T polymorphism is a risk factor for early-onset coronary artery disease (Saedi et al., 2012). In a study, it was shown that MMP9 rs3918242 TT genotype was associated with elevated serum TG and LDL-C in Chinese patients with CHD (Xu et al., 2017). In another study, similar to the previous study, it was shown that the MMP9 rs3918242 T allele was associated with higher LDL-C levels (Mazzotti et al., 2014). Similarly, it was reported that MMP9 rs3918242 T allele carriers had high levels of MMP9 activity, LDL-C, TC (unlike the present study) and homocysteine. The findings of our study were different from these studies. Interestingly, these results for the MMP9 polymorphism in studies for BLLPs were similar to the TIMP1 polymorphism in the present study because there was no such finding of the MMP9 polymorphism in the present study. Our discussion is limited because no study in the literature has examined the polymorphism and exercise interaction like the present study. Therefore, the differences between the above studies may mainly be caused by the different phenotypic differences in different ethnic populations by the polymorphisms specified.

When exercise is considered, it causes the expression of anti-inflammatory and antioxidant substances in the vascular wall, which can block the atherosclerosis (Madden et al., 2011; Wilund, 2007). Unlike the present study, in a study by Fiotti et al. (2009), it was shown that exercise in older women increased body cell mass (BCM) and strength, and these changes were related to specific MMP genotypes (different polymorphisms from the present study). Up to 50% of adaptive processes in skeletal muscle strength are explained by genetic components (Fiotti et al., 2009). In the present study, serum CK and AST activities, which are considered to be the best indicators of muscle damage, increased significantly independent of these polymorphisms after acute exercise. However, the increased ratio in AST level in response to exercise was higher in athletes with the CT genotype than in sedentary individuals with the CT genotype. When these results are evaluated together, this finding can suggest that athletes with the CT genotype (of MMP9 polymorphism) are affected more by the muscle damage from exercise training due to a genetic tendency. That is, the CT genotype group may be more genetically susceptible to sports injuries. It is not possible to discuss this further because there is no other literature on this subject with which we can make comparisons. To the best of our

knowledge, this finding is also the first in the literature. Further studies are needed to fully elucidate the important findings obtained in the present study (increases in AST and LDL-C due to genetic tendency). Illumination of these trends may also contribute to the explanation of the mechanisms of CHD and sports injuries commonly observed in the Caucasian populations.

The number of participants in terms of the polymorphism may appear lower than in population studies in the literature because this study is an experimental study. The TIMP1 gene was evaluated on a single allele because all participants were male. However, to the best of our knowledge, this is the first study to investigate the roles of these genetic polymorphisms on MMP9 and TIMP1 level responses to acute exercise in specific groups of athletes and sedentary individuals. This research will serve as a basis for future studies; further experimental investigations are needed to estimate the role of these polymorphisms on MMPs and TIMPs. From this point of view, orienting individuals to sports branches that are genetically suitable and thus preventing serious sports injuries and AS could be provided.

These findings suggest that the acute exercise increased serum MMP9 and TIMP1 levels in all groups (independent of the polymorphisms). Chronic anaerobic exercise improved MMP9 levels. However, the athletic CT genotype group and C allele carriers may have a greater risk of sports injuries and atherosclerosis than other groups, respectively. Further studies are needed to clarify these findings.

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CHAPTER 3

THE STUDY ON THE RELATIONSHIP BETWEEN SOME BIOMOTOR ABILITIES OF TAEKW+ONDO ATHLETES AND THEIR LOWER EXTREMITY CIRCUMFERENCE-LENGTH MEASUREMENTS

Burakhan AYDEMİR[1],Duygu SEVİNÇ YILMAZ[2]

1 Karadeniz Teknik Üniversitesi, Rektörlük Beden Eğitimi Bölümü, Trabzon/Türkiye, burakhanaydemir61@gmail.com, ORCID:0000-0003-3922-3693
2 bErzincan Binali Yıldırım Üniversitesi, Spor Bilimleri Fakültesi, Antrenörlük Eğitimi Bölümü, Erzincan/ Türkiye, 24duygusevinc24@gmail.com, Gsm:0546 446 87 69, ORCID: 0000-0002-7737-564X

INTRODUCTION

Taekwondo that is an Olympic sport, is a branch of sports in which many athletes participate all around the world.[1] Because the number of athletes is high and it is an Olympic branch, competitive environment increases in this branch. Coaches, sports scientists, etc. focus on selecting athletes who are suitable for Taekwondo (TKD) branch in parallel with the increasing competition. For this, it is important to get detailed information about the athletes.[2]

Changes in the score values of the techniques applied in the TKD branch, narrowing of the playing field, changes in the rules[3] require the development of biomotor abilities as much as required.[2] It is known that many factors have contributions in the performance development of athletes. According to the information obtained from the literature, it is stated that physical characteristics are effective in determination of the athletes' performance as well as motoric characteristics.[4]

Biomotor characteristics are the basis of training and play an important role in determination of the athletes' performance. At the same time, determination of the physical and biomotor characteristics is important in terms of performance development of young and senior athletes.[5] While the performances of the athletes are being determined, the formation of the appropriate conditions and environment and their classification of them according to the branch enable us to make more accurate decisions more easily. It is known that the biomechanical analysis of the movements of the athletes, their body structures and anthropometric characteristics are among the factors affecting the performance directly.[6] The effect of anthropometric characteristics on the athletes' performance is discussed in the studies in the literature.

It is expected that this study will be an important source both in the selection of talented ones among the young athletes and as a criterion in the improvement of the performance of the elite level athletes for TKD sport that is widely done in our country and in the world. It is aimed to determine the relationship between some biomotor abilities of taekwondo athletes and their lower extremity circumference and length measurements in the light of the information that we have obtained from the literature and in order to contribute to the literature.

MATERIAL - METHOD

33 registered taekwondo athletes with red belt and higher belts, who are in the age group 14-16 (17 male, 16 female), participated in the study voluntarily. Athletes who participated in the study, do taekwondo do taekwondo exercise regularly for 2 hours, 2 days a week during 2 years. In order to perform the research, "Ethics Committee Report" was received with the decision number 08/03 taken at the session of Erzincan Binali Yıldırım University, Department of Human Researches, Health and Sports

Sciences Ethics Committee dated 20.10.2021 and number 08.

The study was carried out in accordance with the Principles of the Declaration of Helsinki13 and the parents of the participants were informed in order to carry out the study and a voluntary consent form was signed in order for the athletes to be included in the study.

In the physical measurements of the participants and their application, body analyzer (Tanita Bc 601 Innerscan) was used to determine weight, portable statiometer for measuring body height, document was used for age, back-leg dynamometer (Bravomed-Digital-4-digit LCD display) was used for back and leg strength, anthropometric set (Holtain) was used for length and circumference measurements, hand dynamometer (Bravomed-Digital 3-digit LCD display) was used for grip strength and chronometer was used for 20m sprint and illinois agility test. For circumference measurements, thigh, foot measurements were recorded. Leg, thigh, foot and fathom length measurements were taken from the lengths.

In the analysis of the data, descriptive analyzes were included in order to determine demographic characteristics of the athletes and to examine their distribution to the groups. Then, Kolmogorov-Smirnov normality analysis was made in order to determine conformity of the data to the parametric analysis. As the data distributed normally as a result of the analysis, Pearson Correlation analysis was made and significance level was found as $p<0,05$.

TABLE 1: Demographic Characteristics of the Athletes

Variable	**Group**	**Minimum**	**Maximum**	**Mean±SD**
Age (year)	Female	14	16	14.75±0.77
	Male	14	16	15.17±0.80
Body height (cm)	Female	150	172	159.81±6.25
	Male	135	184	166.35±13.20
Body weight (kg)	Female	40	57.60	48.14±5.72
	Male	40	67	53.64±8.15

Demographic characteristics of the athletes are seen on the Table 1. According to the table, the mean age of the athletes participating in the research is 14.75±0.77 years, their mean height is 159.81±6.25 cm, mean body weight is 48.14±5.72 kg.

FINDINGS

TABLE 2: Values Regarding Motor Performance and Circumference of the Male Athletes

		quadriceps (cm)	calf (cm)	Ankle (cm)
Grip strength (right)	r	-,150	,112	-,264
	p	,566	,669	,305
Grip strength (left)	r	-,118	,102	**-,**236
	p	,652	,696	,361
Leg strength	r	,467	,448	,071
	p	0,59	,071	,787
Back strength	r	**,489***	,405	,056
	p	**,046**	,107	,832
20m sprint	r	,389	,143	,123
	p	,122	,584	,637
Illinois agility tests	r	,345	,090	,204
	p	,176	,732	,433

p<.05* **p<.01****

As it is seen in Table 2, as a result of the analysis performed, it is seen that there is a medium level positive relationship between back strength and thigh circumference of male athletes.

TABLE 3: Values Regarding Motor Performance and Circumference Measurements of the Female Athletes

		quadriceps (cm)	calf (cm)	Ankle (cm)
Grip strength (right)	r	,090	,345	-,092
	p	,737	,190	,734
Grip strength (left)	r	-,069	-,057	**-,**267
	p	,799	,834	,317
Leg strength	r	,420	,218	**,640****
	p	,105	,418	**,008**
Back strength	r	,422	,341	,481
	p	,104	,196	,059
20m sprint	r	-,282	-,059	-,398
	p	,290	,829	,126
Illinois agility tests	r	-,378	,018	-,423
	p	,148	,948	,106

p<.05* **p<.01****

As it is seen in Table 3, as a result of the analysis performed, it is seen that there is a medium level positive relationship between leg strength and ankle circumference of female athletes. As leg strength increases, ankle circumference measurements also increase.

TABLE 4: Relationship Between Motor Performance and Length Measurements of the Male Athletes

		Leg Lenght	Thigh Lenght	Foot Lenght	Fathom Lenght
Grip strength (right)	r	**,548***	-,005	,347	**,772****
	p	**,023**	,983	,172	**,000**
Grip strength (left)	r	**,493***	-,092	,221	**,742****
	p	**,045**	,726	,394	**,001**
Leg strength	r	,405	,146	**,629****	**,560***
	p	,106	,576	**,007**	,019
Back strength	r	,367	,184	**,628****	,470
	p	,147	,480	,007	,057
20m sprint	r	-,309	-,017	,021	**-,483***
	p	,228	,948	,936	**,050**
Illinois agility tests	r	-,195	,003	,173	-,213
	p	,454	,991	,507	,411

p<.05* **p<.01****

As you can see in Table 4, as a result of the analysis made, it is seen that there is a medium level positive relationship between right-left grip strength and leg length of the male athletes, and a high level positive relationship between right-left grip strength and their fathom length. It is seen that there is a high level positive relationship between leg-back strength and foot length, and a medium level positive relationship between leg strength and fathom length. It was found that there was a medium level negative relationship between 20m sprint and fathom length.

TABLE 5: Relationship Between Motor Performance and Length Measurements of the Female Athletes

		Leg Lenght	Thigh Lenght	Foot Lenght	Fathom Lenght
Grip strength (right)	r	-,081	-,018	-,029	-,287
	p	,766	,947	,916	,282
Grip strength (left)	r	-,056	,099	-,079	**-,**337
	p	,835	,716	,770	,202
Leg strength	r	-,023	,000	,291	,358
	p	,933	,999	,274	,173
Back strength	r	-,176	-,114	,210	,163
	p	,513	,674	,436	,546
20m sprint	r	,002	,117	-,118	-,267
	p	,995	,666	,664	,317
Illinois agility tests	r	,120	,032	-,072	-,147
	p	,659	,908	,791	,587

p<.05* **p<.01****

As you can see in Table 5, as a result of the analysis made, it was not found any relationship between the motor performance and length measurements of the female athletes.

DISCUSSION

In this study conducted in order to determine the relationship between some biomotor abilities of TKD athletes and their circumference-length measurements, it is seen that there is a medium level positive relationship between back strength and thigh circumference of male athletes. A positive relationship was determined between biomotor abilities and length measurements of male athletes in other parameters except illinois agility test. It was determined in female athletes that there was a medium level positive relationship between leg strength, ankle circumference, but there was not any relationship in length measurements.

Bekmezci (2021) analyzed the effect of ankle mobility on performance in his study conducted on the taekwondo athletes. Agility, vertical jump and speed abilities were affected positively by high ankle mobility in the study. It was concluded in the study that high ankle mobility would affect the athletes' performance highly.[7]

According to Pekel et al., the performance curve between motor performance and development depends on anthropometric characteristics.[8] Examination of teenagers and children doing regular exercise and their development has been discussed in the researches for many years.[9] It is a great deal what kind of development process young people go through in their motor development processes in TKD sports that is popular in Turkey and in the world.[10]

It is stated in the literature that the increase in motor skills of males is faster between the ages of 7-17.[11] It is stated in another study that the heavy increase in motor skills in this age range is more effective in males.[12] These results are parallel with the data of our study.

In another study conducted in 2019, the effect of lower extremity lengths on agility was analyzed. In this study, it was not found any relationship between agility and anthropometric measurements of female and male TKD athletes. Data of this study data are parallel with our study.[13]

A high level positive relationship was found between leg strength and ankle circumference measurement in the female athletes. Foot techniques are used mostly in TKD competitions. The foot techniques that are used, require highly strong lower extremity muscles.[14] The use of foot techniques also requires the lower extremity to be in a way to gain a physical advantage over the opponent.

It was found that there was a positive relationship between motor performance characteristics of the male athletes and their lower extremity characteristics. Markovic et al. compared the athletes who won a medal and who didn't win a medal in their study conducted on 30 taekwondo

athletes in 2005. It was reported that the lower extremity strength of the athletes who won a medal was significantly different. According to the researchers, it was stated that lower extremity strength could be considered as a significant precondition in determination of the performance.[15]

Güder et al. found that width of the thigh circumference was connected with the strength and affected the maximum strength in their study conducted in 2016.[16] It has been reported in our study that there is a positive relationship between back strength and thigh circumference of male athletes. In the female athletes, it was not found any relationship between thigh circumference and thigh length.

Wazir et al. analyzed the differences between motoric characteristics and physical performance in their study conducted on 98 TKD athletes in 2019. As a result of the study, they found that the lower extremity strengths of successful athletes were higher in the successful athletes.[17] Results are parallel with our study. According to Baştürk, researching biomotor characteristics and kinanthropometry is important for development of the athletes and increasing their performance.[18]

Consequently, it was found that motor performance values and lower extremity measurement values of the young people engaging in TKD sports affected the performance positively. The findings obtained in the study are similar to the literature. It is thought that increasing the number of such studies will help coaches, sports scientists, etc. while selecting the athletes and monitoring the performance development.

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CHAPTER 4

A THEORETICAL STUDY AIMED AT EXAMINING THE RELATIONSHIP BETWEEN UNIVERSITY STUDENT'S PARTICIPATION IN RECREATIONAL ACTIVITIES AND ACADEMIC ACHIEVEMENT[1]

Mehmet Ali CEYHAN[2], Əjdər AĞAYEV[3]

1 This study was produced from the doctoral thesis named "Ali Məktəb Tələbələrinin Akademik Nailiyyətinin Və İxtisas Hazırlığı Keyfiyyətinin Yüksəldilməsində Tyutorluq Fəaliyyətinin Rolu" belonging to Mehmet Ali Ceyhan, which was completed under the supervision of Əjdər Ağayev.

2 Assistant Professor, Bayburt University, Faculty of Sport Sciences, Department of Physical Education and Sports Teaching, mehmetaliceyhan@bayburt.edu.tr

3 Professor, Azerbaijan State Pedagogical University

The purpose of modern education is to develop the individual as a whole, as a moral, high-quality, business-minded, socially useful person, and to help him to recognize himself. Towards this goal to assist students expected from modern education to develop themselves physically, mentally, psychologically and sociologically, providing the necessary services, both inside and outside the institution, so that they can effectively benefit from educational activities and develop themselves as a whole.

"The main purpose of some lessons taught in educational institutions is to identify an issue of determining the correct and operative ways out and problems arising from certain situations encountered in physical and social life. Developing the ability to find the right way out of the problems in time is one of the main objectives of these lessons. However, individual problems faced in a person's life are not the subject of any lesson." [1, p.11]

Social activities and cultural recreation, extracurricular activities play an important role in the educational process. These help the students develop comprehensively. Commitment to traditions, national affiliation, and faith is the essence of extracurricular activities. Participating in these activities helps students to develop special abilities, personal development, communicate with other students. Such activities increase the interest of the students in the subject and encourage them to work independently. These are as important as the lessons in the classroom. Many universities have a long-standing tradition that allows students to spend their lives more consciously and entertainingly.Self-confident people are ready to be more successful in his works. As a student succeeds, he works harder, learns more and gains more trust from those around him. Thus, the students spend more time in their lessons, social and recreational activities and become more active.

It should be borne in mind that it is necessary to eliminate the implementation of various efficient works in achieving success in education. Students should also be actively involved in social activities. Education is not just about classes taught in classrooms, there are also forms of extracurricular education. These are social, educational, and recreational activities such as club activities, sports, group walks, theaters, graduation nights, concerts. These activities are as important as the lessons in students' personal and professional development. Because by participating in such activities, the student has an opportunity to demonstrate and develop skills in class. Learns ways to work with colleagues with different skills and experiences. The ability to live together with individual differences is an essential factor in democratic life. The student learns and develops communication in different and new contexts. Discover ways effectively share their feelings, thoughts and experiences with others. Briefly, the student is better prepared for life by participating in on-campus and off-campus activities.

But most importantly, having a high level of education and professional knowledge, or success in life, depends on the success of students in the classroom and the level of learning, the development of effective teaching, and studying style. Because reading and studying effectively will give them more time.

It is possible to distinguish several leading directions during university years:

1. Educational activity. This includes participation in lectures and seminars, as well as practical training within the curriculum.

2. To assist in the organization of entertaining events in the cultural organization of the university, at the same time to participate personally, to develop and implement various projects, as well as to participate in the work of various creative teams. When examining the relationship between the participation of university students in recreational activities and their academic achievements, we focus on the cultural and organizational activities of students, and this direction characterized by the involvement of active students who are ready to work with a team, as well as the organizational leadership. It is possible to distinguish among this category of students not only participants and organizers of cultural and entertainment events but also scientific and practical conferences.

The participation of students in the cultural and entertainment life of the university to develop their characteristics, skills, acquire new useful habits, to be the center of attention, increase social connections, to see prospects for future employment, spend their free time effectively, and appears with a desire to earn extra income. Simultaneously, the students have the opportunity to travel to other cities and countries for free by participating in various events (entertainment, culture, business, etc.).

3. Scientific activities participating in conferences, scientific teams, writing science articles, conducting research. Students must be able to make decisions about the future. One of the first issues students are interested in their education is acquiring a specialty. Everyone thinks about the future and plans what you want to be when you grow up. Gradually this idea becomes even more specific. The whole educational process prepares young people for individual life. The chosen specialty is one of the main goals of life training. “What will I do after graduation?”, “Can I continue my education?”, “In what direction should I specialize?” questions deeply engage students’ brains. In search of answers to these and other questions, they decide in consultation with their parents, friends, some teachers, professionals, and tutors, and by participating in various

scientific conferences and organizations. While doing so, it is important to pay attention to one's talents, characters, interests and needs, current family situation, and the capabilities of society.

The modern university criticized on the one hand for its attempts to respond to the demands of the economy and the state, as well as for losing the existing educational ideas of the past.However, it is criticized for its inability to meet the pressing needs of postmodern society and its conservative ideas. Simultaneously, there are differences of opinion as to what the modern university can do to engage in activities. For example, Ortega I Gasset, Parsons, Dim, Clark, and others consider that the university should serve only vocational training. J.Derrid believes that the university's departure from "useful programs" and traditional vocational training will ultimately lead to less clear goals (such as politics).

"E. Pascarella "When determining success in higher education: Are We Even Close?" while examining the results obtained from the university, the article also examines the direction of the achievements of students and graduates". [2]

"A major achievement in understanding the problem of evaluating the success of university education was a proposal made in 1984 by The Study Group on the Conditions of Excellence in American Higher Education." [2] This idea was to use students' learning achievements and personal development as indicators of the institution's success. An approach to evaluating the educational performance of universities has emerged, which consists of identifying the achievements of students and graduates as an alternative to the principle of resource and reputation.

Although most universities find ways to achieve success and effective teaching, the term "success" has not received a definitive definition. The training outcomes are usually assessed the economic indicators such as the relative share of employed graduates, their type of employment and the amount of salary, as well as the employer's satisfaction with the graduate. Simultaneously, researchers and managers working in the field of higher education try assessing the basic educational outcomes, thinking skills, knowledge, as well as the proportion of those who continue their education. However, several concepts of success involve definite policies and practices in education. University can be achieved only when education, research activities and services are carried out in a safe environment, without violence, harassment, fraud, theft, violation and intimidation. It is necessary to create social conditions for the formation of university students as individuals. The psychological and social environment in the faculty or department must be very well regulated. In a globalizing world, universities are not only engaged in teaching and scientific activities but

also participate in the implementation and application of scientific activities. One of the most important conditions for this is to have the necessary conditions and to improve the quality of the activities they plan to conduct by these means. It is very important that the universities take steps in this regard. The success of the university is inextricably linked to the achievement of the students, as many higher education institutions are actively involved in research or consulting activities, but their main function is the education and socialization of students.

As mentioned above, a key indicator of a university's success is the experience and knowledge that students gain within the walls of the institution and how that experience and knowledge contributes to their success in professional and personal development. So, the success of the whole university is formed from the individual victories and achievements of its students and graduates. Therefore, a review of approaches to evaluating the performance of higher education institutions will be incomplete without understanding the diversity of areas that explain student success. Then, a student's success is determined by sociological, psychological, organizational, cultural and economic perspectives.

4. Sport life. This includes participation in sporting events and as participants in competitions. You don't have to stay away from sports to gain academic knowledge. It is possible to get an education and do sports. Exercise helps you succeed in education. Sport forms different qualities in students, teaches them patience, perseverance and determination, the joy of victory, learning from defeat.

The modern student is more interested in the benefits and applicability of the knowledge given at the university, rather than the authenticity. Acquiring practical skills while studying at the university is the key to successful employment of university graduates. The interest in the formation of emotional intelligence in higher education, the degree of development of this psychological characteristic of a person has a positive effect on the motivation of students to study at a university, to achieve academic results in education. Students with a high level of emotional stability, the ability to adequately comprehend and manage the experiences of themselves and others, are more successful in acquiring professional skills and, as a rule, communicate better. Student employment is used in a broader sense, including participation in extracurricular activities and the design of the teaching process.

University recreation programs play a solemn role and importance for university youth. Recreation is a part of university life. "Today, every student who spends most of their time in classrooms, labs, or desks should rest. For this reason, the action programs of universities should create con-

ditions for students to relax, reduce the tiring pace of modern life and the intensity of education." [3, s.2]

Because of students' inability to participate in recreation, cultural and mass activities, physical-physiological, psycho-social problems may arise. This can negatively affect students' consciousness, socialization, communication, problem-solving skills, and academic success.

It is important to create centers in universities that will allow students studying academically to participate in social, cultural and sports activities. These centers will contribute to the academic success of young people by increasing their social, cultural and sports success. "In particular, areas for leisure activities on university campuses should be increased and improved. Interest in recreational activities should be increased by providing information on the topic for related activities.Additionally, recreational courses should be added to the relevant curriculum of all education departments, with a special emphasis on the practical part of the courses." [4] This situation will increase students' interest in recreational activities.

During the study period, it is essential to test your strength in various fields of activity and to have the opportunity to be a performer, team member, leader, organizer, and coordinator. The cultural and organizational life of the university creates such opportunity.Students not only enjoy participating in various activities but also learn to work in a team. They understand that only by uniting can they achieve their goals, but also gain invaluable experience and professional skills, which it will also allow them to find a job, get a job in the future and take a high position in society.

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CHAPTER 5

THE RELATIONSHIP BETWEEN YOUTH SOCCER PLAYERS PHYSICAL FITNESS LEVELS AND TECHNICAL SKILLS IN SMALL-SIDED GAMES PLAYED IN DIFFERENT TYPE[1]

Çağlar EDİS[2], Faik VURAL[3], Saadet Rana VAROL[4]

1 Bu araştırma danışmanlığını Prof.Dr. S. Rana VAROL'un Yaptığı, Ege Üniversitesi, sağlık Bilimleri Enstitüsünde Doktora Öğrencisi Olan Çağlar EDİS'in '' Denge, çeviklik, dayanıklılık ve kuvvet yetileri ile futbol pas tekniğinin, futbol müsabakası sırasındaki teknik becerileri etkileme düzeylerinin incelenmesi'' adlı Doktora Tezinden üretilmiştir.

2 Doktor Öğretim Üyesi, Trabzon Üniversitesi Spor Bilimleri Fakültesi, 0000-0001-7784-367X.

3 Profesör Doktor, Ege Üniversitesi Spor Bilimleri Fakültesi, 0000-0002-9196-984X

4 Doktor Öğretim Üyesi, Ege Üniversitesi Spor Bilimleri Fakültesi, 0000-0001-6002-8724.

Introduction

Many training methods are applied in different formats in order to ensure the development of soccer players' technical and physical performance in training. Small-sided games (SSG) are one of the most frequently used methods in training for the development of both technical and physical skills development, so it differs from training method in running formats training (Bennett et all., 2018). Also SSG are applied by coaches to increase the cooperation between soccer players, besides, it is stated that the coaches decide on the strategy and mentality of this cooperation, and that the games are applied with different rules for this purpose (Katis & Kellis, 2009). However, it is known that many external factors variables have different acute effects in the application of small sided games (Hill-Haas, Dawson. Impellizzeri & Coutts, 2011; Fernandez-Gonzalo et all., 2010), (field dimensions, ball contact restrictions, player numbers, coach verbal motivation), but there seems to be very little research on internal factors in the literatüre (Fernandez-Gonzalo et all., 2010; BenOunis et al., 2013; Edis, Vural & Vurgun, 2016). For example, external factors such as the number of players, field sizes and rule changes affect the results of the game intensity and that has been studied frequently in the literature. It is seen that with the decrease in the number of players, the physical stress of the game increases and the chance to apply more technical skills is revealed (Köklü, Asçı, Koçak, Alemdaroglu & Dündar, 2011). While SSG areas keeping constant and the number of players increases has been observed to reduce the physiological stress of the game, it has been revealed that the athletes play more contact games with quicker decision making and less dribbling in games played in a small area (Köklü, Albayrak, Keysan, Alemdaroğlu & Dellal, 2013). Similarly, it is seen that different technical and physiological results occur when the number of contact with the ball of the games is limited. In different uses of ball contact numbers; in games played with 4:4 players, it was found that the free ball contact rule reduced high-intensity runs, while it was found that the athletes applied more technical skills such as tackle in these games. In addition, it was determined that athletes performed more high-intensity runs in these games, while technical skills results were negatively affected (Dellal, Lago-Penas, Wong & Chamari, 2011). As seen in the researches, changes in the game rules affect the technical actions and physiological stress of the soccer players. In order for the trainers to put into practice the game strategy they want in parallel with these results, it helps them to get more efficiency from the games they have designed for the aim by predicting all the external details in the games. In the literature, it is stated that the results that can be obtained from the SSG by using external factors are clearly, and it is emphasized that the games should be selected very carefully in order for the performance gains of these games to be at the optimal level. In addition, although there

is no systematic study in research in terms of technical skills, and they revealing and understanding many technical skills variables in detail can benefit more from technical skills in SSG (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). In addition the physical preparedness of athletes for this game is also important before starting SSG and it is necessary to be physically preparedness for the technical-tactical components in the soccer game (Lacome, Simpson, Cholley, Lambert & Buchheit, 2018). The technical analysis during the competition in the research on this subject, it is seen that many technical skills applied together with movement analysis are related to the physical fitness levels of soccer players (Fernandez-Gonzalo et all., 2010; BenOunis et al., 2013; Edis, Vural & Vurgun, 2016). These lots of physical fitness levels; there are correlations between maximal oxygen consumption ($\dot{V}O_{2max}$), postural control, strength and change of direction runs (COD) and the level of applying technical skills. However, it is seen that there has been limited research on SSG involving internal factors (Edis, Vural & Vurgun, 2016). In this study, the application of different external factors was applied to reveal the relationships between the internal factors of the athletes, such as acute $\dot{V}O_{2peak}$, strength, COD and postural control levels, between technical skills practices in 3:3 player games played in a large and small area with free ball touch and two touch ball contacts. As a result of the research, while the trainers design the games according to their goals, many acute physical fitness levels 3:3 and it will enable us to predict which technical skills the games applied in different variety may be related to and thus have more efficient results 3:3 will be able to help design small-sided games.

Participants, Materials and Methods

24 amateur male soccer players were included in the study. They had been training for at least 3 years (4 training sessions [2 ± 0.5 h per training] and 1 official match per week). The study was designed according to the rules and principles of the Declaration of Helsinki and approved by the University Ethics Committee.

This research was designed on the assessment of acute performances under a single measurement method. All tests were carried out within a 3-week period. In the first week of this period, anthropometric measurements, static postural control (Pc), Illinois change of directions run, 1 repetitions maximal (1RM) squat, lower extremity neuromuscular power and $\dot{V}O_{2peak}$ test were applied, respectively, in the last 2 weeks of the SSG games performed. Large area and small area games were performed with 2 days intervals. During the weeks when the athletes participated in this study, they only participated in tactical training after measurements. In addition, the athletes did not perform postural control, strength, COD and

endurance training during the weeks of the study. Verbal motivation was provided in order to get full efficiency from the athletes in all tests except postural control. In the postural control test, in order not to distract the focal points of the athletes and to ensure their postural control, the tests were carried out in an environment without sound and visual misleading to disrupt their concentration.

Week 1. Day 1 .: Postural Control Tests

Postural control tests of the athletes were performed with the Tekscan (Tekscan Inc. Soth Boston. MA. USA) postural control measuring device (detection area 487.7 x 447.0 mm. 4 sensors per cm^2. Pressure ratio 862 kPa. Mat height 0.57 cm). Postural control levels for 2 × 30 seconds over the centre of pressure (CoP) applied on the mat, postural sway velocity (CoPvel), postural sway variation (CoPvar), right-left postural sway (CoPml), anterior-posterior postural sway (CoPap)), postural sway area (CoParea), and the distance between points of postural sway (CoPdist) were calculated by the device. Tests are conducted with dominant (d), nondominant leg (nd) and bipedal (double legs with eyes closed and eyes open) (eo. ec). The procedure for applying postural control tests was carried out one-on-one similar to previous studies in the literature (Brenton-Rule, Bassett, Walsh & Rome, 2011; Edis, Vural & Vurgun, 2016).

Week 1. Day 2.: Illınoıs COD Test

The Illinois COD test was applied as indicated in the studies in order to obtain the athletes' running skills in change of direction (Šimek, Milanovic & Jukic, 2008). COD performances were recorded with an electronic timing system (Newtest Oy. Oulu. Finland. Powertimer 300-series). The best performance time in the test, which was applied as a total of 3 trials and 3 minutes of passive rest between each trial, was assessment in statistical analysis.

Week 1. Day 3.: Strength Tests

Brzycki method was used to measure the 1RM that athletes can lift on the squat equipment (Brzycki, 1993). In the first stage, a 10 cm apparatus was placed under the heels of the athletes to prevent their torso from flexing in the squat test. Later, the feet were positioned shoulder-width apart. Then, an adjustable stand was used to determine the squat alignment, and the squat alignment where the athletes would settle when the femur was parallel to the floor plane was determined. During the test, the athletes performed concentric contraction and the movement of standing up when the hip touched the stand. The athletes squatted with the sound of the metronome coming from outside, at a tempo of 2:0:1:0 (eccentric, isometric, concentric, respectively) until they were exhausted. The amount

of load used and the number of repetitions performed by the athletes was used in the equation of 1 Maximal Repetition, and 1RM of the athletes was calculated by Brzycki method.

Week 1 Day 4: Strength Power Performance

The countermovement jump test was used to measure the neuromuscular strength of the lower muscle groups (hands-on-waist squat position (Sj), the free jump where athletes feel most comfortable and perform naturally (Fj), and the jump immediately after a sudden squat without swinging their arms (Nasj)). The test was carried out on a special electronic jump platform (Newtest Oy. Oulu. Finland. Powertimer 300-series). The test equipment calculated each measurement itself and recorded the results in watts (w) and jump height (cm). Tests were applied as 3 sets with one repetition of each jump form with 45 seconds of passive rest between sets. The best values between repetitions were evaluated statistically.

Week 1 Day 5: Yo-Yo Intermittent Recovery Test Level 1

YYIR1 test was performed according to the protocol implemented by Bangsbo, Iaia & Krustrup. For the test, groups with a maximum of 6 soccer players were formed and the protocol was applied. Calibration of the sound system was performed before the testing of each group. In the test, the athletes who could not reach the designated areas twice in a row were warned and the tests of the athletes were ended with the third warning. The total distance covered by the athletes was estimated by using indirect method by placing $\dot{V}O_{2peak}$ (mL·min-1·kg-1) levels in the equation (Bangsbo, Iaia & Krustrup, 2008).

Week 2 and 3: Small-sided Games

Two different sizes area for 3:3 SSG: small [20×15 = 300 m^2 (1:50 m^2 pitch ratio per player)] and large [20×30 = 600 m^2 (1: 100 m2 pitch ratio per player)] used (Köklü, Albayrak, Keysan, Alemdaroğlu & Dellal, 2013). SSG in these two different areas; It was carried out in 2 different game types, with 2 ball contact and free ball contact rule. The 3-sided games were run in 4x3 minute play and with 3 minutes rest periods between sets. During the games, the maximal heart rate (%HRmax) of the players was continuously monitored and the rate of perceived exertion (RPE) after each game was noted. In addition, the offensive and defensive technical actions in each game were evaluated as technical skills.

Technical Data of the SSG

All games were recorded with a video camera (Sony Handycam. DCR-SR15) positioned at a height of 2-m outside the area parallel to the center of the playing field. Then, the video recordings were transferred to

the computer and the technical skills of all games were analyzed with the match analysis program Muna (Muna Analysis. 2006). During the games; successful tackle ($Tackle_s$), unsuccessful tackle ($Tackle_{uns}$), successful dribbling past ($Dribbling\ past_s$), unsuccessful dribbling past ($Dribbling\ Past_{uns}$), successful shot ($Shot_s$), unsuccessful shot ($Shot_{uns}$), successful pass ($Pass_s$), unsuccessful pass ($Pass_{uns}$) parameters were evaluated for analysis as technical skills.

Statistical Analysis

The distribution of data was examined using Shapiro-Wilks normality test. Being unsure of the normality of the distribution, the values (technical skills, $\%HR_{max}$ and RPE) after the games within 4 different types of small-sided games were examined by the Wilcoxon signed-rank test and expressed in median values. Effect sizes were calculated as follows: $= Z/\sqrt{N}$. In order to determine the relationship between the variables between technical skills and physical fitness levels the appropriateness of the variables to the normal distribution was evaluated using the Shapiro-Wilk Test and correlation analysis was performed to determine the relationship between variables. Postural control, COD, $\dot{V}O_{2max}$, St (1RM squat and counter movement jump) and the relationship between soccer technical skills parameters in SSG were evaluated with Pearson and Spearman correlation analysis. Statistical analyses were performed using PASW Statistics 25 (SPSS Inc, Chicago, IL) software and alpha levels were set at $p< 0.05$.

Results

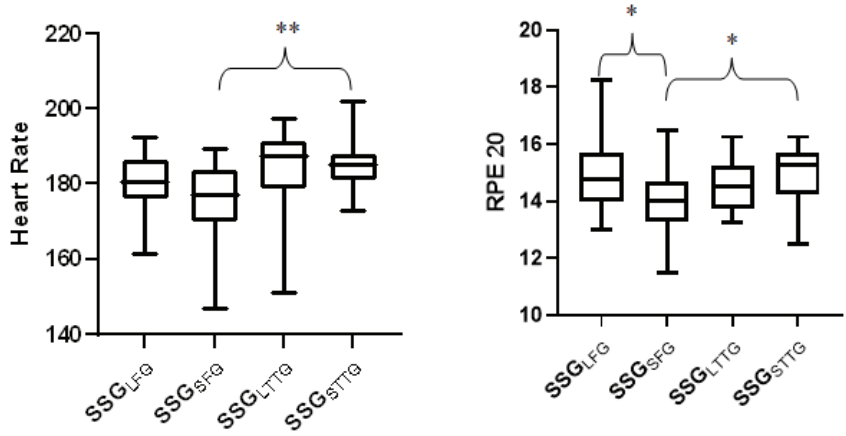
The physical data of the sample of 24 football players show to in Table 1.

Table 1. Descriptive statistics of the sample (n=24) physical measurement data.

	Min.	Max.	$\overline{X}$ ± Ss
Age	16	17	16,41±0,50
Body Height	152.00	191.00	175.88±0.078
Body Mass	39.50	85.00	63.05±9.09

Graph 1. shows the $\%HR_{max}$ and RPE values of 24 participants. While the $\%HR_{max}$ between SSG_{SFG} and SSG_{STTG} ($z= -3.601$, $p= .000$, $r= -0.51$) were found to be different, in terms of RPE, SSG_{SFG} and SSG_{STTG} ($z= -2.034$, $p= .042$, $r= -0.29$) and there was a statistical difference between SSG_{SFG} and SSG_{LFG} ($z= -2.803$, $p= .005$, $r= -0.40$). There were no statistical differences in the number of $\%HR_{max}$ and RPE values in other games ($p> 0.05$).

Graph 1. Comparison of soccer players' $\%HR_{max}$ and RPE



SSG_{LFG}: small-sided games large field free ball touch game. SSG_{SFG}: small-sided games small field free ball touch game SSG_{LTTG}: small-sided games large field two ball touch game. SSG_{STTG}: small-sided games small field two ball touch game.

In the data in Table 2, the results and comparisons number of technical skill for 24 participants in SSG are shown. It is seen that the games played in the SSG small area have a higher number of technical skills than the games in the larger field. In addition, with the change of the game rules, it has been revealed that there are more technical skills in limited ball contact games than free games and there is statistical significance between them.

Table 2. Comparison of technical skill applications in SSG

	SSG_{LTTG} vs. SSG_{LFG}				SSG_{STTG} vs. SSG_{SFG}				SSG_{SFG} vs. SSG_{LFG}			SSG_{STTG} vs. SSG_{LTTG}		
	M	**Z**	**p**	**r**	**M**	**Z**	**p**	**r**	**Z**	**p**	**r**	**Z**	**p**	**r**
Pass	24.50 17.50	3.888	.000	0.56	29.50 19.00	3.874	.000	0.55	1.741	.082	0.25	.873	.383	0.12
Shot	6.00 4.00	2.477	.013	0.35	5.00 4.00	1.483	.138	0.21	.200	.841	0.02	1.309	.190	0.18
Dribble Past	0.00 3.00	4.087	.000	0.58	1.00 3.50	3.607	.000	0.52	.771	.441	0.11	1.109	.267	0.16
Tackle	1.50 3.00	2.380	.017	0.34	1.50 2.00	1.779	.075	0.25	.248	.804	0.03	.582	.561	0.08
Ball interventions	7.00 3.00	3.449	.001	0.49	7.00 6.00	1.370	.171	0.18	3.501	.000	0.50	1.510	.131	0.21
Ball control	1.00 1.50	1.966	.049	0.28	2.00 1.00	-962	.336	0.13	3.301	.001	0.47	0.572	.567	0.08
Ball lose	6.00 1.50	4.203	.000	0.60	4.00 3.00	1.392	.164	0.20	2.033	.042	0.29	2.149	.032	0.31

SSG_{LFG}: small-sided games large field free ball touch game. SSG_{SFG}: small-sided games small field free ball touch game SSG_{LTTG}: small-sided games large field two ball touch game. SSG_{STTG}: small-sided games small field two ball touch game.

When reading the findings, it should be taken into account that the negative correlations results of postural control and COD values with successful technical skills in the tables containing correlations indicate

that the number of successful technical skills of athletes who provide a better postural control values has increased. The fact that $\dot{V}O_{2peak}$ values and strength values are positively correlated with successful technical skills means that athletes with high aerobic endurance capacity apply more successful technical skills.

Table 3. Correlations between SSG_{SFG} technical skills and physical fitness.

	COD	1RM	$\dot{V}O_{2peak}$	Fj	CoP_{ecarea}	CoP_{ecvel}	CoP_{ecvar}	CoP_{ecap}	CoP_{ecml}
$Pass_{s}$	-.114	-.437*	.258	.097	.019	-.012	-.072	-.234	-.114
$Pass_{Uns}$	-.044	.173	.016	.020	.079	-.002	.028	.523**	-.181
Dribble $Past_{s}$	-.327	-.174	.304	.231	-.457*	-.026	-.062	-.380	-.426*
Dribble $Past_{Uns}$	-.332	.305	-.242	.214	-.206	-.317	-.286	-.249	-.123
$Tackle_{s}$	-.238	.009	-.040	.087	.038	-.119	-.114	.006	.215
$Tackle_{Uns}$	-.106	.167	-.073	-.009	.051	.009	.021	.145	.121
$Shot_{s}$	.005	-.024	-.201	-.300	.273	-.170	-.127	.199	.216
$Shot_{Uns}$	-.099	-.115	.225	-.042	.137	.259	.229	.282	.012

p<0.05*

COD: change of directions. 1RM: 1 repetition maximal. $\dot{V}O_{2peak:}$ maximum oxygen consumptions capacity, Fj: Free Jump. $CoP_{ecarea:}$ centre of pressure eyes close area. $CoP_{ecdist:}$ centre of pressure eyes close distance $CoP_{ecvel:}$ centre of pressure eyes close velocity. $CoP_{ecvar:}$ centre of pressure eyes close variations. $CoP_{ecap:}$ centre of pressure eyes close anterior-posterior. $CoP_{ecml:}$ centre of pressure eyes close medial-lateral.

Table 3 shows the relationships between technical skills and physical fitness levels of 24 players in SSG_{LFG} and SSG_{SFG}. SSG_{LFG} a significant relationship between the athletes' $Pass_{uns}$ numbers and CoP_{eoap} (r= .523**). Among the postural control values and technical skills in the data not included in the table; while $Pass_{s}$ and CoP_{ecarea} (r= .412*) and Ball loss (r= .458 *) and $Tackle_{uns}$ (r= .604**) between CoP_{ecap} (r= .503*) were relationships. In addition, positive correlation were between $Tackle_{uns}$ and CoP_{ecarea} (r= .461*). Negative correlation between CoP_{dap} and $Pass_{s}$ (r= -.425*), CoP_{darea} and Dribble $past_{s}$ (r= -.418*) were detected. Relationships between CoP_{ndap} and $Pass_{uns}$ (r= .414*), unsuccessful CoP_{ndvar} and Ball control (r= -.416), successful CoP_{ndarea} and Ball control (r= -.406*) have detected from the nondominant leg postural control values. Jump performance and technical skills were relations (r values between .405* and .564**). There was no relationship between other physical fitness values and SSG_{LFG} technical data (p> 0.05). In the SSG_{SFG} games significant relationships have detected between the athletes' $Pass_{s}$ in these games and their COD skills (r= -.524**). In correlation analyzes not included in the table, negative correlations were detected between $Pass_{s}$ and the postural control values of CoP_{eodist} (r= -.450*), CoP_{ecvel} (r= -.450*) and CoP_{ecvar} (r= -.443*). CoP_{eoml} with Ball lose (r = .419*), CoP_{ecarea} with $Tackle_{s}$ (r= .604**) and CoP_{ecap} (r= .530**), CoP_{darea} with successful ball controls (r= -.428*) and statistical relationships between CoP_{dml} (r= -.501*) have detected. A statistical significance has founded between the $shot_{s}$ and the strength values of Nasjp (r= .435*) in

these games. There were no statistical relationships between other physical fitness values and SSG_{SFG} technical data (p> 0.05).

Table 4. Relationships between technical skills in SSG_{STTG} games and Physical Fitness values

	COD	1RM	$\dot{V}O_{2peak}$	Fj	CoP_{darea}	CoP_{dvel}	CoP_{dvar}	CoP_{dap}	CoP_{dml}
$Pass_{S}$	-.244	-.497*	.028	.097	-.392	-.020	-.127	-.406*	-.407*
$Pass_{Uns}$	-.014	.095	.264	-.070	-.151	-.386	-.419*	-.266	.067
Dribble $Past_{S}$	-.238	-.062	-.146	-.053	.341	.024	-.062	.041	.298
Dribble $Past_{Uns}$	.221	-.113	-.072	-.263	-.236	.195	.211	-.139	.085
$Tackle_{S}$	-.385	-.270	.120	-.096	.154	.228	.072	.070	-.032
$Tackle_{Uns}$	.583**	-.359	-.283	-.241	-.425*	-.117	.012	-.228	-.257
$Shot_{S}$	-.072	.012	-.316	-.258	-.101	.241	.241	.004	.096
$Shot_{Uns}$	.078	.205	.069	.044	.021	-.209	-.209	.124	-.106

p<0.05*

COD: change of directions. 1RM: 1 repetition maximal. $\dot{V}O_{2peak:}$ maximum oxygen consumptions capacity. Fj: Free Jump. $CoP_{darea:}$ centre of pressure dominant leg area. $CoP_{ddist:}$ centre of pressure dominant leg distance $CoP_{dvel:}$ centre of pressure dominant leg velocity. $CoP_{dvar:}$ centre of pressure dominant leg variations. $CoP_{dap:}$ centre of pressure dominant leg anterior-posterior. $CoP_{dml:}$ centre of pressure dominant leg medial-lateral.

Table 4 shows the relationships between soccer players' technical skills practices in SSG_{STTG} and $SSG_{LTTG,}$ in SSG_{STTG} games and their physical fitness values. In these games, significant correlations detected between soccer players' COD skills and their $Tackle_{uns}$ (r= .583**). In correlations between postural control and technical skills not included in the table; CoP_{eodist} (r= -.431*), CoP_{ecvel} (r= -.431*) and CoP_{ecvar} (r= -.407*) with $Shot_{uns}$, CoP_{eodist} with successful ball controls (r= .443*), CoP_{eovel} (r = .443*), and CoP_{eovar} (r= .436*), relationships have detected between unsuccessful Ball control and CoP_{eovar} (r= .421*). Among other technical skills applications and strength values were correlated (r values between .411* and .526**). There was no correlation between other physical fitness values and SSG_{STTG} technical data (p> 0.05).

Successful ball intervention in SSG_{LTTG} games not included in the tables with CoP_{ecvar} (r= -.417*), CoP_{ecml} (r= -.411*), $Tackle_{s}$ with $\dot{V}O_{2peak}$ (r= .404*) and $Tackle_{uns}$ with COD (r= .414*) have detected. There were no statistical relationships between other physical fitness values and SSG_{LTTG} technical data (p> 0.05).

Discussion

It was applied in order to reveal whether the technical skills of the athletes were in relation with the physical fitness levels by applying different game rules due to the limited number of studies examining the relationship between technical skills in SSG and internal factor levels. In the main findings of the study, in games played with the free ball contact

rule in an area of 100 m^2 per athlete, the anterior-postreior and right-left (CoP_{ap}-CoP_{ml}) of the postural control were played in 50 m^2 of the field, and the CoP_{ap}-CoP_{ml} postural control data as well as the mean value of the postural sway in all directions data (CoP_{vel}-CoP_{var}) and COD characteristics are in significant correlations with technical skills due to the requirement to play faster due to the nature of the game at 50 m^2, the limitation of ball touches and the increase in the $\%HR_{max}$ and RPE, the $\dot{V}O_{2peak}$ levels of soccer players are in correlation with technical skills has been determined.

It has been determined that the in the SSG_{LFG} $\%HR_{max}$ and RPE in the games are played with higher intensity than SSG_{SFG}, and SSG_{STTG} and SSG_{LTTG} games are played with higher intensity than SSG_{SFG} games. In studies, it has been stated that in SSG with 3:3 and 4:4 players, the intensity of $\%HR_{max}$ and RPE values in games played in larger areas than 3 different field sizes (small, medium and large) revealed higher values than the physiological stresses of small and medium games. Similarly, it was stated that games played with the number of 4:4 players, and games played in the large area create more intensity physiological stress than games in the small area (Köklü, Albayrak, Keysan, Alemdaroğlu & Dellal, 2013). In technical skills applications, it is stated that the number of technical skills applications in games played with the same number of players in a large area compared to small areas is less than in small areas, and the number of technical skills applications increases as the field size reduced (Casamichana & Castellano. 2010). The common point of the studies is that the increase in the number of m^2 per player creates an increase in the total distance running and the sprint running, so it has been stated that the athletes have more physiological stress parameters in the games played in a large area. At the same time, it turns out that in parallel with keeping the fields large, dribbling technical skills are applied more than the games played in a small area. As a result of the small of the field and the more pressure of the opponent teams players, the soccer players practice technical skills such as passing and tackling very quickly, and naturally they take less distance and apply less sprint, reducing the physiological stress in athletes. In different uses of ball contact numbers, it was observed that the free ball contact rule reduced high-intensity runs in games played with 4vs. 4 players, while it was found that athletes performed more sprints in games played with 1 ball contact and 2 ball contact rules (Dellal, Lago-Penas, Wong & Chamari, 2011). Similar to the literature, in the games in this research, with the increases of the fields, more $\%HR_{max}$ and RPE values have emerged. In addition, similar to the literature, it was revealed that the limitation of contact with the ball increased the $\%HR_{max}$ and RPE

In studies on COD, it is stated that the ability to change of direction is a complex skills and is affected by many physical fitness levels, and it

is stated that the factors affecting the COD skills include sudden stops and accelerations, and it has a structure that requires both postural control and strength (Little and Williams, 2003; Sporis, Jukic, Milanovic & Vucetic, 2010). In the study examining the relationship between COD and technical skills, it was revealed that athletes with better COD had more successful passing in the Loughborough Soccer Passing Test (Ali. 2011). This situation can be said as the explanation of the sudden stopping, acceleration and direction change features in the pass technique test. In this study, the correlation between COD and SSG_{SFG} games (r= -.524**) is similar to the results in the literature (Ali, 2011), as a result of the athletes meeting the opponent teams players in a shorter time than the larger areas in a 1:50 m^2 area, soccer players have to run quickly and have to thought that it is caused by the necessity of making a decision and practicing passing skills quickly by making sudden stops and accelerations. Because, similar to this study, it was determined that the number of short passes from technical skills, tackles, shooting against defense increased, more sprints and COD skills emerged (Köklü, Albayrak, Keysan, Alemdaroğlu & Dellal, 2013; Silva, Garganta, Santos & Teoldo, 2014; Dellal et al., 2012). It is also stated that athletes must have better COD and agility skills to get rid of rival players during the competition (Young, Dawson & Henry, 2015).

It is known that while soccer players apply technical skills during the match, they provide postural control and apply technical movements with dynamic muscle contractions they create on one leg (Hrysomallis, 2011; Nikolaos, Evangelos, Nikolaos, Emmanouil & Panagiotis, 2012). In the study examining the relationships between soccer technique and postural control, it was revealed that the dynamic and static postural control assessment of 3 different age groups were correlated with soccer dribbling, passing and shooting skills (Cometti, Maffiuletti, Pousson, Chatard & Maffulli, 2001). Among the technical skills in SSG performed with 2:2, and 3:3 players, it has been determined that there are significant relationships between postural control values and tackles, passes, goal passes, dribbles, and sliding interventions (Edis, Vural & Vurgun, 2016). Results similar to the literature (Edis, Vural & Vurgun, 2016) emerged in the results of free ball contact games obtained in this study; significant relationships were found between SSG_{LFG} and SSG_{SFG} technical skills and postural sway data. While the postural sway in the direction of CoP_{ap}-CoP_{ml} from the postural sway data in SSG_{LFG} games were related to technical skills, technical skills in SSG_{SFG} games were also related to CoP_{vel}-CoP_{var} besides CoP_{ap}-CoP_{ml}. These results are thought to be related to the dimensions of the field and the game rules. Supporting this result, it is seen in the literature that running distances and high-intensity runs increase as field sizes increase (Casamichana and Castellano, 2010). In the relationships that emerged in

this study, due to the expansion of the field and the fact that the opponent was encountered later than the small area, the distance of running fornt-to-back, back-to-front or running left-right could be interpreted as the emergence of relationships with CoP_{ap}-CoP_{ml} from the postural sway test results. It has been determined that in the games played in a smaller area in SSG, the athletes have more tackle and play more contact games (Casamichana and Castellano, 2010). In this research, it was revealed that games played in 50 m^2 areas had more technical skills applications than games in 100 m^2 area (Table 2). We can interpret the fact that technical skills, which increase with the small area games, will be carried out by protecting the postural control against external stress from all directions, and the CoP_{vel}-CoP_{var} values, which give the postural control variation and velocity values to the anterior-posterior-right-left directions, may have emerged with the need to apply technical skills.

Relationships have emerged between $\dot{V}O_{2peak}$ values in SSG_{LTTG} games and successful tackles. In this study, it was revealed that the $\%HR_{max}$ and RPE differed from free ball contact games. The increase of the playing field and playing the game with tackle with the ball is not enough for us to provide clear information about the $\dot{V}O_{2peak}$ values of the tackle. However, in a study conducted on this subject, a relationship was found between the drop jump feature and the technical skills in full-field soccer competitions, passing, shooting, dribbling, heading and tackles, and between the repetitive jumping ability and shooting, passing, dribbling, ball control and heading. Positive correlations were found between $\dot{V}O_{2peak}$ and shooting, passing, dribbling and ball control (Fernandez-Gonzalo et al., 2010). Similar to this study, in our research, significant relationships between $\dot{V}O_{2peak}$ values and tackle have also emerged in the largest size games (100 m^2) of SSG played with the rule of touching the ball twice. They think that the result is due to the nature of the soccer game that a 90-minute match requires endurance, so being successful in a tackle in these games. In addition, it is thought that playing games with the ball touch rule for 2 times requires more effort than the free ball touch rule games, which may lead to the emergence of relationships between endurance levels and tackle. The common point in this study and the research in the literature is that the endurance feature is related to the soccer game.

Especially in all games in this study, the relationship between the strength and the games, and the relationship between the 1RM and jump performance of the athletes and the technical skills in the games revealed that they have negative and positive, significant and meaningless relationships. In researches on strength, it is clearly stated in studies that

there are discussion about which strength measurement technique and which strength properties are most accurately associated with soccer (Fernandez-Gonzalo et al., 2010). In this study, it was aimed to reveal the relationships between the athletes' technical skills by manually measuring the maximal squat strength on the Smith machine. The 1RM force measurement and the testing of the explosive strength properties of the athletes on a special platform constitute the limitation of our research. We think that different strength measurements and measurements to be made with different devices should be done on this subject. In future studies, testing the strength properties in several different ways, perhaps, will reveal different relationships between them.

Results

In order to get a well result for technical skills applications in SSG, the COD and postural control of the athletes should be at a well level before playing games in 50 m^2 areas. In addition, before playing 100 m^2 SSG, athletes must have a good level of endurance capacity and postural control values, and small-sided games should be designed according to the level of preparedness of the athletes according to the physical fitness levels at the beginning of the season. This research will allow coaches to predict in which games the fitness levels are in relation to technical skills by using the physical fitness levels of the athletes from the small-sided games, which are applied to provide soccer players with the game philosophy they want from their teams and at the same time to improve the endurance and technical skill practices of soccer players. It will allow to be designed.

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