

Research Article / Araştırma Makalesi

# The relationships between static and dynamic core stability and anaerobic exercise capacity in young elite male soccer players

## Genç elit erkek futbolcularda statik ve dinamik kor stabilite ile anaerobik egzersiz kapasitesi arasındaki ilişki

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### ABSTRACT

**Objective:** To investigate the associations between static and dynamic core stability and anaerobic exercise capacity in young elite male soccer players.

**Materials and Methods:** Thirty-five athletes with a median (IQR 25/75) age of 17 (17/18) years were participated in the study. Static core stability and dynamic core stability were evaluated with side bridge test and Y balance test, respectively. Vertical Jump Test and Running-Based Anaerobic Sprint Test (RAST) were used as anaerobic exercise capacity related performance tests. Anaerobic exercise capacity was determined by using Wingate Anaerobic Test (WAnT).

**Results:** Significant but weak correlations were observed between dynamic core stability and WAnT average power ( $r=0.370$ ,  $p=0.029$ ) and between dynamic core stability and RAST peak power ( $r=0.371$ ,  $p=0.028$ ). No other significant relationships were detected between other core stability and anaerobic exercise capacity related measures ( $p>0.05$ ).

**Conclusions:** It was determined that anaerobic exercise capacity is not related to static core stability, while poorly associated to dynamic core stability.

**Keywords:** Anaerobic capacity, soccer, core stability

### ÖZ

**Amaç:** Genç elit erkek futbolcularda statik ve dinamik kor stabilite ile anaerobik egzersiz kapasitesi arasındaki ilişkinin araştırılmasıdır.

**Gereç ve Yöntemler:** Çalışmaya ortanca (IQR 25/75) yaşı 17 (17/18) yıl olan otuz beş sporcu katıldı. Statik ve dinamik kor stabilite sırasıyla lateral köprü testi ve Y denge testi ile değerlendirildi. Dikey Sıçrama Testi ve Koşmaya Dayalı Anaerobik Sprint Testi (RAST) anaerobik egzersiz kapasitesi ile ilişkili performans testleri olarak kullanıldı. Anaerobik egzersiz kapasitesi ise Wingate Anaerobik Testi (WAnT) kullanılarak belirlendi.

**Bulgular:** Dinamik kor stabilite ile WAnT ortalama gücü ( $r=0,370$ ,  $p=0,029$ ) ve dinamik kor stabilite ile RAST tepe gücü ( $r=0,371$ ,  $p=0,028$ ) arasında anlamlı ancak zayıf düzeyde korelasyon saptandı. Diğer kor stabilite ve anaerobik egzersiz kapasitesi ile ilgili ölçümler arasında anlamlı ilişki bulunmadı ( $p>0,05$ ).

**Sonuçlar:** Anaerobik egzersiz kapasitesinin statik kor stabilite ile ilişkili olmadığı, ancak dinamik kor stabilite ile zayıf düzeyde ilişkili olduğu belirlendi.

**Anahtar Sözcükler:** Anaerobik kapasite, futbol, kor stabilitesi

### INTRODUCTION

Soccer is one of the most popular sports around the world. Performance in the soccer is not only related to technical abilities and tactical knowledge, but also depends on physical characteristics including exercise capacity, muscle strength and endurance, balance, and coordination as well as mental status including motivation (1-3). Since it is a highly competitive sport, exercise capacity is one of the

most important determinants of the performance for soccer players (3). Although aerobic energy system is dominantly utilized during a soccer game, many quick and explosive actions such as high jumps, short sprints, tackles, and dual play require anaerobic energy (4,5). During a soccer game, players cover approximately 10-13 km, and 10-15% of this distance is running in remarkably high speeds around 19

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km/h (6-9). These high intensity movements were advocated important for determining the outcome of the game (10).

Muscle strength and endurance are other important aspects for the performance. One can assume that lower extremity muscles are essential for the success, however, many authors emphasize the importance of the trunk region as well (11,12). Core stability refers to the muscle control of the lumbo-pelvic region to maintain functional stability and provide optimum energy transfer from the trunk to the distal segments (12). Therefore, core region mainly referred as the powerhouse of the body.

Previous studies investigated the relationships between core stability assessments and athletic performance for various sports (13-15). While the results of earlier studies supported the relationship between core stability and athletic performance (13), others could not detect any significant relationships between these parameters (14,15).

Many high intensity tasks (sprinting, shooting, jumping) may require maintenance of optimal core stability during a soccer game (11). Even though, the relationships between static core stabilization and anaerobic exercise were investigated in soccer players previously (16-19), best to our knowledge, there are no studies that examined the possible associations between dynamic core stability and anaerobic exercise capacity. Therefore, in the present study the potential link among these parameters in young elite male soccer players was interrogated. The tested hypotheses of the present study were a) there is a relationship between static

core stability scores and lower extremity anaerobic exercise capacity measures, b) there is a relationship between dynamic stability scores and lower extremity anaerobic exercise capacity measures.

## MATERIALS AND METHODS

The present cross-sectional study was carried out in Altınordu Football Club. The ethics approval was obtained from the local ethics committee of İzmir Katip Çelebi University with decision number 86 on 05.11.2020. Prior to the study, all participants were checked by an internist, and then, they signed written informed consents. The study was performed in compliance with Declaration of Helsinki.

### Participants

The number of participants were determined as 31 individuals by using G-Power program by using 95% confidence interval and 95% power according to values from the study of Nesser et. al (the relationship between trunk stabilization scores and vertical jump test scores was  $r: 0.591$ ) (19). The number of the participants was increased by 10% and thirty-five Male Elite Academy League soccer players who were competing in Elite U17 and Elite U19 leagues were included in the study (Table 1). Participants were excluded if they (a) had a musculoskeletal or neurological problem affecting the lower extremity, (b) had a history of a trauma requiring surgery and/or physiotherapy within the last month or (c) refused to participate in the study.

**Table 1.** Demographic characteristics of the athletes

	Mean± SD or Median (IQR 25/75) (n=35)	Min/Max
Age (years)	17 (17/18)	16/19
Height (cm)	177.1 ± 6.2	163/196
Body Weight (kg)	65.1 ± 6	53/77
BMI (kg/m <sup>2</sup> )	20.7 ± 1.7	16.14/23.77
Length of the Dominant Lower Extremity (cm)	98.4 ± 3.6	90/109

SD: Standard Deviation, n: number, IQR 25/75: Interquartile range between the 25th and 75th percentiles, Min/Max: Minimum/Maximum, cm: centimeters, kg: kilograms, kg/m<sup>2</sup>: kilogram/meter<sup>2</sup>

### Procedures

Demographic information and physical data (height, body weight, body mass index, dominant lower extremity length) were recorded in a structured form. Sport age, weekly training times, and injury counts were inquired additionally. An injury was described as any event which prevents player to attend training/match.

Each participant was evaluated for a total of four times with 24-hour intervals. All the assessments were performed at the same time of the day and under same conditions for

each participant. For example, if a participant was assessed at 9:00 am, then he was assessed for the second time at 9:00 am on the following day. The running exercises (part 1 and part 3) of the FIFA 11+ warm-up program was employed as a standard warm-up before the assessments (20). On the first day static and dynamic core stability; on the second (vertical jump test) and on the third days (anaerobic sprint test) anaerobic performance tests; and on the fourth day anaerobic exercise capacity were assessed.

## Assessments

**Static Core Stability:** Side bridge test was used to assess the static core stability. Each participant was asked to lie on his dominant side with the foot of the upper leg placed on the foot of lower legs and non-dominant arm crossed across the chest (Figure 1). Stopwatch was started when the participant lifted his body over his forearm and outer lateral surface of his foot, then he was asked to maintain this position as long as he can. Test was finished when the participant could no longer hold the position, and the elapsed time was recorded in seconds. Test was repeated for three times and best score was used for the analysis (21). Five minutes rest were provided between attempts.



Figure 1. Side Bridge Test

**Dynamic Core Stability:** Y balance test which is a simple and widely used test was applied to evaluate the dynamic core stability (22). The test was performed on a “Y” shaped platform where the participant was asked to stand on one leg and push the mobile part of the platform by reaching out as far as he could anteriorly, posteromedially and posterolaterally (Figure 2). Participants performed six trials prior to actual testing for familiarizing. The distance reached were recorded as centimetres. The tests were repeated for three times and the best scores were used for the analysis. Each distance was normalized to lower extremity length. A composite score was calculated using the following formula for the dominant side (23):

$$([\text{Normalized Anterior} + \text{Normalized Posteromedial} + \text{Normalized Posterolateral}] / 3)$$

**Anaerobic performance:** Vertical Jump Test and Running-Based Anaerobic Sprint Test (RAST) were used as anaerobic performance tests.

**Vertical Jump Test:** The SmartJump Mat (SmartJump; FusionSport, Coopers Plains, Queensland, Australia) which is reported to be one of the most accurate methods for measu-

ring vertical jump height, was used for Vertical Jump Test. The test was explained verbally to the participants prior to assessment. The participant was asked to place his hands on his waist and to keep this position during the test. Then, he was asked to perform a deep squat, and jump as high as he could (Figure 3). The test was repeated three times and the highest jump was used to calculate the peak power (24).



Figure 2. Y Balance Test



Figure 3. Vertical Jump Test

**Running-Based Anaerobic Sprint Test (RAST):** The test includes six sprint runs over 35 meters with 10 seconds of passive rest intervals. For each sprint measurement, a photocell system was placed at a height of 75 cm both on the start line and on the finish line. The photocell system uses infrared rays to precisely measure the time between the start and finish lines (Fusion Smartspeed lightgates, Hab International, Warwickshire, England) (25, Figure 4). The participant was informed that following each 35-meter sprint, he should return to the start line. During the test, the participant was verbally motivated. Each participant completed six sprints and the total time was recorded. The system calculated the anaerobic power (25).



Figure 4. Running-Based Anaerobic Sprint Test



Figure 5. Wingate Anaerobic Test

**Wingate Anaerobic Test (WAnT):** Wingate Anaerobic Test was employed to determine the anaerobic exercise capacity (Figure 5). The test was explained to participant prior to actual testing. The test was carried out on an Ergonomic 894-E cycle ergometer (Monark, Switzerland). The seat height of the bicycle was adjusted to the participant. The external load was calculated as the 7.5% of the participant's body weight (26). The participant was asked to pedal for 150 seconds at an increasing rate starting from 80 rpm for the test-specific warm-up. Following warm-up, the athletes were asked to accelerate and press the start button which lowers the load pan when they reach maximum speed. When the external load was applied, 30-second actual testing period started. Throughout the test, the participant was verbally motivated to maintain his speed. Peak power/kg (peak power adjusted to bodyweight), and average power/kg (average power adjusted to bodyweight) values were calculated by Monark All-in-One Software.

## Statistical Analysis

Data analysis was carried out by using Statistical Package for the Social Sciences (SPSS Inc. Version 15; IBM, Raleigh, NC, USA) for Windows. Shapiro-Wilk test was used to check the distribution characteristic of the data. Continuous data was expressed as mean and standard deviation for normally distributed variables, and as median and interquartile range 25/75 (IQR 25/75) for not normally distributed variables. Pearson Correlation Coefficient ( $r$ ) and Spearman Rank Correlation coefficient ( $\rho$ ) was used to analyze the relationships between variables, for parametric and non-parametric conditions, respectively. Correlations were interpreted as follows:  $>0.90$  very high,  $0.90-0.70$  high,  $0.70-0.50$  moderate,  $0.50-0.30$  low,  $\leq 0.3$  negligible (27). A  $p$  value of  $<0.05$  was accepted as statistically significant.

## RESULTS

The study was completed with 35 participants with a median (IQR 25/75) age of 17.0 (17.0/18.0) years. Most of the participants (80%) were using their right legs dominantly. Eleven of the participants were forwards (31.4%), ten were midfielders (28.6%), ten were defenders (28.6%), and four were goalkeepers (11.4%). Median sport age was 7.1 (min/max: 5/12.30) years, and median injury count was 1 (min/max: 0/4) for all-time sport career. Weekly training time was approximately 10 hours. Demographic characteristics were summarized at Table 1. Anaerobic exercise capacity, anaerobic exercise capacity related performance tests, static core stability and dynamic core stability values were shown at Table 2.

Our first hypothesis was rejected as no correlations were detected between side bridge test and any of the anaerobic exercise capacity measures ( $p > 0.05$ , Table 3). Second hypothesis was confirmed as there were low-level relationships between dynamic core stability and average anaerobic exercise capacity, and between dynamic stability and RAST peak scores ( $p < 0.05$ , Table 3).

## DISCUSSION

The aim of the present study was to investigate the possible relationships between anaerobic exercise capacity related measures and static and dynamic core stability in young elite male soccer players. According to our results, low level correlations were detected between dynamic core stability and some anaerobic exercise capacity related measures, on the other hand, no significant associations were observed between static core stability and anaerobic exercise capacity related measures. Best to our knowledge this was the first study investigating the relationship between anaerobic performance and dynamic core stability.

**Table 2.** Results of anaerobic capacity and core stability tests

	Mean ± SD or Median (IQR 25/75) (n=35)	Min/Max
<b>WAnT</b>		
WAnT Peak Power (W/kg)	14.2 ± 1.7	9.5/17.2
WAnT Average Power (W/kg)	9.6 ± 0.7	7.6/11.1
<b>RAST</b>		
RAST Peak Power (W)	769.5 ± 102.2	579.4/1035.4
RAST Average Power (W)	592.4 ± 114.3	403.4/892.5
<b>Vertical Jump Test</b>		
Vertical Jump Height (cm)	41.3 ± 3.8	34.5/49.6
Vertical Jump Peak Power (W)	3401.0 ± 396.2	2616.1/4107.6
<b>Static Stability</b>		
Side Bridge Test (sec)	129 (121/144)	89/255
<b>Dynamic Stability</b>		
Y Balance Test (cm)	91.1 ± 5.1	79.9/100.5

SD: Standard Deviation, n: number, IQR 25/75: Interquartile range between the 25th and 75th percentiles, Min/Max: Minimum/Maximum, W: Watt, kg: kilogram, cm: centimeters, sec: seconds, WAnT: Wingate Anaerobic Test, RAST: Running-Based Anaerobic Sprint Test

**Table 3.** Correlation between anaerobic exercise capacity test results and core stability test results

	Side Bridge Test (sec)		Y Balance Test (cm)	
	rho	p*	r	p*
<b>WAnT</b>				
WAnT Peak Power (W/kg)	0.162	0.352	0.309	0.071
WAnT Average Power (W/kg)	0.327	0.055	0.370	<b>0.029</b>
<b>RAST</b>				
RAST Peak Power (W)	0.009	0.960	0.371	<b>0.028</b>
RAST Average Power (W)	0.002	0.993	0.307	0.072
<b>Vertical Jump Test</b>				
Vertical Jump Height (cm)	-0.020	0.910	0.192	0.268
Vertical Jump Peak Power (W)	-0.075	0.669	0.215	0.215

\*p<0.05, rho: Spearman correlation coefficient, r: Pearson correlation coefficient, W: Watt, kg: kilogram, cm: centimetres, sec: seconds, WAnT: Wingate Anaerobic Test, RAST: Running-Based Anaerobic Sprint Test

Previous studies determined that the dynamic core stability showed some relation to various performance parameters in different sports. Cengizhan et al. reported that dynamic core stability was a predictor of core muscle endurance and agility in elite basketball players (28). Behm et al. found dynamic stability was associated with agility and performance in hockey skating players (29). Additionally, Guler et al. showed that balance training improved activities that were anaerobic in nature such as jumping and sudden direction changes (30). Most of the anaerobic activities performed during a soccer game involve swift direction changes and high speed, thus, maintaining the centre of gravity in limits of stability while executing these activities may be important. Our results along with literature support this assumption. It seems that soccer players who present better dynamic stability may better perform anaerobic activities. However, there must be other factors that are yet to be discovered related to these parameters as the relationships were found in a low level in the present study.

On the other hand, we did not observe any associations between static core stability and anaerobic exercise capacity related measures in our study. We have employed the side bridge test which is advocated as a good indicator of static core stability (31). However, it might not capture the dynamic stability which is commonly utilized during a soccer game. The anaerobic actions in the soccer involve dynamic

activities which require explosive power. Previous studies also support our results (17,32). Ozmen observed no significant correlation between squat jump height and side bridge test times in soccer players (32). Nesser et al. report no significant relationships between shuttle run test, 40 meters sprint test and static core stability tests in Division I female soccer players (17). On the contrary, same authors found poor relationships (between r= 0.374 and r= 0.435) between side bridge test and 20-m sprint run, 40-m sprint run, and vertical jump in Division I male soccer players (19). Besides Okada et al. detected a poor relationship (r= -0.383 for the right side, and r= -0.448 for the left side) between agility T-test and side bridge test (18). Agility T-test includes direction changes, despite of running in a line as used in the present study. This might have led to the different results in our study.

Even though, there are conflicting results about the relationship between static core stability and anaerobic performance, we believe that a core stability evaluation test with a more dynamic composition may be warranted for demonstrating possible relationships between core stability and anaerobic performance.

In our study, we did not detect a relationship between vertical jump and any of the core stability measures. Requena et al. reported that the jumping in the soccer happens to head

the ball and requires an acceleration phase, thus is not same as the vertical jumping (33). This might be the reason that we could not detect any relationship between vertical jumping and core stabilization.

Our results only reflect the status of young elite male soccer players, and they might be different for female soccer players or more experienced players. Recruiting participants from only one soccer club is another limitation of our study. Besides, our results were obtained from a cross-sectional study, and yet to be confirmed by future prospective longitudinal studies. Investigating the relationships between core stability status and soccer-related anaerobic movements such as shooting a ball and tackling may provide a deeper insight to the topic.

## CONCLUSION

Anaerobic exercise capacity was found to be poorly associated with dynamic core stability, but not with static core stability in young elite soccer players. Training professionals may consider dynamic core stability exercises rather than the static ones to enhance athletic performance for young soccer players.

### Ethics Committee Approval

The approval for this study was obtained from Clinical Research Ethics Board of Izmir Katip Celebi University (Approval number: 86, Date: 05.11.2020).

### Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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### Author Contributions / Yazar Katkıları

Concept: SBB, DB; Design: SBB, UZK, DB; Supervision: DB, Data Collection and/or Processing: SBB, SG, GK, NA; Analysis and Interpretation: SBB, DCS; Literature Review: SBB, DCS; Writing Manuscript: SBB, DCS; Critical Reviews: UZK, DB

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