ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Can We Predict Success of Orienteering Athletes?

Oryantiring Sporcularının Başarısını Tahmin Edebilir miyiz?

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ABSTRACT Objective: Orienteering is an extreme sport which require different physical and cognitive properties from other sports. We aimed to predict whether the athletes will be successful or not in the competitions by pre-season performance tests. **Material and Methods**: Total 45 athletes who are in the same orienteering club were included in the study. Demographic data, balance, coordination and strength parameters were assessed before season. Tanita Body Composition Analyzer, Holtain skinfold, vernier caliper, Vmax Encore Viasys Program, Balance System SD ™ and Biodex System 4 Pro were used. According to the individual ranking list created as the result of the same year's competitions, athletes were divided into two groups: Successful and Unsuccessful. Groups were compared as to measurement results. Kolmogorov Smirnov, Mann-Whitney U, Pearson's chi-square, Wilcoxon Signed-Rank tests and ROC curve analysis (area under the curve) were used for statistical analyses. **Results:** Left OSI (overall stability index), right OSI, left API (anterior posterior index) and right API were statistically significant differences (p=0.032, p=0.013, p=0.045, p=0.009, respectively). ROC curve analysis of measurements: The first value is right API 0.749 (95% confidence interval in 0.582-0.915), the second right OSI 0.737 (95% confidence interval in 0.573-0.901), the third left OSI 0.712 (95% confidence interval in 0.535-0.888) and the fourth left API 0.694 (95% confidence interval in 0.517-0.871) in total statistics. Left OSI 0.908 (95% confidence interval in 0.729-1.000) in males and 0.540 (95% confidence interval in 0.275-0.805) in females. **Conclusions:** For determining the competition success of an orienteering athlete; balance tests may be the best choice.

Keywords: Athletic performance; muscle strength; competition.

ÖZET Amaç: Oryantiring, diğer spor türlerine nazaran daha üstün fiziksel ve kognitif özellikler gerektiren bir spordur. Bu sporla ilgilenen atletlerin müsabakalardaki başarı oranını, sezon öncesi performans testleri ile tahmin etmeyi amaçladık**. Gereç ve Yöntemler:** Çalışmaya aynı oryantiring kulübünden toplam 45 sporcu dâhil edildi. Sezon öncesinde demografik veriler, denge, koordinasyon ve güç parametreleri değerlendirildi. Tanita Vücut Kompozisyonu Analiz Cihazı, Holtain skinfold, vernier kaliper, Vmax Encore Viasys Programı, Balance System SD ™ ve Biodex System 4 Pro kullanıldı. Aynı yılki yarışmaların sonucu olarak yaratılan bireysel sıralama listesine göre sporcular iki gruba ayrıldı: Başarılı ve Başarısız. Ölçüm sonuçlarına göre gruplar karşılaştırıldı. İstatistiksel analizler için Kolmogorov Smirnov, Mann-Whitney U, Pearson Ki-Kare, Wilcoxon Signed-Rank testleri ve ROC eğrisi analizi (eğri altındaki alan) kullanıldı. **Bulgular:** Sol OSI (overall stability index), sağ OSI, sol API (anterior posterior index) ve sağ API değerlerinde istatistiksel olarak anlamlı farklılık saptandı (p=0,032, p=0,013, p=0,045, p=0,009, sırasıyla). Bu ölçümlerin ROC eğrisi analizi başarıyı tahmin etmek için yapıldı: Sağ API 0,749 (%95 güven aralığı 0,582-0,915), sağ OSI 0,737 (%95 güven aralığı 0,573-0,901), sol OSI 0,712 (%95 güven aralığı 0,535-0,888), sol API 0,694 (%95 güven aralığı 0,517-0,871). Sadece erkekler değerlendirildiğinde sol OSI 0,908 (%95 güven aralığı 0,729-1,000) ve kadınlarda 0,540 (%95 güven aralığı 0,275-0,805) olarak bulundu. **Sonuç:** Oryantiring sporcularının yarışma başarısını saptamak için denge testleri kullanımı en iyi tercih olabilir.

Anahtar Kelimeler: Atletik performans; kas kuvveti; yarışma

Orienteering is a running-related endurance sport comprised of physical and cognitive components. Orienteering athletes compete on a timed run through unknown cross-country terrain, checking in at predetermined control sites while navigating with only a map and compass.[1] Athletes are required to provide the right decision as soon as possible with taking into account their own properties, other athletes, the characteristics of the land. The courses are found in a variety of places outdoors, and they range from about 1.25 miles (2 km) to 9.3 miles (15 km) in length. Parks, forests, open grasslands and mountains are common venues for orienteering courses.[2] Changes in environments between venues would favor certain athletes more than others based on their relative strengths, e.g., athletes skilled at running in rough-forest terrain would perform better on a predominantly forested rather than asphalted course.[3]

Orienteering sports is an extreme sports which require different physical and cognitive properties from other sports. There are a few studies about map reading in the literature. There is a study about colour code of the maps.[4] Three studies about visual attention at rest and physical effort.[5-7] Two studies about map reading under physical effort.[8,9] These studies emphasise the importance of map-reading in the area of controls since parts of the races seem to bear a great deal of potential to optimize running times, thereby enabling runners to achieve their maximum performance levels.[8,9] Nevertheless there is no a valid method for the level of map reading. We accepted that orienteers who are in the same orienteering club were trained at the same level for map reading and they were same for cognitive properties. So the difference between the athletes must be the result of their physical performances. We found only two studies which investigates balance and knee muscle strength performance measures of orienteering athletes.[10,11] However, we did not find any study which investigates performance measures of orienteering athletes that affect the competition success. We aimed to predict whether the athletes will be successful or not in the competition results in orienteering sports with pre-season performance tests. Our hypothesis is that if we can identify the tests that demonstrate the success of the competition, we can also use it as a training method.

MATERIAL AND METHODS

A total of 45 athletes in the same orienteering club with age of 18 to 34 years, 21 female and 24 male were included in the study. 13 of the athletes (3 male, 10 female) were accepted as successful. For this retrospective study, we evaluated athletes in Gülhane Military Medical Academy Sports Medicine Clinic between August 2012 and October 2012. The study protocols were approved by the Ethics Committee of the Gülhane Military Medical Academy, Ankara, Turkey. Athletes were performed tests voluntarily. The study was conducted according to ethical principles of the World Medical Association Declaration of Helsinki.

There is no a similar study for orienteers (when we planned the study) so we have chosen the parameters to be evaluated. Then Çınar et. al's analyzed performance measures of the orienteers and set the differences between adolescents, young adults and adults. İsokinetic knee muscle strength test, sit and reach test, T-drill test, 20 meters shuttle run test, star excursion balance test, flamingo balance test, vertical jump and 20 meters shuttle run test were performed in this study.[11] Age, height, weight, gender, body mass index, fat percentage, lengths of leg, upper body, arm and hand, fat mass of triceps, scapular, suprailiac and calf, circumference of flexor biceps, calf, elbow and knee, vertical jump, standing long jumping, 20 meters running time, spirometry, isokinetic test, balance and coordination measurements were assessed before the season. Evaluation of each athlete completed in 3 days. In first day, vertical jump, standing long jumping and anthropometric measurements; in second day 20 meters running time and spirometry; in last day, isokinetic test, balance and coordination measurements were assessed. Every day before the tests started, the athlete was allowed a 10 minute warm up at a light intensity (less than 50 W) on a cycle ergometer, followed by a 30 second stretch of all body muscles. Athletes waited 15 minutes between vertical jump and standing long

jumping test. Spirometry was done before 20 meters running. Balance and coordination test and isokinetic test were done respectively, with at least 2-hour-of-break between tests.

Individual ranking list of 2013, which was created as a result of 5 competitions in the same season including one Turkish championship and four stage races, was taken from Turkish Orienteering Federation. According to this individual ranking list athletes were divided into two groups: successful and unsuccessful. The first ten percent of all age and gender groups were considered as successful. Groups were compared to measurement results.

ANTHROPOMETRIC MEASUREMENTS

The height was measured with an inextensible iron tape and the result was expressed in centimeters (cm). The height and weight were measured with barefoot. The weight and percentage of body fat were taken using Tanita Body Composition Analyzer (Type TBF-410 MA, JAPAN). Skinfold thickness measurements were taken using Holtain skinfold calipers at four sites (triceps, subscapular, suprailiac and calf). Skinfold thicknesses were measured three times and the average was used in further calculations. Body Mass Index (BMI) was calculated as body mass divided by height squared and expressed as kg m^{-2}. Mid-upper arm and calf circumferences were measured by using flexible tape. Elbow and knee diameters were measured using a vernier caliper.[12]

Standing Long Jump (SLJ) was measured from a horizontal line, where the athletes were told to jump as long as they can in a non-sliding surface. Tests were repeated two times and the best value used as SLJ score. The distance was measured with an inextensible iron tape and the result was expressed in centimeters (cm).[13]

Vertical jump (VJ); Athletes were requested to stand with feet flat on the ground, extend their arm and hand, and mark the standing reach height. After assuming a crouch position, each athlete was instructed to spring upward and touch the Yardstick device at the highest possible point. No specific instructions were given about the depth or speed of the countermovement. Vertical jump height was calculated as the distance from the highest point reached during standing and the highest point reached during the vertical jump. Vertical jump height was measured to the nearest 1 cm with the highest value obtained from two trials used as the vertical jump score.[12]

Twenty Meter Run; measured in a flat surface where the athletes were instructed to run as fast as they can. Athletes started to run one meter before the test's distance, to eliminate the slow beginning and ensure a good final velocity. The time elapsed to cover the 20m distance, was recorded with a digital chronometer Casio® (1/100Seg), by two evaluators, at each side of the arrival line. Tests where repeated three times and the mean of the best two values was considered as best performance.[12]

Pulmonary function testing; The parameters used for analysis included ratio of forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory flow (FEF) and the coefficient of Tiffeneau (FEV1/ FVC), which were calculated according to the gender, age, height, and weight of each athlete (Vmax Encore Viasys Program, Yorba Linda, CA, USA).[14]

BALANCE MEASUREMENT PARAMETERS

Measurements of balance and coordination were performed using the Biodex device (Balance System SD ™, USA) with postural stability mode. The information about the test procedure was given to athletes before the test. The balance positions of the foot were determined and measurements were performed both before the trial and during the test on the platform. For ensuring compliance with the test, athletes were tried two times on the right and left foot for a period of 60 sec at the 3 difficulty level. Test was performed one time at the 3 difficulty level and period.[15]

ISOKINETIC MEASUREMENT

The knee to be tested was placed on the knee flexion extension plate of the Biodex Norm device [Biodex System 4 Pro (Biodex Medical Systems, New York, USA)] and secured with Velcro straps,

according to the manufacturer's instructions for isolating knee flexion and knee extension. The length of the dynamometer was adapted to the length of the knee of each athlete. To synchronize themselves with the testing device, athletes were instructed to perform three active repetitions of knee movement ranging from maximal flexion to maximal extension. Standard stabilization strapping was placed across the distal thigh and chest, and placements were limited to grasping the waist stabilization strap. Before the testing session started, the athlete was allowed a 10 minute warm up at a light intensity (less than 50 W) on a cycle ergometer, followed by a 30 second stretch of the quadriceps and hamstring muscles. Selection of the extremity was random. The same investigator performed all the tests. Athletes were encouraged to give 100% effort and received positive feedback during testing. In order to adapt to the test conditions, athletes were allowed three submaximal contractions of the quadriceps and hamstring muscle group at the beginning of the tests. They were given five maximal concentric contractions at 60°/sec and 10 maximal concentric contractions at 240°/sec for each test condition. The best peak torque and power contraction of the five and 10 test contractions for each test condition were collected for data analysis. Between each condition, the athletes were allowed to rest for one minute and gravitational corrections were performed.[15]

STATISTICAL ANALYSES

Data analysis was done on SPSS (Statistical Package for Social Science) for Windows 15.0. The comparison of continuous variables spread with the normal spread was done using Kolmogorov Smirnov test. Descriptive statistics were defined as mean ± standard deviation or median for continuous variables and as case number (n) and percentage (%) for nominal variables. Comparing the two groups do not meet the normal distribution of continuous variables were analyzed by Mann-Whitney U test, discrete variables were analyzed by Pearson's chi-square test. Comparisons of repetitive measurements within groups were done by Wilcoxon Signed-Rank test. ROC curve analysis (The area under the curve) of these measurements was performed to estimate success. Values of $p<0,05$ were defined as statistically significant.

RESULTS

Demographic data, anaerobic performance, strength, balance and coordination parameters of the athletes were given in (Table 1).

Demographic data, anaerobic performance, strength, balance and coordination parameters of successful and unsuccessful athletes were compared. Values of height, leg length, standing long jump, left OSI, right OSI, left API, right API, 60°/sec peak torque in the right and left leg extension, 240°/sec peak torque in the right and left leg extension were found statistically significant differences ($p=0.047$, $p=0.008$, $p=0.012$, $p=0.032$, $p=0.013$, $p=0.045$, $p=0.009$, $p=0.037$, $p=0.004$, $p=0.004$, $p=0.001$, respectively). Other variables had no significant difference between successful and unsuccessful athletes ($p>0.05$) (Table 2).

ROC curve analysis (the area under the curve) of these measurements was performed to estimate success. The first value is right API 0.749 (95% confidence interval in 0.582-0.915), the second right OSI 0.737 (95% confidence interval in 0.573-0.901), the third left OSI 0.712 (95% confidence interval in 0.535-0.888) and the fourth left API 0.694 (95% confidence interval in 0.517-0.871) in total statistics (Table 3) (Figure 1). Left OSI 0.908 (95% confidence interval in 0.729-1.000) ($p=0.025$) in male athletes and 0.540 (95% confidence interval in 0.275-0.805) ($p=0.762$) in female athletes (Figure 2). Sensitivity was found to be 100% and selectivity to 66.7% when left OSI value decreased below 2.1 in male athletes.

DISCUSSION

Demographic data, anaerobic performance, strength, balance and coordination parameters of orienteering athletes were measured before the season and these measures were compared with the individual ranking list of after season in the study. Successful and unsuccessful athletes' data were compared by these measures. We showed that bal-

TABLE 1: Demographic data, anaerobic performance, strength, balance and coordination parameters of the athletes.

	Mean±SD	Min-Max
Age. year	21.0±3.5	18.0-34.0
Sex. n (%) Male	24 53.3%	
Female	21 46.7%	
Height. cm	171.9±8.7	155.0-190.0
Weight. kg	63.1±7.4	48.0-83.0
BMI. kg/m²	21.3±2.2	16.9-26.3
Fat percentage. %	12.5±8.1	1.3-26.9
Leg length. cm	88.8±6.3	76.0-102.0
Upper body length. cm	83.0±4.3	67.0-91.0
Arm length. cm	73.6±4.8	62.5-86.5
Hand length. cm	18.1±0.9	16.5-21.0
Triceps thickness. cm	11.8±5.3	5.0-25.0
Subscapularis thickness. cm	10.6±3.0	6.0-22.1
Suprailiac thickness. cm	9.3±2.7	4.0-14.8
Calf thickness. cm	11.7±5.1	5.6-25.1
MUAC. cm	34.7±12.1	22.0-59.0
Calf circumference. cm	35.5±2.2	30.0-41.0
Elbow diameters. cm	7.8±0.8	6.0-10.0
Knee diameters. cm	10.0±0.9	9.0-12.0
VJ. cm	34.4±11.0	19.0-68.0
SLJ. cm	160.2±36.8	100.0-225.0
20 meter run. sec	3.6±0.6	2.2-5.1
Left OSI	2.4±1.2	0.8-5.6
Right OSI	2.2±1.3	0.8-6.9
Left API	1.7±0.9	0.5-4.2
Right API	1.5±1.1	0.5-5.7
Left MLI	1.3±0.6	0.6-2.8
Right MLI	1.2±0.6	0.5-3.3
Right PT 60°/sec ext (N.m)	161.9±52.6	80.3-290.7
Left PT 60°/sec ext (N.m)	156.5±54.3	65.9-291.5
Right PT 60°/sec flx (N.m)	88.1±32.0	35.0-167.6
Left PT 60°/sec flx (N.m)	79.8±27.2	26.4-131.1
Right PT 240°/ sec ext (N.m)	91.8±29.0	43.4-149.8
Left PT 240°/ sec ext (N.m)	88.9±26.3	47.0-132.5
Right PT 240°/sec flx (N.m)	58.5±17.9	22.6-95.0
Left PT 240°/sec flx (N.m)	57.7±16.3	26.8-95.6
FVC	4.5±0.8	2.9-6.6
FEV1	3.7±0.6	2.7-4.9
FEV1/FVC	83.8±7.7	68.0-97
FEF	4.0±0.9	2.3-5.9
PEF	6.2±2.2	2.9-12.1

MUAC: Mid-upper arm circumference; OSI: Overall stability index; API: Anteroposterior stability index; MLI: Mediolateral stability index; PT: Peak torque; Ext: extantion; Flx: flexion; VJ: Vertical jump; SLJ: Standing long jump; BMI: Body mass index: FVC: Forced vital capacity; FEV: Forced expiratory volume; FEF: Forced expiratory flow; PEF: Peak expiratory flow.

ance and coordination parameter was important in success of orienteering athletes.

In medical decision process, one of the methods used to determine the discrimination of the test is the ROC curve analysis. ROC curves are used for purposes such as determining the discrimination power of the test, determining the appropriate positivity threshold, monitoring the quality of the laboratory results, comparing diagnosis performance of two or more diagnoses or laboratory tests. With this method, diagnostic test criterias are also obtained. The size of the area under the curve shows the importance of diagnosis test's discrimination ability statistically. If the diagnosis test has no discrimination ability, the expected value of the area under the curve will be 0.50; but if is an excellent test, then the value of the area will be 1.00. Test should be in an area between these two values. The following grades can be used to interpret the area under the curve. 0.90-1.00=excellent, 0.80-0.90=good, 0.70-0.80=medium, 0.60-0.70=weak, 0.50-0.60=failed.[16]

There were only two studies which report isokinetic knee strength and balance values in orienteering athletes. Çınar-Medeni et al. analyzed the relationship between knee muscle strength and other performance measures. The knee muscle strength assessment performed at the angular velocity of 120°/sec and showed that increased knee muscle strength had positive effects on all performance measures.[10] In our study the knee muscle strength performed at the angular velocity of 60°/sec and 240°/sec and in contrast to this study decreased knee muscle strength had positive effects on all performance measures. Height, leg length and standing long jumping parameters were statistically significant in our study, we think the cause of this difference was the majority of female gender in successful athletes group. Çınar-Medeni et al. founded that increased knee extensor muscle strength seen with decreased balance loss in flamingo balance test.[10] In our study we showed the most important parameter for predicting success is balance. We estimated balance directly and direct estimations may be more sensitive than indirect estimations. Çınar-Medeni et al.'s other study com-

TABLE 2: Comparison of demographics, anaerobic performance, strength, balance and coordination parameters of successful and unsuccessful athletes.

	Successful Athletes Mean±SD	Unsuccessful Athletes Mean±SD	P Value
Age. year	23.9±4.0	19.9±2.6	<0.001
Sex. n (%) Male	3 23.07%	21 65.62%	0.010
Female	10 76.92%	11 34.37%	
Height. cm	167.9±6.5	173.5±9.0	0.047
Weight. kg	61.7±9.4	63.7±6.4	0.260
BMI. kg/m²	21.8±2.2	21.2±2.3	0.298
Fat percentage. %	16.0±6.0	11.0±8.5	0.074
Leg length. cm	85.0±4.9	90.4±6.1	0.008
Upper body length. cm	83.1±3.2	83.0±4.7	0.669
Arm length. cm	71.6±4.2	74.4±4.8	0.060
Hand length. cm	17.6±0.8	18.3±0.9	0.097
Triceps thickness. cm	12.8±3.8	11.4±5.9	0.148
Subscapularis thickness. cm	11.4±3.8	10.2±2.5	0.535
Suprailiac thickness. cm	9.9±2.7	9.0±2.7	0.344
Calf thickness. cm	12.2±5.8	11.4±4.9	0.823
MUAC. cm	30.2±10.5	37.1±12.3	0.059
Calf circumference. cm	36.3±2.5	35.1±1.9	0.184
Elbow diameters. cm	7.8±0.6	7.8±0.9	0.947
Knee diameters. cm	9.8±0.8	10.1±0.9	0.376
VJ. cm	32.0±9.4	35.4±11.6	0.403
SLJ. cm	139.0±28.8	169.1±36.5	0.012
20 meter run. sec	3.8±0.5	3.6±0.6	0.138
Left OSI	3.0±1.5	2.1±0.9	0.032
Right OSI	3.1±1.9	1.9±0.7	0.013
Left API	2.2±1.2	1.5±0.7	0.045
Right API	2.3±1.6	1.2±0.5	0.009
Left MLI	1.5±0.7	1.2±0.5	0.218
Right MLI	1.5±0.7	1.1±0.5	0.242
Right PT 60°/sec ext (N.m)	136.7±43.5	172.4±53.2	0.037
Left PT 60°/sec ext (N.m)	122.0±40.9	170.9±53.2	0.004
Right PT 60°/sec flx (N.m)	85.5±26.8	89.2±34.3	0.817
Left PT 60°/sec flx (N.m)	81.8±25.9	78.9±28.1	0.887
Right PT 240°/ sec ext (N.m)	73.3±23.9	99.5±27.6	0.004
Left PT 240°/ sec ext (N.m)	69.5±20.4	97.1±24.4	0.001
Right PT 240°/sec flx (N.m)	57.4±17.0	59.0±18.5	0.671
Left PT 240°/sec flx (N.m)	57.5±14.9	57.8±17.0	0.928
FVC	4.4±0.9	4.5±0.8	0.980
FEV1	3.8±0.7	3.7±0.6	0.659
FEV1/FVC	86.4±6.5	83.0±8.0	0.363
FEF	4.1±0.7	3.9±0.9	0.769
PEF	6.5±1.5	6.1±2.4	0.377

MUAC: Mid-upper arm circumference; OSI: Overall stability index; API: Anteroposterior stability index; MLI: Mediolateral stability index; PT: Peak torque; Ext: Extantion; Flx: Flexion; VJ: Vertical jump; SLJ: Standing long jump.

pared the differences of performance measures between adolescents, young adults and adults.[11] This study emphasizes the importance of balance similar to our study.

To date, much of the researches on high-performance orienteering has focused on physical or cognitive factors. At the same time, each orienteering race is unique with respect to race length

TABLE 3: ROC curve analysis results of height, leg length, SLJ, muscle strength, balance and coordination parameters.

	ROC Curve Analysis Value	95% Confidence Interval	P Value
Height. cm	0.703	0.543-0.862	0.037
Leg length. cm	0.765	0.621-0.910	0.006
SLJ. cm	0.756	0.601-.0912	0.008
Left OSI	0.712	0.535-0.888	0.029
Right OSI	0.737	0.573-0.901	0.014
Left API	0.694	0.517-0.871	0.046
Right API	0.749	0.582-0.915	0.010
Right PT 60°/sec ext (N.m)	0.692	0.523-0.862	0.047
Left PT 60°/ sec ext (N.m)	0.767	0.614-0.920	0.006
Right PT 240°/ sec ext (N.m)	0.772	0.609-0.934	0.005
Left PT 240°/ sec ext (N.m)	0.808	0.659-0.956	0.002

OSI: Overall stability index; API: Anteroposterior stability index; MLI: Mediolateral stability index; PT: Peak torque; Ext: Extantion; SLJ: Standing long jump.

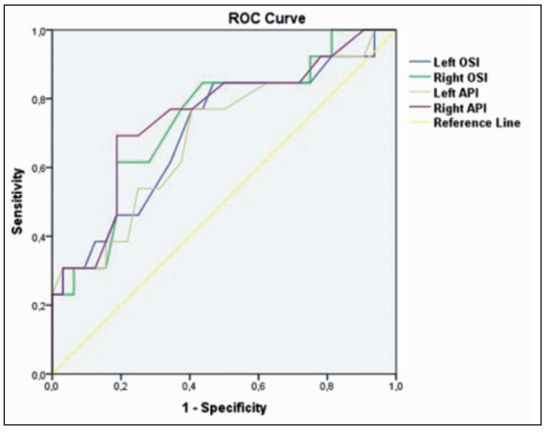

FIGURE 1: ROC Curve Analyze of Balance and coordination parameters. OSI: Overall stabilite index; API: Anteroposterior stabilite index.

and terrain.[3] Because of the nature of orienteering sport, which involves speedy traversing on uneven terrain, uphill running ability is a determining factor of performance. In orienteering competition, athlete's navigating the fastest route based on the his/her own running ability will influence overall performance.[17] Since orienteers compete on variable grounds such as sand, grass, stiff, sold soil and obstacles; running biomechanics alter in each of these conditions, so we can say that environmental and biomechanical factors affect orienteering performance highly. Consequently, orienteer athletes must adapt their running biomechanics to various surfaces, with suggested mechanisms including increased hip and knee flexion to augment postural stability and robustness.[18] Orienteers run with slightly flexed hips and knees, allowing an instantaneous balance counteracting when necessary, on uneven ground. A well-trained orienteer must have the ability to run fast in extremely rough terrain. This ability discriminates successful orienteers from the others. Jumps over obstacles in the terrain, running downhill and uphill require strong muscles as well as high endurance capacity.[18-21] Orienteering athletes must have great balance performance so that they can run in different terrain conditions and press right to the terrain after they jump over obstacles. Our study showed that suc-

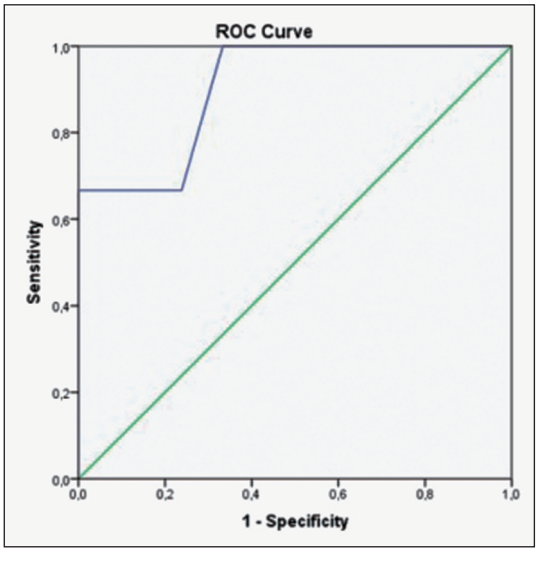

FIGURE 2: ROC Curve Analyze of OSI for male athletes. OSI: Overall stabilite index.

cessful athletes have better balance performance too. The most decisive factor for predicting success is right API in overall athletes group, but for male athletes this factor is left OSI. Sensitivity was found to be 100% and selectivity to 66.7% when left OSI value decreased below 2.1 in male athletes. Balance parameter is also important for protection from injuries. If an ankle injury develops, the complete healing process will be prolonged or recurrence will be occurred because of the terrain in orienteering sport.

Although orienteering is primarily an endurance sport, anaerobic fitness level is also important for high performance. It is necessary when negotiating difficult terrain (anaerobic power is required to clear obstacles) and also during periods of ascent (anaerobic capacity).[22] For this reason the athletes have heavy training programmes. No balance training programme was used by our orienteering athletes before this study. Balance and coordination test that we used in the study is a laboratory method and cannot be used in the field. There are other balance tests that can be used in the field instead of this balance and coordination test. Balance exercises should be added to the training programme of all orienteering athletes. Balance tests can be used by athletes and coaches as a training programme before the competition or can also be used to follow improvement of athletes' performance in the season. Maybe the best method that can be used to assess the orienteering athlete's position in the field is balance as we found.

Limitation of this study is that cognitive factors were not assessed. Millet et al. study examined the influence of fatigue on running biomechanics in normal running, in normal running with a cognitive task, and in running while map reading. Orienteers performed a fatiguing running exercise of duration and intensity similar to a classic distance orienteering race on an instrumented treadmill while performing mental arithmetic, an orienteering simulation, and control running at regular intervals. They did not show any significant difference between mental arithmetic and control running for any of the kinematic and kinetic parameters. However, these parameters were systematically different between the orienteering simulation and the other two conditions (mental arithmetic and control running). All changes in running pattern observed during the orienteering simulation.[9] The importance of map-reading in the area is known,[8,9] may be the biggest factor. But there is no a valid method for the level of map reading. More studies are necessary to define a valid method.

Another limitation of this study is small sample size. The majority of female gender affected our results negatively, so a gender difference has been occurred. Forty five orienteers are sufficient for a study but we could compare the gender difference only in balance parameters when we allocated to groups. If the sample size had been larger, the effect of gender difference would have been put forward more clearly

CONCLUSION

Balance and coordination tests can be used for predicting success of orienteering athletes before the competition. To increase the success of the athletes in the orienteering sport competitions; anaerobic performance, knee muscle strength, endurance, especially balance and coordination parameters should be improved. Sports specific training should be done before the competition to increase the success. For this purpose balance can be used. More studies are necessary to define predicting tests that might be the best for success of orienteering athletes and to determine a method that might show level of map reading. In other sports, sports specific parameters can be found.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Concept: *Aydan Örsçelik;* ***Design:*** *Aydan Örsçelik;* ***Supervision:*** *Aydan Örsçelik, Ali Haydar Apaydın;* ***Resource:*** *Aydan Örsçelik, Ali Haydar Apaydın, Yavuz Yıldız;* ***Data Collection and/or Processing:*** *Aydan Örsçelik, Ali Haydar Apaydın;* ***Analysis and/or Interpretation:*** *Aydan Örsçelik, Yavuz Yıldız;* ***Literature Search:*** *Aydan Örsçelik;* ***Writing:*** *Aydan Örsçelik, Ali Haydar Apaydın;* ***Critical Reviews:*** *Yavuz Yıldız.*

REFERENCES

1. Roos L, Taube W, Zuest P, Clénin G, Wyss T. Musculoskeletal injuries and training patterns in junior elite orienteering athletes. Biomed Res Int 2015;2015:259531.
2. Champion N. What is orienteering. Orienteering. 1st ed. New York: The Rosen Publishing Group Inc; 2009. p.4-6.
3. Hébert-Losier K, Platt S, Hopkins WG. Sources of variability in performance times at the world orienteering championships. Med Sci Sports Exerc 2015;47(7):1523-30.
4. Long JA, Junghans BM. Orienteers with poor colour vision require more than cunning running. Clin Exp Optom 2008;91(6):515-23.
5. Eccles DW, Walsh SE, Ingledew DK. Visual attention in orienteers at different levels of experience. J Sports Sci 2006;24(1):77-87.
6. Pesce C, Cereatti L, Casella R, Baldari C, Capranica L. Preservation of visual attention in older expert orienteers at rest and under physical effort. J Sport Exerc Psychol 2007;29(1): 78-99.
7. Hancock S, McNaughton L. Effects of fatigue on ability to process visual information by experienced orienteers. Percept Mot Skills 1986;62(2):491-8.
8. Gasser BA. [Predictors of average speed in orienteering: the number of controls is crucial]. Sportverletz Sportschaden 2016;30(2): 90-4.
9. Millet GY, Divert C, Banizette M, Morin JB. Changes in running pattern due to fatigue and cognitive load in orienteering. J Sports Sci 2010;28(2):153-60.
10. Çinar-Medeni Ö, Colakoglu FF, Yüce K, Ipekoğlu G, Baltaci G. The relation between knee muscle strength and performance tests in orienteering athletes. J Sports Med Phys Fitness 2016;56(111261):1261-8.
11. Çinar-Medeni Ö, Çolakoglu FF, Yüce K, İpekoğlu G, Baltaci G. The performance measures of orienteers: late adolescents, young adults and adults. Turkiye Klinikleri J Sports Sci 2016;8(1):1-7.
12. Günay M, Tamer K, Cicioğlu İ. Performans ölçümü. Cicioğlu İ, editör. Spor Fizyolojisi ve Performans Ölçümü. 2. Baskı. Ankara: Gazi Kitabevi; 2010. p.427-587.
13. Koç H, Aslan CS. [The comparison of male handball and volleyball players' selected physical and motor skills]. Selçuk University Journal of Physical Education and Sport Science 2010;12(3):227-31.
14. Montes J, Wulf G, Navalta JW. Maximal aerobic capacity can be increased by enhancing performers' expectancies. J Sports Med Phys Fitness 2017 Feb 22. Doi: 10.23736/S0022-4707.17.07254-1. [Epub ahead of print].
15. Örsçelik A, Yıldız Y. Comparison of single and triple platelet rich plasma injections in the treatment of patellofemoral pain syndrome. Turkiye Klinikleri J Med Sci 2015;35(2):78-87.
16. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 1982; 143(1):29-36.
17. Lauenstein S, Wehrlin JP, Marti B. Differences in horizontal vs. uphill running performance in male and female Swiss world-class orienteers. J Strength Cond Res 2013;27(11):2952-8.
18. Hébert-Losier K, Mourot L, Holmberg HC. Elite and amateur orienteers' running biomechanics on three surfaces at three speeds. Med Sci Sports Exerc 2015;47(2):381-9.
19. Rolf C, Andersson G, Westblad P, Saltin B. Aerobic and anaerobic work capacities and leg muscle characteristics in elite orienteers. Scand J Med Sci Sports 1997;7(1):20-4.
20. Westblad P, Svedenhag J, Rolf C. The validity of isokinetic knee extensor endurance measurements with reference to treadmill running capacities. Int J Sports Med 1996;17(2): 134-9.
21. Pinnington HC, Lloyd DG, Besier TF, Dawson B. Kinematic and electromyography analysis of submaximal differences running on a firm surface compared with soft, dry sand. Eur J Appl Physiol 2005;94(3):242-53.
22. Creagh U, Reilly T. Physiological and biomechanical aspects of orienteering. Sports Med 1997;24(6):409-18.