# The Performance Measures of Orienteers: Late Adolescents, Young Adults and Adults

## Oryantiring Sporcularının Performans Ölçümleri: Geç Ergenler, Genç Erişkinler ve Yetişkinler

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**ABSTRACT Objective:** To analyze performance measures of the orienteers including, static and dynamic balance, agility, speed, flexibility, knee muscle strength, aerobic and anaerobic performance and to set the differences between adolescents, young adults and adults. **Material and Methods:** 31 male orienteering players included in the study. First group consisted of adolescents aged between 15-19 years (n=9), second group consisted of young adults aged between 20-24 years (n=11), third group consisted of adults aged between 25-30 years (n=11). Isokinetic knee muscle strength testing, sit and reach test, star excursion balance test, 20 meter sprint test , flamingo balance test, vertical jump and reach test, T-drill test and 20 meters shuttle run test were performed in two sessions. **Results:** $MaxVO_2$ levels and flexor and extensor peak torques of nondominant legs at 120°/sec were different among groups, respectively (p=0.006, p=0.01, p=0.003). The differences in MaxVO2 levels were between adolescents and young adults (p=0.007) and between adolescents and adults (p=0.002). The differences flexor and extensor peak torques of nondominant legs at 120 °/sec were between adolescents and young adults respectively (p=0.02, p=0.02). Extensor peak torque of nondominant legs at 120°/sec was different between young adults and adults (p=0.001). Other performance measures were not different among groups (p>0.05). **Conclusion:** It was seen that late adolescents have similar performance capacity when compared with young adults and adults except aerobic power and knee muscle strength of nondominant legs at 120°/sec. Aerobic capacity and knee muscle strength of nondominant legs should be increased by training.

**Key Words:** Muscle strength; power; adolescence; orienteering

**ÖZET Amaç:** Oryantiring sporcularının statik ve dinamik denge, çeviklik, esneklik, hız, diz kas kuvveti, aerobik ve anaerobik gücü içeren performans ölçümlerini incelemek ve ergen, genç erişkin ile yetişkin grupları arasındaki farkları ortaya koymak. **Gereç ve Yöntemler:** 31 erkek oryantiring sporcusu çalışmaya alındı. Birinci grup 15-19 yaş arasındaki ergenlerden (n=9), ikinci grup 20-24 yaş arasındaki genç erişkinlerden (n=11), üçüncü grup 25-30 yaş arasındaki yetişkinlerden (n=11) oluştu. İzokinetik diz kas kuvveti değerlendirmesi, otur-uzan testi, yıldız denge testi, flamingo denge test, dikey sıçrama testi, T-çeviklik testi ve 20 metre mekik koşu testleri iki seans içinde yapıldı. **Bulgular:** Gruplar arasında MaxVO2 düzeyleri ve dominant olmayan bacağın 120°/sn hızda fleksör ve ekstansör tepe torkları farklı bulundu (p=0,006, p=0,01, p=0,003). $MaxVO_2$ düzeylerindeki fark ergen ve genç erişkinler arasında (p=0,007) ve ergen ile yetişkinler arasında bulundu (p=0,002). Dominant olmayan bacağın 120°/sn hızda fleksör ve ekstansör tepe torkları ergenler ve genç erişkinler arasında birbirinden farklıydı (sırasıyla p=0,02, p=0,02). Dominant olmayan bacağın 120°/sn hızda ekstansör tepe torku genç erişkin ve yetişkinler arasında birbirinden farklı bulundu (p=0,001). Diğer performans ölçümleri gruplar arasında birbirinden farklı değildi (p>0,05). **Sonuç:** Geç ergenlerin, aerobik güç ve dominant olmayan bacağın 120°/sn hızdaki kuvveti dışında genç erişkin ve yetişkinler ile benzer performans kapasitesine sahip olduğu görülmektedir. Aerobik kapasite ve dominant olmayan bacağın kas kuvveti antrenman ile artırılmalıdır.

**Anahtar Kelimeler:** Kas kuvveti; güç; ergenlik; oryantiring

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Orienteering is an endurance sport, requires cognitive demands with high intensity running in terrain with obstacles.[1] Both aerobic and anaerobic performances are needed for better orienteering performance.[2] Physical performance is the outcome of the motor tasks requiring speed, local muscular strength, agility, balance, flexibility, explosive strength and static muscular strength.[3]

World Health Organization (WHO) accepted the adolescence age limits as 10-19 and defined "youth" between the age ranges of 15-24 years.[4,5] The late adolescence is generally accepted as the ages 15 to 19 years, and young adulthood is 20-24 years.[6,7] Peak performance of the long distance runners was between the age of 23 and 30 years, including both young adult and adult ages.[8]

Adolescents' sports participation is a great deal of interest.[9] Performance of an adolescent individual differs from adults in some instances.[3] Some performance parameters such as; speed, agility, vertical and long jumps, static balance, flexibility; improve up to 12-18 years.[3] Maximal oxygen uptake increases linearly between 8 and 16 years in male adolescents.[10] The performance of the adolescents was analyzed in previous researches;[3] however in orienteering sport we are not aware of any studies. Because of this we aimed to analyze performance measures of the orienteers including, static and dynamic balance, agility, speed, flexibility, knee muscle strength, aerobic and anaerobic performance, and to set the differences between adolescents, young adults and adults. Our hypothesis is that performance measures of orienteers differ among different age groups.

## MATERIAL AND METHODS

A total of 31 male orienteering players were included in the study. Inclusion criteria were not to have any orthopedic injury in last 6 months, not to have any orthopedic surgery, not to have any neurologic or systemic diseases. Athletes who had pain during assessments were excluded from study. All subjects were informed about the study and they participated voluntarily. Athletes in young adult and adult group signed an informed consent form. Parental consent was received from the late adolescent group. The study was conducted according to ethical principles of the World Medical Association Declaration of Helsinki and ethical approval was obtained from Selçuk University's ethical commission (2015/3).

Orienteers were grouped according to their age groups. First group consisted of adolescents aged between 15-19 years with the number of 9 subjects. Second group consisted of 11 young adults aged between 20-24 years. Third group consisted of 11 adults older than 25 years (25-30 years). Dominant leg was accepted as the leg preferred for kicking a ball. In adolescent group 8 athletes was right-dominant, 1 athlete left-dominant, in young adult group 8 were right-dominant, 3 were left-dominant, in adult group 9 were right-dominant, 2 were left-dominant.

Orienteers were tested in two sessions. At the first session isokinetic knee muscle strength testing, "sit and reach test" (SRT), "star excursion balance test" (SEBT) and 20 meter sprint test were done in a randomized order with five minutes of resting period between tests. After two days in the second session, "flamingo balance test" (FBT), "vertical jump and reach test" (VJRT) and T-drill test were done in a randomized order with five minutes of resting period between tests and after 30 minutes of resting period 20 meters shuttle run test was performed.

Knee muscle strength was evaluated by using ISOMED 2000 (D&R Ferstl GmbH, Hemau, Germany) isokinetic dynamometer, which was found to be a reliable device to evaluate isokinetic knee muscle strength.[11,12] After five-minute warm up on treadmill, the subject seated with the hip and knee flexed 90°. Center of the knee joint was aligned with the center of the dynamometer using a laser-pointing device. The subject was asked to push up the lever arm of the dynamometer as strongly as possible and to return to the starting position five times at the angular velocity of 60°/sec and then after a 1 minute break; same procedure was repeated at the angular velocity of 120°/sec five times.

Mean score of the five trials were recorded as athlete's score. Output data from the assessment were "flexor peak torque" (FPT), "extensor peak torque" (EPT), and "hamstring/quadriceps strength ratio" (H/Q). The data were normalized by dividing strength values to body weight for each subject.

"*Flamingo balance test*" (FBT) was performed to evaluate static balance ability. Athletes stood on one leg with shoes removed. Stand on the beam with shoes removed. While balancing on the preferred leg, the free leg was flexed at the knee and the foot of this leg held close to the standing knee. The number of falls in 60 seconds was recorded.[13]

"*Star Excursion Balance Test*" (SEBT) was done to assess dynamic balance of the subjects. Subjects were asked to stand on tested leg, in the middle of the grid formed by three lines (anterior, posterolateral and posteromedial directions).[14] Subjects were instructed to reach as far as possible along each of the three lines, make a light touch on the line, return back and stand on double legs. After practicing six times in each line, participants performed three trials beginning with anterior direction and progressing to clock wise around the grid. The physiotherapist recorded each distance with the tape and mean of three scores were used for analyze.

"*Vertical jump and reach test*" (VJRT) was done to determine anaerobic power. The athlete was asked to stand near the wall at the dominant side. A measuring tape was placed to the wall longitudinally and keeping the feet flat on the ground the athlete was asked to reach as high as possible with the dominant hand and touch the wall with fingers while the nondominant hand stayed near the body. In this position the point of the fingertip is marked and this height was called the standing reach height. The athlete then stood away from the wall and jumped vertically as high as possible using both arms and legs to assist in projecting the body upwards and touched the wall again with fingers. The difference in distance between the standing reach height and the jumping height was recorded as the score. The best of three attempts is recorded. The Lewis formula (Average Power (Watts)= √4.9 x body mass (kg) x √jump-reach score (m) x 9.81) was used to calculate average power.[15]

"*T-Drill Test*" (T-test) was performed to evaluate agility of the subjects. 3 cones were set five meters apart on a straight line. A fourth cone was placed 10 meters from the middle cone so that the cones formed a 'T'. The athlete was asked to start from the cone at the base of the 'T'. The athlete ran to the middle cone, touch it, then side stepped 5 meters to the left cone, touched that cone. The athlete then side steps 10 meters to the far cone and touches that one. The athlete the side steps 5 meters back to the middle cone and touched that one. Finally the athlete ran 10 meters backwards to the base of the 'T' and touched that cone. The time was recorded.[16]

"*20 meters Shuttle-Run Test*" (SRT) was performed to analyze aerobic power of the subjects. The athletes were asked to run back and forth on a 20 meter course. They must touch to the block at the 20 meter line when a sound signal was heard from a prerecorded tape. The frequency of the sound signals increases 0.5 km/h for each minute starting from 8.5 km/h. The test was stopped when the subjects could not carry on the test.[17] Maximal $O_2$ uptake was determined according to Ramsbottom et al.[18]

"*20 Meters Sprint Test*" was performed to analyze speed of the orienteers.[19] Subjects performed a single maximum sprint over 20 meters, starting from a stationary position, with one foot in front of the other with the time recorded. The front foot was placed behind the starting line. This starting position held for 2 seconds prior to starting, and no rocking movements were allowed. The tester encouraged subjects to continue running hard through the finish line.

"*Sit and Reach Test*" was performed to assess lower back and hamstring flexibility.[20] A sit and reach box which have a ruler on the top, was used to position the subjects. Subjects sat on the floor with shoes removed and put feet against the table with knees extended. They were asked to reach as far as possible with their fingers and stay at the last position for 5 seconds while knees were extended.

The subjects performed three trials and the best score seen on the ruler of the table was recorded. The table has an overhang of 15 cm, the subject who reached to his toes scored as 15 cm.

Statistical analysis: Due to low number of subjects in groups nonparametric tests were used to analyze data. Differences in scores of each test among groups were analyzed with the Kruskal Wallis test. Post-hoc comparisons were done with the Mann-Whitney U test. A p value of 0.05 was set to infer statistical significance.

**TABLE 1:** Demographic information of the subjects.

| | Age groups | | |
|---|---|---|---|
| | 15-19 years | 20-24 years | 25-30 years |
| | Mean± SD | Mean± SD | Mean± SD |
| Age (years)* | 17.00 ±1.32 | 22.09±1.51 | 27.27±1.79 |
| Body height (cm) | 175.78±7.55 | 177.45±5.05 | 176.27±5.57 |
| Body mass (kg) | 63.00±9.37 | 66.36±5.20 | 65.73±9.43 |
| Body mass index (kg/m$^2$) | 20.33±2.20 | 21.09±1.22 | 22.13±1.70 |
| Sport year | 5.11±2.09 | 5.55±3.14 | 6.82±3.06 |

*Significant difference was found among groups (p<0.05).
SD: Standard deviation.

## RESULTS

Demographic information of the groups was given in table 1. Body height, body weight, body mass index and sports year were not different among groups (p>0.05). Only the age of the orienteers was different among groups (p<0.05) (Table 1). Descriptive statistics of the performance measures were given in the Table 2. Max$VO_2$ levels of the groups were different among groups (p=0.006) (Table 2). The differences in Max$VO_2$ levels were between adolescents and young adults (p=0.007) and between adolescents and adults (p=0.002) (Figure 1). FPT and EPT of nondominant legs at 120 °/sec were different among groups respectively (p=0.01, p=0.003). Post-hoc comparisons showed that there were significant differences in FPT and EPT of nondominant legs at 120 °/sec between adolescents and young adults respectively (p=0.02, p=0.02) (Table 3). EPT of nondominant legs at 120 °/sec was different between young adults and adults (p=0.001). Other performance measures were not different among groups (Table 3).

**TABLE 2:** Descriptive statistics of the performance measures.

| | Age groups | | |
|---|---|---|---|
| | 15-19 years | 20-25 years | 25-30 years |
| | Mean± SD | Mean± SD | Mean± SD |
| Jump height (cm) | 50.00±8.41 | 50.64±7.90 | 45.45±5.80 |
| Anaerobic power (watts) | 70.26±18.52 | 74.36±13.18 | 65.55±9.96 |
| Max$VO_2$ level (ml/kg/min)* | 43.66±4.92 | 51.28±5.33 | 52.73±5.82 |
| 20 m sprint (sec) | 3.38±0.30 | 3.22±0.18 | 3.21±0.13 |
| T test (sec) | 11.48±0.77 | 11.68±0.63 | 11.91±0.97 |
| Flexibility (cm) | 27.33±5.63 | 26.91±8.06 | 20.27±11.90 |
| FBT-dominant side (count) | 1.44±1.33 | 0.64±1.03 | 1.45±1.44 |
| FBT-nondominant side (count) | 2.00±2.18 | 0.82±0.87 | 1.09±1.45 |
| Star excursion balance test-dominant side (cm) | | | |
| Anterior d. | 74.31±6.80 | 75.95±5.68 | 70.15±6.44 |
| Posterolateral d. | 85.35±7.50 | 83.69±4.09 | 82.62±7.32 |
| Posteromedial d. | 86.66±6.79 | 88.72±6.19 | 83.41±6.92 |
| Star excursion balance test-nondominant side (cm) | | | |
| Anterior d. | 73.08±6.55 | 74.18±8.70 | 71.01±6.54 |
| Posterolateral d. | 85.05±5.78 | 85.14±4.54 | 82.71±4.60 |
| Posteromedial d. | 86.20±8.98 | 88.27±5.97 | 84.48±8.46 |

*Significant difference was found among groups (p<0.05).
FBT: Flamingo balance test; d: Direction; SD: Standard deviation.

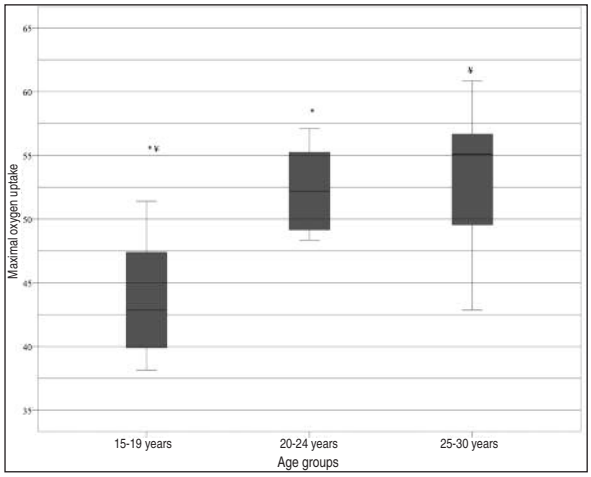


**FIGURE 1:** MaxVO$_2$ levels (calculated from 20 m shuttle-run test) of the subjects according to age groups.

*,¥: Significant difference was found between groups (p<0.05).

## DISCUSSION

This study aimed to analyze performance levels of the orienteers in different age groups. The hypothesis of this study was accepted for aerobic performance and nondominant leg's knee flexor and extensor muscle strength at 120°/sec angular velocity, and rejected for other performance measures. Aerobic performance of the adolescent orienteers was lower than young adult and adult orienteers.

Orienteers in different age groups showed similar body weight and body mass index in this study. Our results are not affected from these parameters. Additionally sports year might be another factor, which has an effect on performance parameters. In this study sports year of the orienteers were not different among age groups, so the effect of sport year was eliminated. The only factor, which may affect performance was the age of the subjects in this study.

In our study mean maxVO$_2$ levels of young adult and adult orienteers were lower than previously published data (61-75 ml/kg/min) of adult male orienteers, however similar with another study which included a huge age range including both adolescents and adults (age between 12-25).[2,21] In this study maxVO$_2$ levels were predicted from 20 m shuttle-run test which was an indirect method to determine maxVO$_2$ level and this might be a reason for low values; however it's correlation with maxVO$_2$ levels. In Colakoglu et al's study[21] com-

**TABLE 3:** Difference of the strength values of three groups.

| | Age groups | | |
|---|---|---|---|
| | 15-19 years | 20-25 years | 25-30 years |
| | Mean± SD | Mean± SD | Mean± SD |
| **Muscle strength testing at 60°/sec.** | | | |
| FPT-D side (Nm/kg) | 1.69±0.27 | 2.01±0.32 | 1.88±0.37 |
| EPT-D side (Nm/kg) | 2.78±0.33 | 2.82±0.28 | 2.63±0.24 |
| F/E-D side (%) | 61.67±9.41 | 71.98±10.34 | 71.52±13.09 |
| FPT-ND side (Nm/kg) | 1.63±0.33 | 1.98±0.42 | 1.85±0.28 |
| EPT-ND side (Nm/kg) | 2.52±0.45 | 2.77±0.48 | 2.49±0.37 |
| H/Q-ND side (%) | 65.56±9.28 | 69.73±9.72 | 74.62±8.27 |
| **Muscle strength testing at 120°/sec.** | | | |
| FPT-D side (Nm/kg) | 1.48±0.26 | 1.82±0.31 | 1.67±0.35 |
| EPT-D side (Nm/kg) | 2.14±0.26 | 2.30±0.26 | 2.05±0.26 |
| F/E-D side (%) | 69.22±11.36 | 78.59±12.52 | 82.64±19.93 |
| FPT-ND side (Nm/kg) | 1.41±0.23* | 1.83±0.20* | 1.61±0.29 |
| EPT-ND side (Nm/kg) | 2.01±0.24* | 2.29±0.22*,¥ | 1.89±0.19¥ |
| H/Q-ND side (%) | 70.87±6.90 | 79.94±5.71 | 74.88±24.61 |

*Significant difference was found between adolescents and young adults (p<0.05).

¥ Significant difference was found between young adults and adults (p<0.05)

FPT: Flexor peak torque; EPT: Extensor peak torque; F/E: Flexor/ extensor peak torque; D: Dominant; ND: Nondominant; SD: Standard deviation.

parison of adolescents with adults was not performed. Our results showed that max$VO_2$ levels of the adolescent orienteers were lower than young adults and adults. Mean age of the adolescents was seventeen in this study, so the difference which was found in max$VO_2$ level may be due to the increase of maximal oxygen uptake through adolescence up to 16-18 years in male adolescents.[10,22] However this difference was not seen for anaerobic performance. The mean values of the young adult and adult orienteers' anaerobic power was lower than Knowlton's study and higher than Colakolu s study.[21,23] The inconsistencies among these three studies show that future research is needed to decide on. Additionally the sport years of groups were not different from each other; all athletes had similar experience in their sport. Together with these we predicted anaerobic power from vertical jump and reach test and a direct analysis was not performed. These should be reasons of why the difference of the anaerobic power between adolescent and adult populations could not be seen in this study.

Orienteers need more strengthful knee muscles than other long distance runners because of the running on uneven ground.[1] In this study at 60°/sec velocity no difference was seen between three age groups showing that late adolescents have similar muscle strength with young adult and adults. When comparing the muscle strength values with other studies which were done in orienteers previously, our EPT results of three groups (both dominant and nondominant legs) at 60 °/sec was better Thorstensson et al.'s study that reported approximately 2.5 Nm/kg at 60°/sec.[24] At 120 °/sec velocity, EPT values of three groups for dominant legs were similar with that study which reported ~2.1 Nm/kg at 120°/sec velocity, however for nondominant legs lower values were observed for adolescents and adults in this study.[24] The difference which was seen in EPT between adolescents and young adults, and between young adults and adults might result from the low values of these groups. We could not find any study which reports isokinetic FPT values in orienteering players. The mean F/E strength ratio in this study is above 60% at both 60°/sec and 120°/sec angular velocities which shows good muscle balance of thigh region.[25] However, adolescents have lower FPT in nondominant legs when compared with young adult group at 120°/sec velocity showing that adolescent orienteers need to strengthen nondominant legs at high angular velocities.

The mean score of the T-drill test of the subjects were similar to the current literature which were done in sedantaries and orienteers.[21,26,27] Speed of the orienteers was better than previous literature which included orienteers however worse than other studies which included other sportsmen.[21,28] Comparison between age groups showed no difference, thus representing that orienteers' agility and speed are improved in late adolescence ages. Flexibility scores of the athletes showed that they can touch forward from their toes and all groups had required low back and hamstring flexibility. Balance is another important parameter that may affect orienteering performance. Except for this study and Colakoğlu's study we did not aware of any study which investigates balance ability of the orienteers.[21] Static balance of the orienteers evaluated in this study was better than, however dynamic balance was worse than Colakoğlu's study.[21] The comparison among groups showed that late adolescent orienteers have similar balance ability with young adult and adult orienteers.

The small sample size is one of the limitations of this study. Additionally in this study a longitudinal analysis was not performed. Further studies should focus on performance of different age groups with high number of subjects. In addition to these female orienteers were not included in this study. In further studies the difference between male and female orienteers should be investigated.

## CONCLUSION

This study showed that most performance parameters of late adolescent orienteers are similar with young adult and adult orienteers. Aerobic capacity seems lower than young adult and adult orienteers and knee flexor and extensor muscle strength values seem lower than young adult population in adolescents. These should be improved with a planned training program.

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