International Journal of Early Childhood Special Education (INT-JECSE)
DOI:10.9756/INTJECSE/V14I5.254 ISSN: 1308-5581 Vol 14, Issue 05 2022

Physiological and Performance Response to Repeat Sprint Tests in Women Athletes

Gökmen Kilinçarslan,
Associate Professor, Bingöl University, Faculty of Sport Sciences, Turkey.
E-mail: gkilincarslan@bingol.edu.tr

İdris Kayantaş,
Associate Professor, Bingöl University, Faculty of Sport Sciences, Turkey.
E-mail: idris_kayantas@hotmail.com

Akan Bayrakdar,
Associate Professor, Alanya Alaaddin Keykubat University, Faculty of Sport Sciences, Turkey.
E-mail: akanbayrakdar@gmail.com

Işık Bayraktar,
Associate Professor, Alanya Alaaddin Keykubat University, Faculty of Sport Sciences, Turkey.
E-mail: isik.bayraktar@alanya.edu.tr

Abstract--- This research was conducted to examine the physiological and performance responses of repeated sprint tests in female athletes. Thirteen female athletes from Bingöl province participated in the research. The measurements were made in the Bingöl University gym. In the study, height, body weight, age, year of sport, body mass index (BMI) and body fat percentage measurements were taken for the descriptive characteristics of the participants. For repeated sprint measurements, the participants, on three separate days and in random order, participated straight repetition sprint (6x25m; straight repeat sprint test) with a 25-second passive rest, 180° shuttle repeat sprint (6x(2x12.5m); shuttle repeat sprint test) and 100 ° change of direction (6x25m; repeated sprint test with change of direction) tests. After three different repeated sprint tests, the participants' best sprint time, total sprint time and performance decrease percentage values were determined as performance responses. In addition, resting heart rate and heart rate during warm-up were determined by a polar clock. The mean age of the athletes participating in the study was 20.46±1.66, the year of sport was 5.00±3.69, height 1.66±0.05 m, body weight 50.06±5.65 kg, body mass index 18.00±1.68 kg/height2, body fat percentage 22.70±2.33 (%) and skeletal muscle weight 17.56±4.98 (%). As a result of the comparison of different sprint tests, no significant difference was found in the number of resting heartbeats before the warm-up and the percentage of performance decrease (%) ($p>0.05$). As a result of different sprint tests, a significant difference was found at the $p<0.05$ level in the pre-exercise heart rate, best sprint time, total sprint time and perceived difficulty level$_{max}$ values. It is seen in the table 2 that the straight repeated sprint test - the best sprint time values are better than the shuttle repeated sprint test - the best sprint test and the repetitive sprint test with change of direction - best sprint time. Likewise, it was determined that the straight repeated sprint test - total sprint time values were better than the shuttle repeated sprint - total sprint time and repetitive sprint test with change of direction - total sprint time values. As a result, although straight, shuttle and repetitive sprint tests with change of direction show differences in terms of the best sprint time, total sprint time and perceived difficulty level, the lack of difference in the percentage of performance decrease and heart rate shows that these three tests do not differ in terms of fatigue and physiological-metabolic characteristics.

Keywords--- Sport, Repetitive Sprint, Physiological, Performance.

I. Introduction

The term speed for sports is defined as the ability of an individual to move or move himself or any part of his body from one place to another [1]. According to another definition for speed, it has been seen that it is defined as the organism's reaction to this stimulus by taking action at the highest speed, as a result of a stimulus and in a very short time [2]. There are many factors that affect speed. Genetic structure, which is among them, is known to affect speed, but it is not a factor that determines speed alone. While the speed is increased by the fact that the high-twitch muscle fibers are more than the slow-twitch fibers, it can be improved more with regular conscious training [3].

Time-motion analysis results revealed that short and high-intensity sprints varying between 10-30 m distance and 2-4 seconds (sec) during a competition for team or individual sports occur just before the moments that lead to the conclusion [4,5]. While Nikolaidis et al. [6] define repetitive sprint ability as the ability to perform repetitive sprints with minimal recovery time, according to another definition, repetitive sprint ability or performance is accepted as the capacity to produce the best possible average sprint performance over a series of repetitive sprints with short rest [7,8]. In other words, Repetitive Sprint Ability is known as the ability that includes short rest periods and occurs with the repetition of maximum sprint effort and is considered an important conditioning component in many sports branches [9]. In many sports branches, athletes have to run multiple repetitive sprints varying from low to high levels [10]. Although repetitive sprints cover a very short period of competition in intermittent team sports, it is accepted that it is an important parameter to affect the outcome of a match [11]. This research was conducted to examine the physiological and performance responses of repeated sprint tests in female athletes. More importantly, it was aimed to reveal which of the tests among straight repetitive sprint (6x25m; flat repetition sprint test) with 25 seconds of passive rest, 180° shuttle repetitive sprint (6x(2x12.5m); shuttle repetitive sprint test) and 100° reversing sprint (6x25m; repetitive sprint test with change of direction) tests is more effective on physiology and performance by repeated sprint measurements of participants.

This research was conducted to examine the physiological and performance responses of repeated sprint tests in female athletes.

II. Methodology

Research Model and Participants

This research was conducted with an experimental model. Thirteen female athletes aged 20.46±1.66 years participated in the study. The research was carried out in Bingöl University gym. Participants participated in different repeated sprint tests in random order on 3 different days at least 24 hours apart. All tests were carried out between 12:00 and 14:00 in the afternoon. Participants were asked not to do any training, not to consume caffeinated beverages, and to eat at least 2 hours before the tests [12].

DOI:10.9756/INTJECSE/V14I5.254 ISSN: 1308-5581 Vol 14, Issue 05 2022

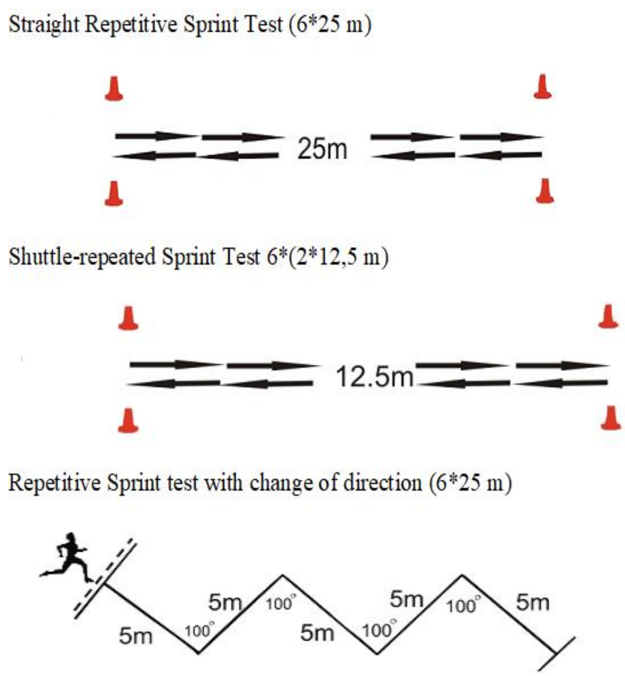
Data Collection Tools

Height, Body Weight, Height Weight Index and Body Fat Percentage: Participants' height was measured with a wall-mounted stadiometer (Holtain, England) with an accuracy of ± 1mm. The body weight and body fat percentage measurements of the participants were measured using an electronic scale with an accuracy of ±100 g and the bioelectrical impedance method (Inbody 270). Body mass index assessment was calculated using the kg/height2 formula.

Heart Rate Measurements: Participants' resting heart rate and heart rate during warm-up and heart rates were recorded with telemetric heart rate monitors (Polar M400, USA) at one-second intervals.

Perceived Difficulty Level: The participants' perceived difficulty levels were determined by Borg's Perceived Difficulty Scale, whose scores ranged from 6 to 20. On the scale, 6 represents the lowest level of difficulty and 20 represents the highest level of difficulty [13].

Repeated Sprint Test: Repetitive sprint performance, determined by applying three different repetitive sprint tests, was measured using a two-door photocell system (Fusion Sport, Australia). As Repeated Sprint Test, Straight repetitive sprint test 6*25 m, Shuttle repeated sprint test 6*(2*12.5 m) and Repetitive sprint test with change of direction 6*25 methods were used.



Data Collection

Before the repeated sprint tests, each participant made 2 maximal 25 m sprint runs with a 2 minute rest interval for each repeated sprint test. These runs, which were made to determine the maximum sprint run time, were made to ensure that the participants participate in the repeated sprint tests with maximum effort. For each repeated sprint test performed after the maximal sprint run, the participants were expected to run the first sprint run in a time that corresponds to at least 95% of the maximal sprint run value [5,12,14,15]. No participant ran less than 95% of their maximal sprint in their first sprint run for all tests. After the maximal sprint run, the participants did passive rest for 5 minutes and then participated in the straight-repeat sprint test

DOI:10.9756/INTJECSE/V14I5.254 ISSN: 1308-5581 Vol 14, Issue 05 2022

with 25-second rest interval, the shuttle-repeated sprint test, and the sprint with change of direction on different days in random order. Before the repetitive sprint tests, the participants took the ready position 5 seconds before the end of the rest period and started the test by counting backwards audibly 3 seconds before the start of the test. Perceived difficulty levels were recorded for each sprint repetition [12].

Determination of Repetitive Sprint Tests Performance Variables

The following performance variables were determined for each repetitive sprint test (the straight-repeat sprint test, the shuttle-repeated sprint test, and the sprint with change of direction).

Best Sprint Time (s): The fastest sprint time achieved during 6 sprint repetitions [16].

Total Sprint Time (s): The sum of all sprint times run during the test [16].

Percentage Decrease in Performance (%): The decrease or decrease in sprint time during the test was calculated by the formula developed by Wadley and Le Rossignol [12,16].

Performance Decrease (%): [(Total Sprint Time x 100)/Ideal Sprint Time]-100

In this formula, the ideal sprint time was accepted as the time obtained by multiplying the best sprint time value obtained during the test with the number of sprints.

Analysis of Data

Statistical analysis of the obtained data was made in SPSS 23 program and the level of significance was accepted as 0.05. Descriptive statistics (Mean ± Standard Deviation) of the variables were calculated. The fit of the variables to the normal distribution was checked with the Kolmogorov-Smirnov test. Deviation from the normal distribution was found to be insignificant for all variables (p>0.05). The effects of repeated sprint tests of different structures on physiology and performance variables were determined by using MANOVA in repeated measurements.

III. Findings

Table 1: Characteristics of the Participants

Variables	M	S.D.
Age (years)	20.46	1.66
Sports year (year)	5.00	3.69
Length (m)	1.66	.05
Body weight (kg)	50.06	5.65
Body Mass Index (kg/m2)	18.00	1.68
Body fat percentage (%)	22.70	2.33
Skeletal muscle weight (%)	17.56	4.98

BMI: Body Mass Index, BFP: Body Fat Percent, M: Mean, SD: Standart Devition

Table 2: Comparison of Performance and Physiological Responses to different Repeated Sprint Tests

Variables	**Straight repeat sprint test** x̄±SS	**Shuttle-repeat Sprint test** x̄±SS	**Repetitive Sprint With Change of Direction** x̄±SS	**F**	**p**

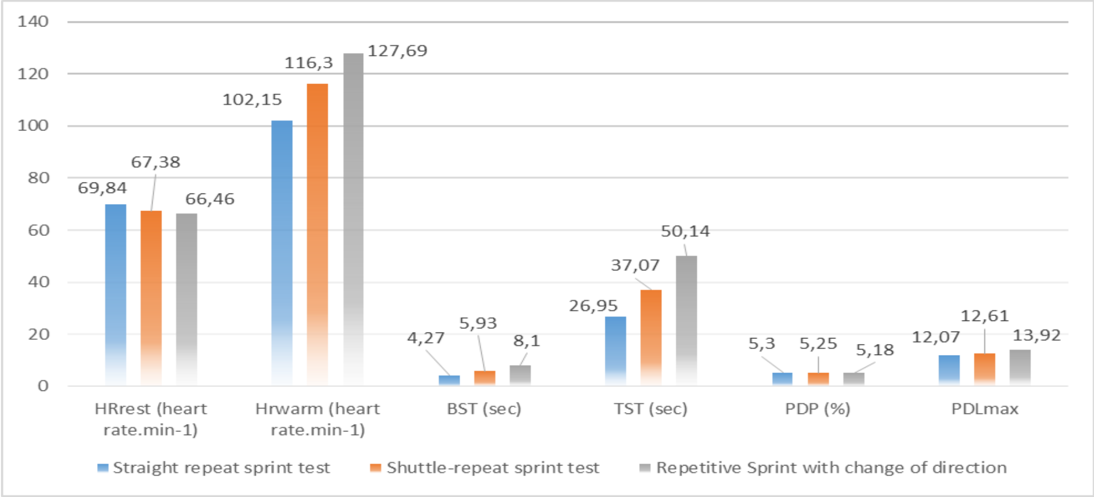
DOI:10.9756/INTJECSE/V14I5.254 ISSN: 1308-5581 Vol 14, Issue 05 2022

Resting Heart Rate (beat.min^{-1})	69.84±6.85	67.38±7.45	66.46±5.30	0.914	0.410
Heart Rate during warm up (beat.min^{-1})	102.15±11.84*	116.30±13.21*	127.69±8.71*	**16.337***	0.000
Best Sprint Time (second)	4.27±0.21*	5.93±0.38*	8.10±0.61*	**250.502***	0.000
Total Sprint Time (second)	26.95±1.25*	37.07±2.13*	50.14±3.46*	**290.683***	0.000
Performance Drop Percentage (%)	5.30±0.18	5.25±0.12	5.18±0.13	1.960	0.156
Perceived Difficulty Level$_{maks}$	12.07±1.65*	12.61±1.19	13.92±1.25*	**6.121***	0.005

StRST: Straight Repeated Sprint Test, ShRST: Shuttle Repeated Sprint Test, RCODST: Repeated Change of Direction Sprint Test, BST: Best Sprint Time, TST: Total Sprint Time, PDP: Performance Decreasing Percentage, RPEmax: Rating of Perceived Maximal Exertion, RHRPMrest: Resting Heart Rate Per Minute, WHRPM warm: Warm-up Heart Rate Per Minute

In Table 2, the mean resting heart rate) before the 3 different sprint tests is 69.84±6.85 beats.min-1 in the straight-repeat sprint test, and 67.38±7.45 beats.min-1 in the shuttle-repeated sprint test and 66.46±5.30 beats.min-1 in the repetitive sprint test with change of direction. Heart rate (warm up) averages were 102.15±11.84 beats.min-1 in the straight-repeat sprint test, 116.30±13.21 beats.min-1 in the shuttle-repeated sprint test, and 127.69±8.71 beat.min-1 in the repetitive sprint test with change of direction. The best sprint time averages in 3 different sprint tests were determined as 4.27±0.21 sec in the straight-repeat sprint test, 5.93±0.38 sec in the Shuttle-repeat sprint test, and 8.10±0.61 sec in the repetitive sprint test with change of direction. Total sprint time values were determined as 26.95±1.25 seconds in the straight-repeat sprint test, 37.07±2.13 seconds in the shuttle-repeated sprint test, and 50.14±3.46 seconds in the repetitive sprint test with change of direction. Percentage decrease in performance was determined as 5.30±0.18% in the straight-repeat sprint test, 5.25±0.12% in the shuttle-repeated sprint test, and 5.18±0.13% in the repetitive sprint test with change of direction. The mean of the maximum perceived difficulty level was determined as 12.07±1.65 in the straight-repeat sprint test, 12.61±1.19 in the shuttle-repeated sprint test, and 13.92±1.25 in the repetitive sprint test with change of direction. As a result of the comparison of the different sprint tests, no significant difference was found in the resting heart rate before the warm-up and the Percent Performance decrease (%) values ($p>0.05$). As a result of different sprint tests, a significant difference was found at the $p<0.05$ level in the values of warm-up heart rate, best sprint time, total sprint time and maximum perceived difficulty before exercise. Table 2 shows that the straight repeat sprint test - the best sprint time values are better than the Shuttle repeated sprint test - the best sprint test and the repetitive sprint test with change of direction - the best sprint time. Likewise, it was determined that the straight-repeat sprint test - total sprint time values were better than the Shuttle repeated sprint test - total sprint time and repetitive sprint test with change of direction - the best sprint time values.

DOI:10.9756/INTJECSE/V14I5.254 ISSN: 1308-5581 Vol 14, Issue 05 2022



Graph 1: Average of Physiological and Performance Responses of Participants

StRST: Straight Repeated Sprint Test, ShRST: Shuttle Repeated Sprint Test, RCODST: Repeated Change of Direction Sprint Test, BST: Best Sprint Time, TST: Total Sprint Time, PDP: Performance Decreasing Percentage, RPEmax: Rating of Perceived Maximal Exertion, RHRPMrest: Resting Heart Rate Per Minute, WHRPMwarm: Warm-up Heart Rate Per Minute

According to the average resting heart rate variable per minute before the different sprint test in Figure 1, it is seen that the participants have similar physiological characteristics. In addition, even if the total sprint time increases in different sprint tests, the results of the perceived difficulty level do not change.

IV. Discussion and Conclusion

This study was conducted to examine the physiological and performance responses of repeated sprint tests in female athletes. More importantly, it was aimed to reveal which of the tests among straight repetitive sprint (6x25m; flat repetition sprint test) with 25 seconds of passive rest, 180° shuttle repetitive sprint (6x(2x12.5m); shuttle repetitive sprint test) and 100° reversing sprint (6x25m; repetitive sprint test with change of direction) tests is more effective on physiology and performance by repeated sprint measurements of participants.

The mean age of the athletes participating in the study was 20.46±1.66, the year of sport was 5.00±3.69, height 1.66±0.05 m, body weight 50.06±5.65 kg, body mass index 18 .00±1.68 kg/height2, body fat percentage 22.70±2.33 (%) and skeletal muscle weight 17.56±4.98 (%).

As a result of the comparison of different sprint tests in our study, no significant difference was found in the resting heart rate values per minute before the warm-up ($p>0.05$). As a result of different sprint tests, a significant difference was found at the $p<0.05$ level in the heart rate values per minute during the warm-up before the exercise. When the physiological responses in resting conditions were examined before the three different repetitive sprint tests, it was seen that there was no difference between the resting heart rate values of the participants. These results show that the participants participated in three different repeated sprint tests under similar physiological conditions. In addition, there was a significant difference at $p<0.05$ level between the heart rate values per minute during the warm-up before the repeated sprint test. While physiological responses are expected to be similar to each other at the same metabolic level both at rest and during warm-up [12], it was determined in our study that the value of heart rate per minute during warm-up differs. The reason for this is thought to be due to the fact that the participants are in different branches.

As a result of the comparison of different sprint tests in this study, no significant difference was found in the percentage of performance decline (%) values ($p>0.05$). When the literature is examined, it has been observed that few studies generally support this finding [5,17,18,19,20].

In this study, a significant difference was found at the $p<0.05$ level as a result of different sprint tests in the values of the best sprint time, total sprint time and maximal perceived difficulty. Table 2 shows that the values of straight repeated sprint test-best sprint time are better than Shuttle-repeat sprint test-best sprint test and repeated sprint test with change of direction-best sprint time. Likewise, it was determined that the values of the straight repeated sprint test-total sprint time values were better than the shuttle-repeated sprint test-total sprint time and the repetitive sprint test with change of direction-total sprint time values. In the literature, a limited number of studies examining the performance responses of different repetitive sprint tests and findings supporting the findings of this study were found. Ziyagil and İmamoğlu [21] found a relationship between repeated sprint test and heart rate, Buchheit et al. [5] state that there is a significant difference in favor of the straight-repeat sprint test between the best sprint time and total sprint time values obtained from the straight-repeat sprint test (6x25 m) and the 180º-turn shuttle-repeated sprint test and Nikolaidis et al. [6] state that the one-way repetitive sprint test results in better best sprint time and total sprint time values than the two-change repetitive sprint test [22,23]. Compared to the straight repetitive sprint test, as in this study, the reason for slower the best sprint time and total sprint time during the repeated sprint test, which is applied as 180º one change of direction and 100º four change of direction may be that more time is needed due to the application of greater lateral force and more acceleration-negative acceleration during deflections [12, 24,25]. Similarly, the fact that the shuttle repeated sprint test results in better best sprint time and total sprint time performance than the repeated sprint test with change of direction may be because of the increase in time due to the increase in acceleration-negative acceleration as the number of direction changes increases [26].

In addition, these findings show that straight and repetitive sprint tests with direction change are separate (different) motor skills, as it is stated many studies in written sources [17,26,27,28].

As a result, although straight, shuttle and repetitive sprint tests with change of direction show differences in terms of best sprint time, total sprint time and perceived difficulty, the absence of difference in terms of performance decrease percentage and resting heart rate shows that these 3 tests do not differ in terms of fatigue and physiological-metabolic characteristics.

References

[1] Demirci, A. Atletizm öğretimi. 1. Baskı. Ankara: Nobel Yayın Evi; 2010, s: 12, s.65-71.

[2] Demir, M. Koşular, A., Atlamalar, A. 4. Ankara: Baskı Nobel Yayınevi; 2008, s: 362-370.

[3] Bompa, T.O., & Buzzichelli, C. (2019). *Periodization-: theory and methodology of training*. Human kinetics.

[4] Spencer, M., Bishop, D., Dawson, B., & Goodman, C. (2005). Physiological and metabolic responses of repeated-sprint activities. *Sports medicine, 35*(12), 1025-1044. https://doi.org/10.2165/00007256-200535120-0003

[5] Buchheit, M., Bishop, D., Haydar, B., Nakamura, F.Y., & Ahmaidi, S. (2010). Physiological responses to shuttle repeated-sprint running. *International journal of sports medicine, 31*(06), 402-409. https://doi.org/10.1055/s-0030-1249620

[6] Nikolaidis, P.T., Clemente, F.M., Torres-Luque, G., & Knechtle, B. (2017). Repeated sprint ability exercise in a 9-year-old basketball players: effect of change of direction. *Annals of Medical and Health Sciences Research*, *7*(6).

[7] Bishop D, Girard O, Mendez-Villanueva A. (2011) Repeated-sprint ability—Part II. *Sports Medicine, 41*(9): 741-56. https://doi.org/10.2165/11590560-000000000-00000

[8] Stojanovic, M.D., Ostojic, S.M., Calleja-González, J., Milosevic, Z., & Mikic, M. (2012). Correlation between explosive strength, aerobic power and repeated sprint ability in elite basketball players. *Journal of Sports Medicine and Physical Fitness, 52*(4), 375. https://pubmed.ncbi.nlm.nih.gov/22828459/

[9] Spencer M., Pyne D., Santisteban J., Mujika I. (2009). Fitness Determinants of Repeated-Sprint Ability in Highly Trained Youth Football Players. *International Journal of Sports Physiology and Performance, 6,* 497-508. https://doi.org/10.1123/ijspp.6.4.497

[10] Ozdemir F., Yilmaz A., Kin-İşler A. (2014). Genç Futbolcularda Tekrarlı Sprint Performansının Yaşa Göre İncelenmesi. *Hacettepe Spor Bilimleri Dergisi, 25*(1), 1-10. https://dergipark.org.tr/en/pub/sbd/issue/16369/171302

[11] Oliver, J.L., Armstrong, N. ve Williams, C.A. (2009). Relationship between Brief and Prolonged Repeated Sprint Ability. *Journal of Sience and Medicine in Sport, 12,* 238-243.
https://doi.org/10.1016/j.jsams.2007.09.06

[12] Göveli, H. (2019). *Farklı Tekrarlı Sprint Testlerinin Performans ve Fizyolojik Yanıtlarının İncelenmesi* (Master's thesis, Sağlık Bilimleri Enstitüsü).

[13] Borg, G.A. (1982). Psychophysical bases of perceived exertion. *Med sci sports exerc, 14*(5), 377-381. https://doi.org/10.1249/00005768-198205000-00012

[14] Gantois, P., Aidar, F.J., De Matos, D.G., De Souza, R.F., Da Silva, L.M., De Castro, K.R., & Cabral, B.G. (2017). Repeated sprints and the relationship with anaerobic and aerobic fitness of basketball athletes. *Journal of Physical Education and Sport, 17*(2), 910.
https://doi.org/10.7752/jpes.2017.02139

[15] Chaouachi, A., Manzi, V., Wong, D.P., Chaalali, A., Laurencelle, L., Chamari, K., & Castagna, C. (2010). Intermittent endurance and repeated sprint ability in soccer players. *The Journal of Strength & Conditioning Research, 24*(10), 2663-2669. https://doi.org/10.1519/JSC.0b013e3181e347f4

[16] Wadley, G., & Le Rossignol, P. (1998). The relationship between repeated sprint ability and the aerobic and anaerobic energy systems. *Journal of Science and Medicine in Sport, 1*(2), 100-110. https://doi.org/10.1016/S1440-2440(98)80018-2

[17] Buchheit, M., Haydar, B., & Ahmaidi, S. (2012). Repeated sprints with directional changes: do angles matter? *Journal of sports sciences, 30*(6), 555-562. https://doi.org/10.1080/02640414.2012.658079

[18] Gaitanos, G.C., Williams, C., Boobis, L.H., & Brooks, S. (1993). Human muscle metabolism during intermittent maximal exercise. *Journal of applied physiology, 75*(2), 712-719.
https://doi.org/10.1152/appl.1993.75.2.712

[19] Ruscello, B., Tozzo, N., Briotti, G., Padua, E., Ponzetti, F., & D'Ottavio, S. (2013). Influence of the number of trials and the exercise to rest ratio in repeated sprint ability, with changes of direction and orientation. *The Journal of Strength & Conditioning Research, 27*(7), 1904-1919. https://doi.org/10.1519/JSC.0b013e3182736adf

[20] Zagatto AM, Ardigò LP, Barbieri FA, Milioni F, Iacono AD, Camargo BH, ve ark. (2017). Performance and metabolic demand of a new repeated-sprint ability test in basketball players: Does the number of changes of direction matter? *The Journal of Strength and Conditioning Research, 31*(9): 2438-46. https://doi.org/10.1519/JSC.0000000000001710

[21] Ziyagil, M.A., İmamoğlu, O. (2000). Tekrarlı sprintlerin erkek ve bayan futbolcuların ortalama sürat ve dakika kalp atım sayılarına etkileri. II Futbol ve Bilim Kongresi, Program ve Bildiri Özet Kitapçığı, s: 13, 16-18 Ekim, İzmir.

[22] Bayrakdar, A., & Boz, H.K. (2020). Examination of Physiological and Performance Responses of Repeated Sprint Tests in Football Players. *International Journal of Applied Exercise Physiology, 9*(3), 204-212. http://www.ijaep.com/index.php/IJAE/article/view/786

[23] Gharbi, Z., et al. (2014). "Effect of the number of sprint repetitions on the variation of blood lactate concentration in repeated sprint sessions. *Biology of sport*, 31.2-151. https://doi.org/10.5604/20831862.1099046

[24] Young, W.B., McDowellL, M.H., & Scarlett, B.J. (2001). Specificity of sprint and agility training methods. *The Journal of Strength & Conditioning Research, 15*(3), 315-319. https://pubmed.ncbi.nlm.nih.gov/11710657/

[25] Wong, D.P., Chan, G.S., & Smith, A.W. (2012). Repeated-sprint and change-of-direction abilities in physically active individuals and soccer players: training and testing implications. *The Journal of Strength & Conditioning Research, 26*(9), 2324-2330. https://doi.org/10.1519/JSC.0b013e31823daeab

[26] Young, W., Hawken, M., & McDonald, L. (1996). Relationship between speed, agility and strength qualities in Australian Rules football. *Strength Cond Coach, 4*(4), 3-6.

[27] Brughelli, M., Cronin, J., Levin, G., & Chaouachi, A. (2008). Understanding change of direction ability in sport. *Sports medicine, 38*(12), 1045-1063. https://doi.org/10.2165/00007256-200838120-00007

[28] Young, W.B., McDowell, M.H., & Scarlett, B.J. (2001). Specificity of sprint and agility training methods. *The Journal of Strength & Conditioning Research, 15*(3), 315-319. https://journals.lww.com/nsca-jscr/Abstract/2001/08000/Specificity_of_Sprint_and_Agility_Training_Methods.9.aspx