ORIGINAL ARTICLE

Evaluation of repeated sprint test protocols used in soccer with a global positioning system

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Abstract

Background and Study Aim: The aim of the research is to evaluate the 7x34.2 m Repeated Straight Sprint Test (RSST) and 7x34.2 m Repeated Change of Direction Sprint Test (RCST), which are used for improvement, measurement, and evaluation of repeated sprint ability, by using Global Positioning System (GPS).

Material and Methods: Twenty-two professional soccer players participated in the research voluntarily. Internal and external load data were examined comparatively by using data as before and after the repeated sprint tests. External load data measured by 10 Hz GPS.

Results: When the findings of the research are examined, it is seen that values of blood lactate concentrations which are taken after three and five minutes of the RCST are significantly higher than RSST protocol ($p < 0.001$***, $p = 0.042$*, respectively). In the study, the value of lactate which is taken five minutes after the RSST was measured as 9.60 ± 2.65 mM, while the value which is taken three minutes after RCST was measured as 9.75 ± 2.51 mM. Nevertheless, whereas there was a difference between the two tests in terms of lactate values, no significant difference was found in terms of perceived exertion.

Conclusions: As a conclusion, according to the analyzes made after the RCST and RSST, we can say that the internal and external load performances of the athletes were very different. It has been observed that coaches, athletes, and practitioners can use two different test protocols for different objectives according to the purposes they set.

Keywords: soccer, repeated sprint ability, performance, internal load, external load

Introduction

Soccer has game rules that everyone can understand easily, and it is one of the most popular sports branches that can be played by people of all ages, genders, and levels. This sport is a high-intensity and intermittent sport. Also for soccer, which is based on struggle and competition, the aerobic and anaerobic fitness of the athletes have to be improved [1, 2]. For soccer in the world today, there are some physiological and physical demands which are required for optimal performance. These demands include high-level (sprint, jumping, change of direction) intermediate-level (jogging), and low-level (walking) movements [3]. Studies indicate that both male and female soccer players cover a distance of 9-12 km during the competition [4, 5]. It is noted that 12 % of these distances are covered by sprint or high-intensity running [4, 5, 6] and the number of sprints for each player is in the range of 17-81 per game [7]. In addition, studies have stated that the average sprint time is between 2 and 4 seconds and also a majority of sprint distances are shorter than 20 meters [5, 6]. Riccardo et al. [8] indicated in their research in 2018 that soccer players sprint every 90 seconds and these sprints cover %0.5-3 of the total time.

There are many ways to measure, monitor, and evaluate the physical or physiological results of athletes during match or training. These can be analyzed under two main headings as laboratory and field tests. Most of the physiological and performance tests of the athletes are conducted in well-controlled laboratory environments. Though, the disadvantage of well-controlled situations is that laboratory tests cannot fully measure the sport-specific performance [9]. Unlike laboratory tests, Global Positioning Systems (GPS), which can be used in fields specific to the nature of sports with the help of today's technology and do not damage the game flow of the athlete, are notably successful in measuring objectively and interpreting the real performance of players. Thanks to technological developments of GPS units, monitoring, and measurement of athletes' performances are becoming science which we can observe more accurate results [10]. GPS is widely used in Rugby League, Rugby Union, Australia Football League, cricket, hockey, and soccer [11]. There are lots of studies examining the validity and reliability of GPS for movement measurement in sports such as soccer, hockey, and cricket [11, 12, 13]. It is stated that GPS is observed as a practical and unequalled tracking system when compared to other methods such as time-motion analysis, video-based system

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in a study that is on the validity and reliability of GPS [14]. In their study, Yanci et al. [13] mentioned that GPS has become commonly used as a tool to measure fast-paced actions at distances between 15 and 30 meters.

The ability that occurs with the repetition of short rest periods and maximum sprint effort is known as "Repeated sprint ability" and also this ability is recognized as a significant conditioning component in many team sports [15]. In many team sports such as soccer athletes, sprint that are in different numbers and repeated [16]. Athletes are required to produce more power that has to be maximum or close to the maximum (1-7 seconds) during the competition (60-90 minutes) in short recovery periods [17]. Even though repeated sprints cover a very short period of the competition, they have importance enough to affect the score of a game [18]. When the importance of repeated sprint ability is considered, it is very essential to develop a test that is valid and reliable for evaluation of conditioning component. A valid and reliable test would be very helpful in evaluating the training that coaches and sports scientists have designed to improve this ability [17]. Especially for soccer players, the ability to change direction quickly is a feature that stands out among all of sports-specific running types [19]. Therefore, repeated sprint tests which include changes of direction inherent in soccer may yield more successful results.

When the literature is examined, it is seen that the studies on repeated sprint are mostly selected from the protocols (laboratory, parquet floor, and athletics track) that generally include consecutive and straight runs and also these protocols are not made on a football-appropriate ground. Yet, due to the nature of soccer, there are too many change of direction runnings. Measurements and evaluations should be made on fields and grounds that suitable for soccer in order to measure the real performance of the athletes. Taking into consideration the stated reasons, the aim of this research is to compare the two different protocols, which are 7x34.2 m Repeated Straight Sprint Test (RSST) and 7x34.2 m Repeated Change of Direction Sprint Test (RCST), by using GPS technology on a football-appropriate ground, in terms of determined internal and external loads.

Materials and Methods

Participants.

Twenty-two licensed football players who play in the U19 team of Eskisehirspor football club, which is in the 1st League of Turkish Football Federation, voluntarily participated in the research. Descriptive statistics of the participants are given in Table 1. Since all of the participants are 18 years old, age information is not given in Table 1. Approval was obtained from the University Ethics Committee for the study to be implemented. Before the tests were conducted, the participants were given detailed information about the tests to be performed and the voluntary consent form was approved.

Research Design.

On the first day of the study, the height of the participants was measured with a stadiometer (Holtain Ltd, UK) with an accuracy of ±0,1 mm. Then, the body weights and body fat ratios of the participants were measured in the morning and on an empty stomach using a bioelectrical impedance device.

On the second day of the study, the resting heart rate of the participants was measured before the RSST. Measurements were made with a GPS device (GPSports, Australia) after participants had a full rest for 20 minutes. At this stage, the resting blood lactate concentrations of the participants were measured with EKF lactate scout (EKF Diagnostics GmbH, Barleben, Germany) as well. After these measurements, the participants completed the jogging for eight minutes and then performed the standard warm-up movements. RSST was applied to all participants after the warm-up sessions and heart rate (HR), blood lactate concentrations (La), and Rating of Perceived Exertion Scale (RPE) data were collected at the 3rd and 5th minutes after the end of the test.

On the third day of the study, the resting heart rate and blood lactate concentrations of the participants were measured before the RCTS. The warm-up protocol that applied on the second day was re-applied as standard and then the RCST protocol was implemented. HR, La, and RPE data were collected in the same way at the third and fifth minutes after the tests.

Bangsbo's Repeated Straight Sprint Test (Figure 1.A) consists of 7 repetitions at a distance of 34.2 meters and there are 25 seconds active rest intervals between each sprint [20].

Athletes came back to the starting point within 25 seconds after each sprint lap and as soon as the recovery period is completed, they started the next round. The values at the beginning and ending of each repetition number were measured with timing gates (Smartspeed, Fusion Sport) with an accuracy of 0.01/sec. The internal and external loads of the athletes were measured by GPS throughout the test. Recovery speeds between sprints in the test protocol were also included in the Mean-Speed measurements.

In this part of the study, the participants have applied the modified version of Bangsbo's 7x34.2 meter repeated change of direction sprint test (Figure 1.B). In this repeated sprint test, the number of sprints of the athletes was set to 7 times, and rest intervals are given as 25 seconds. In this repeated sprint test which consisted of a total distance of 34.2

meters, as soon as the athletes passed the timing gates at the 10th meter from the starting line, they turned to the left and continued 5 meter of the track. Then they turned to the right for 5 meters again and passed through the timing gate at the 20th meters. Then they passed straight through the finish gate at the 34.2nd meter and completed the track. Athletes returned to the starting line within 25 seconds of recovery time and were ready. As soon as the active rest period was completed, they started another sprint. Recovery speeds between sprints in the test protocol were also included in the Mean-Speed measurements.

Statistical Analysis.

SPSS 21 (IBM SPSS Statistics 21, IBM Corp., USA) package program was used for statistical analysis of the data. The mean and standard deviations of all data of the athletes were calculated. Paired Sample T-test was used to determine if there was a variation between RSST and RCST. While the significance level of the test results was accepted as $p \leqslant 0.05$, the high level of significance was accepted as $p \leqslant 0.01$. The correlation between the tests was determined by the Pearson Correlation test. Also, the Cohen effect size was determined in the analysis.

Results

The demographic information of the athletes is presented in Table 1 (Table 1). As a result of La measurements taken three minutes after completion of test protocols, it is seen that La level in RCTS was found to be significantly higher than in RSST ($p < 0.001^{***}$). Also, the amount of La in the RCST was found to be higher in the measurements made after five minutes ($p = 0.042^{*}$). There was no significant difference in Heart Rate (HR), Rating of Perceived Exertion (RPE), Max-HR, Mean-HR, Performance Decreasing Percentage (PDP) ve Body Load (BL) values between the tests (Table 2).

Best Sprint Time (BST) and Total Sprint Time (TST) values are significantly better in RSST ($p < 0.001^{***}$). Max-Speed and Mean-Speed values are also better in RSST protocol ($p < 0.001^{***}$). As a result of Pearson Correlation Analysis, 3min-HR, 5min-La, 5min-HR, and TST values increased with a significant correlation in RCST according to RSST (Table 3). To analyze whether there is a correlation between the tests performed after RCST, Pearson Correlation Test was performed and it was observed that there was a significant correlation between all the parameters examined (Table 4).

Discussion

La measurement results represent that RCST uses the lactic acid system more. Especially three minutes after the end of the repeated sprint test protocols,

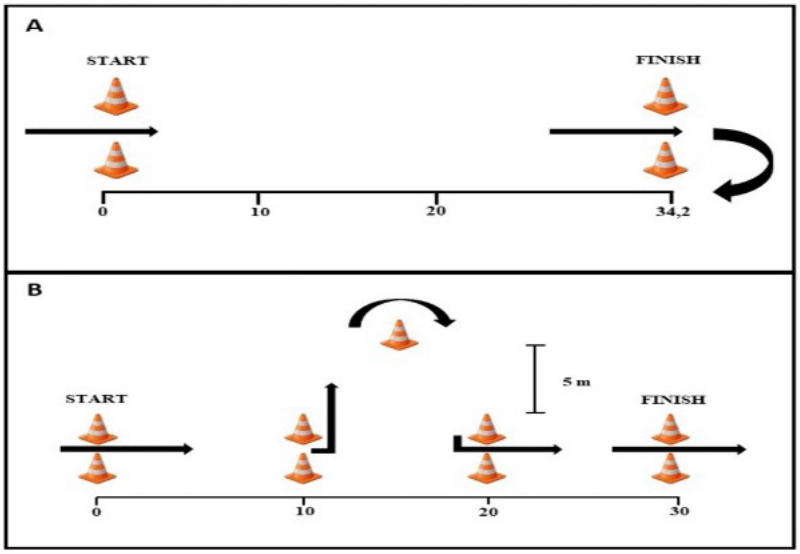

Figure 1. (A) Design of the 7x34.2 m Repeated Straight Sprint Test and (B) 7x34.2 m Repeated Change of Direction Sprint Test [20].

Table 1. Demographic data of the U19 soccer players.

Variables	Mean (n=22)	Sd
Height (cm)	177.00	8.64
Weight (kg)	70.56	8.69
BFP (%)	11.08	4.97
BMI	23.48	1.95

BFP = Body Fat Percentage; BMI = Body Mass Index; Sd = Standard deviation

Table 2. Means and t-test results of internal and external load RSST and RCST.

Variables	RSST		RCST		*t*-Value	*p*-Value	D-Value
	Mean	Sd	Mean	Sd			
Internal							
Rest-La (mM)	1.40	0.35	1.25	0.43	1.751	0.095	0.373
Rest-HR (bpm)	68.31	6.07	74.45	10.27	-2.632	.016*	-0.561
3min-La (mM)	6.70	1.72	9.75	2.51	-5.386	.000***	-1.148
3min-HR (bpm)	118.41	11.39	120.05	11.69	-0.638	0.530	-0.136
5min-La (mM)	9.60	2.65	10.77	2.10	-2.163	.042*	-0.461
5min-HR (bpm)	110.36	10.45	112.32	7.63	-0.965	0.345	-0.206
RPE	7.23	0.87	7.68	7.80	-1.800	0.086	-0.384
Max-HR (bpm)	185.23	7.36	183.55	7.94	1.135	0.269	0.242
Mean-HR (bpm)	173.95	8.15	171.86	8.20	1.540	0.139	0.328
External							
BST (sec)	4.66	0.19	7.2	0.15	-57.307	.000***	-12.218
TST (sec)	35.17	1.56	53.65	1.3	-76.236	.000***	-16.254
PDP (%)	7.89	4.18	6.48	2.71	2.029	0.055	0.433
Max-Speed ($km.h^{-1}$)	29.88	1.31	25.15	1.11	17.513	.000***	3.734
Mean-Speed ($km.h^{-1}$)	9.95	0.82	8.94	0.93	5.54	.000***	1.181
MP	862.27	59.22	797.86	61.42	4.03	.001**	0.859
BL	11.14	3.06	11.91	3.26	-1.933	0.067	-0.412

RSST = Repeated Straight Sprint Test; RCST = Repeated Change of Direction Sprint Test; Sd = Standard deviation; D = Cohen Effect Size; Rest-La = Resting blood lactate; Rest-HR = Resting Heart Rate; 3min = 3 minutes later; 5min = 5 minutes later, RPE = Rating of Perceived Exertion Scale (Between 1-10); BST = Best Sprint Time; TST = Total Sprint Time; PDP = Performance Decreasing Percentage; MP = Metabolic Power; BL = Body Load; *p < 0.05; **p < 0.01; ***p < 0.001.

Table 3. Pearson Correlation results of internal and external load RSST and RCST for 3min-HR, 5min-LA, 5-min-HR and TST.

	RSST		RCST			
Variables	Mean (n=22)	Sd	Mean (n=22)	Sd	r-Value	p-Value
3min-HR (bpm)	118.41	11.39	120.05	11.69	0.457	0.032*
5min-LA (mM)	9.60	2.65	10.77	2.10	0.451	0.035*
5min-HR (bpm)	110.36	10.45	112.32	7.63	0.48	0.022*
TST (sec)	35.17	1.56	53.65	1.3	0.698	0.000***

RSST = Repeated Straight Sprint Test; RCST = Repeated Change of Direction Sprint Test; Sd = Standard deviation;3min = 3 minutes later; 5min = 5 minutes later, TST = Total Sprint Time; *p < 0.05; **p < 0.01; ***p < 0.001.

the high significance can be seen in the difference in La amount (RSST = 6.70 ± 1.72 mM; RCST = 9.75 ± 2.51 mM; p < 0.001***) (Table 2). At the same time, even though the significance value decreases (p = 0.042*), it is seen that the La level after RCST is higher in the measurements taken at the fifth minute and a significant correlation can be observed in the increase of La amount. Three minutes after the RCST protocol, the amount of La accumulated in the athletes is %45.52 more than the RSST and after five minutes it is %12.19 higher. Castagna et al. [21] mentioned that change of direction (15 m shuttle test) runnings significantly increased the blood lactate level in young basketball players and stated that directional tests can be used to develop lactate tolerance in athletes. In our study, it was observed that while the La level of the athletes was 9.60 ± 2.65 mM five minutes after the RSST, they reached the

Table 4. Pearson Correlation results of RCST with internal and external load parameters

Variables	Mean (n=22)	Sd	r-Value	p-Value
3min-La (mM)	9.75	2.51	0.618	0.002**
3min-HR (bpm)	120.05	11.69		
3min-La (mM)	9.75	2.51	0.751	0.000***
5min-HR (bpm)	112.32	7.63		
3min-HR (bpm)	120.05	11.69	0.728	0.000***
5min-HR (bpm)	112.32	7.63		
RPE	7.68	7.80	-0.449	0.036*
BST (sec)	7.2	0.15		
RPE	7.68	7.80	0.564	0.006**
PDP (%)	6.48	2.71		
RPE	7.68	7.80	-0.486	0.022*
Max-HR (bpm)	183.55	7.94		
BST (sec)	7.2	0.15	-0.620	0.002**
Max-Speed (km.h^{-1})	25.15	1.11		
BST (sec)	7.2	0.15	-0.688	0.000***
MP	797.86	61.42		
TST (sec)	53.65	1.3	0.668	0.001**
PDP (%)	6.48	2.71		
TST (sec)	53.65	1.3	-0.479	0.024*
MP	797.86	61.42		
MP	797.86	61.42	0.557	0.007**
Max-Speed (km.h^{-1})	25.15	1.11		

Sd = Standard deviation; La = Blood lactate; HR = Heart Rate; 3min = 3 minutes later; 5min = 5 minutes later, RPE = Rating of Perceived Exertion Scale (Between 1-10); BST = Best Sprint Time; TST = Total Sprint Time; PDP = Performance Decreasing Percentage; MP = Metabolic Power; *p < 0.05; **p < 0.01; ***p < 0.001.

level around 9.75 ± 2.51 mM three minutes after the RCST. Similar to the suggestion of Castagna et al. [21], the RCST can also be used as a training method to improve football players' lactate tolerance.

Although there was more La accumulation in the RCST in the athletes, no significant difference was found between the tests in terms of the perceived exertion by athletes. These results show that even though the athletes used more anaerobic energy systems in RCTS, the perceived exertion was not more. This may be due to the fact that the RCST is closer to soccer than traditional tests and it is a sport-specific test. Taylor et al. [22] in their study with soccer players, they applied linear and directional sprint studies within a 2-weeks training program. Nevertheless, when the results of the study were examined, Taylor et al., reported that they could not find any difference between the RSST and RCST protocols in terms of adaptation of training. Letzelter et al. [23] indicated that speed ability will increase from month to month depending on the level of genetic and other characteristics. In this case, the two-week training period can be insufficient for the repeated sprint training with change of direction to develop the sprint ability. This situation also suggests that longer-term studies should be conducted and should be considered to understand whether two test protocols make a difference in terms of sprint performance improvement.

Since the sprints in the RSST are linear, BST and TST values gave different results compared to RCST. Kaplan [24] applied RCST to soccer players with an average age of 20.95 ± 3.8 years and found the BST values as 7.37 ± 0.26 sec. In our study, the BST average of 19 years old athletes was determined as 7.20 ± 0.15 sec. Simultaneously, the increase in TST value showed a significant correlation (Table 3). The RCST protocol involves change of directions as is the nature of soccer. Therefore, the speed of the runs of the athletes decreased according to RSST. Max-speed and Mean-Speed results also support these findings (Table 2). It can be seen that in the RCST protocol, which is closer to the way soccer is played, the best sprint speeds of the athletes were %54.51 slower when we compare with the RSST results, which are traditionally used more in

the performance measurement of soccer players. The maximum speed reached by athletes in RCST is %15.83 lower than in RSST. It was also found to be %10.15 lower at average speeds. Changing in direction, which is often practices during a competition, requires a deceleration or stop. Therefore, compared to linearly applied sprint test, the information given by the RCST may be closer to the competition performance of the athletes. Fessi et al. [19] underlined that it is important that the players can quickly change of direction for high soccer performance. Baranovic and Zemkova [25] could not find a significant difference between the directional sprint test and the linear sprint test in terms of total time in their research. The findings of our study determined that there is a significant difference between the total sprint times between RSST and RCST (35.17 ± 1.56; 53.65 ± 1.3 sec; respectively) ($p < 0.001$). The fact that MP values were also found to be significantly lower in RCST supports these results.

Pearson Correlation analysis was performed for all measurements in order to verify the combined effects of RCST on performance parameters. Significant correlations were observed between measurements made after RCST (Table 4). A positive correlation was seen between the La levels of the athletes and their HR. As the BST values of the athletes decreased, their effort increased. Also, the difficulty perceived by the athletes, who have best sprint time from the test, increased correspondingly. There is a positive correlation between the highest speeds of the athletes and their MP values. In RCST, a significant increase was observed in the percentage of performance decrease depending on the length of the test period. Fessi et al. [19] stated that athletes covered less distance in change of direction runnings than in straight runnings in the same amount of time. This result also shows that linear tests cannot fully reflect competition performance. Considering that the sprint times of the players in soccer are between 2-4 seconds on average and the sprint distances are less than 20 meters, it can be said that tests that include longer and only linear runnings cannot reflect soccer competition performance [5, 6]. These findings indicate that the RCST can be used to measure the performance of soccer players. In addition, Beato et al. [26] stated that sprint training with a change of direction is more beneficial for the sprint performance of soccer players than training involving linear spirnts. When viewed from this aspect, RCTS can be used as a training method as well as a performance test.

Conclusions

As a conclusion the performance values obtained by the analyzes made after RCTS gave very different results when compared to RSST. The results of this study showed that the sprint tests, which are used more frequently in the performance measurements of soccer players to date and include linear runnings, do not accurately reflect soccer. Especially impressive differences between blood lactate measurements made after both repeated sprint tests show that RCST whose implementation is more similar to soccer, should be used more in soccer player performance measurement. In soccer, which changes of direction and stops take place with a high frequency, performing the performance measurements of the athletes with tests, which also include change of direction both at the stage of talent selection and at the stage of performance evaluation of soccer players can give results closer to the reality. To conclude, the using of RCST and similar changes of direction tests can provide more positive results than traditional tests in measurement of performance in soccer.

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Conflict of interest

The authors report no conflict of interest.

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