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Investigation of real time and post-match data relationships of wearable GPS systems

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ABSTRACT

The aim of this study is to compare the data obtained by using the real time analysis (RTA) and post competition analysis (PCA) of the Polar Team Pro GPS. The number of participants in this study was 20 football players who play in the Amateur League (23 ± 4 years old, 173.75 ± 8 height, 87 ± 11.8 kg). The participants wore GPS systems during three matches, and their data of the distance covered (> 6.99 km/hr, 7.00 to 12.99 km/h, 13.00 to 17.99 km/h, >18.00 km/h) and heart rates (%HRmax 80 to 84, %HRmax 85 to 89, %HRmax 90 to 94, %HRmax 95 to 100, HR mean beats/min) is recorded as RTA and PCA. The Pearson correlation test is used in order to determine the level of the relationship between the measurements of the RTA and the PCA. When evaluating the scatter plots, simple linear regression analysis is performed. According to the results of the analysis of the level of the relationship between the measurements of the RTA and PCA, there is none concerning the parameters of the distance covered and the heart rate. Within these findings, the Real-time and post-competition data of the Polar Team Pro GPS system shows that it can be used by sports' scientists and coaches for tracking internal and external loads.

Keywords: GPS, wearable technology, football.

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INTRODUCTION

Many developments have taken place in the world of sports science along with the technological developments (Seshadri et al., 2019). These developments have enabled sports scientists and coaches to obtain more objective data more easily (McLaren et al., 2018). Wearable GPS systems, which have been commonly used in recent years, are also seen as the reflection of technological developments in sports science (Bourdon et al., 2017; Buchheit and Simpson, 2017b; Martín-García et al., 2018; Seshadri et al., 2019). Wearable GPS systems are used during activities in order to plan the training of the athletes based on evidence (Bourdon et al., 2017; Bredt et al., 2020). GPS systems make it easy to determine the amount of internal and external loads that occur in athletes mechanically and physiologically (Akyıldız, 2019; Bourdon et al., 2017; Buchheit and Simpson, 2017b; Seshadri et al., 2019).

The manufacturers of GPS systems allow data to be analyzed by their users in the form of Real Time Analysis (RTA) and Post Competition Analysis (PCA) for the control of physiological and kinematic loads on athletes (Aughey and Falloon, 2010; Barrett, 2017; Weaving et al., 2017). RTA is very important for taking action by following the instant answers that occur as a result of the activity performed (Aughey and Falloon, 2010; Barrett, 2017; Weaving et al., 2017). The training loads of the athletes, the protection from injuries, and effective periodizations can be done much more effectively thanks to PCA by determining the internal and external loads occurring in training and competitions objectively (Bourdon et al., 2017; Buchheit and Simpson, 2017b; Dalen and Lorås, 2019; Martín-García et al., 2018).

Although there are many studies examining the validity and reliability of the operating speed of GPS systems, the brand differences and differences in parameters (Coutts and Duffield, 2010; Fox et al., 2019; Johnston et al., 2014; Johnston et al., 2012), there are limited studies examining the RTA and PCA values of GPS systems (Aughey and Falloon, 2010; Barrett, 2017; Weaving et al., 2017). Unlike previous studies, in our study, heart rate parameters were examined. According to the literature research conducted by the authors, no study that examined the RTA and PCA parameters of the HR data was found, so the study we conducted is the first in the literature. However, although Polar Team Pro GPS Systems are involved in many studies in the literature (Brandão et al., 2019; Dalen and Lorås, 2019; Fox et al., 2019; Iturricastillo et al., 2015; Madsen et al., 2019; Marszałek et al., 2019; Marszałek et al., 2019; Reinhardt et al., 2019), no studies investigating the relationship between RTA and PCA data have been seen. In our study, it was assumed that there is a close relationship between RTA and PCA. At the same time, the comparison of the data of the RTA and PCA in the Polar Team Pro GPS Systems is the first in the literature.

MATERIALS AND METHODS

The number of participants in this study was 20 football players who play in the Amateur League (23 ± 4 years old, 173.75 ± 8 height, 87 ± 11.8 kg). All the participants were chosen from the players who train regularly. Matches took place in the afternoon. Within 24 hours of the start of the competition, the participants were encouraged to maintain adequate hydration and a balanced diet. Moreover, the participants were to avoid exhausting activities. A full description of the procedures was provided for the participants in accordance with the Helsinki Declaration Principles and they were asked to fill in a written informed consent form.

Experimental approach to the problem

The study was carried out with the participation of 20 trained male football players in order to investigate the relationship between the real time analysis (RTA) and post-competition analysis (PCA) of 10 Hz Polar Team Pro GPS units. In three official football matches, 10 Hz Polar Team Pro GPS units were positioned in the chest area of the players with the help of a strap. The data obtained from the 10 Hz Polar Team Pro GPS units was installed on an iPad Pro (Apple, USA) tablet equipped with Bluetooth 4.2 technology by the Polar Team Pro (App Store, Finland) application and was received in real time. The Polar Team Pro GPS units were transmitted to the online cloud system with the help of special data transmitters in the system in order to analyze the data after the competition. All the data transmitted to the cloud system was downloaded to a Macbook Computer having MacinTosh 13.0.1 Software as a Microsoft Excel 2016 file.

The total distance covered (TM), distance (meters) traveled in the speed ranges of <6.99 km/s, 7.00 to 12.99 km/s, 13.00 to 17.99 km/s, >18.00 km/s, and parameters obtained from the heart rate monitor were examined. The maximal number of heart beats was calculated automatically based on the information of the athletes that was entered into the Polar Team Pro system according to the Haskell and Fox 220-age formula. The heart rate was examined in 5 different areas. The 1st area time spent in % HRmax 75 to 79, 2nd area time spent in % HRmax 80 to 84, 3rd area time spent in %HRmax 85 to 89, 4th area time spent in %HRmax 90 to 94, 5th area time spent in %HRmax 95 to 100, and the average number of heart beats (HRmean beats/min) were determined, and the real-time and post-competition analysis were evaluated statistically.

Statistical analysis

The data obtained in real time in the competition was recorded as a separate data file, and then the data of speed, distance, and heart rate from the sensors were transferred from the Polar Team Pro online platform (teampro.polar.com) to a personal computer for analysis. The GPS data was analyzed by converting it to speed and distance data through special software used for the Polar Team Pro GPS.

The descriptive statistics were calculated for all the variables and shown as mean ± SD. The SPSS 26.0 software program was used to analyze the data (Trial version, Version 26.0 for Mac, SPSS Inc., Chicago, IL, USA). The normal distribution of the data was tested by looking at Kolmogorov-Smirnov and its homogeneity, skewness, and kurtosis values. After determining that the data showed a normal distribution, the level of the relationship between the two measurements was determined by using the Pearson correlation test. As the level of the relationship: Minor (0.0), small (0.1), medium (0.3), large (0.5), very large (0.7), almost perfect (0.9) and perfect (1.0) levels were used. $p < 0.05$ alpha level was determined as the significance level (Hopkins, 2015).

Simple linear regression analysis for RTA and PCA values for heart rate averages and times spent were in %HRmax 80 to 84, %HRmax 85 to 89, %HRmax 90 to 94, %HRmax 95 to 100. The linear regression analysis results were converted to images using a scatter plot.

RESULTS

The RTA and PCA data of the distance (meters) traveled in the speed ranges of <6.99 km/s, 7.00 to 12.99 km/s, 13.00 to 17.99 km/s, >18.00 km/s showed a perfect

relationship (r = 1.00). The details concerning the data are presented in Table 1.

The RTA and PCA data of the times spent in different ranges of the heart rate showed a perfect relationship (r = 1.00 to 0.99). The details concerning the data are presented in Table 2.

The scatter plot graphic related to the linear regression analysis of the RTA and PCA parameters for the distance covered in the speed ranges of <6.99 km/s, 7.00 to 12.99 km/s, 13.00 to 17.99 km/s, >18.00 km/s and the heart rate 1st area time spent in %HRmax 75 to 79, 2nd area time spent in %HRmax 80 to 84, 3rd area time spent in %HRmax 85 to 89, 4th area time spent in %HRmax 90 to 94, 5th area time spent in %HRmax 95 to 100%, and the average number of heart beats (HRmean beats/min) are presented in Figures 1 to 5.

Table 1. Comparison of real time and post competition GPS data.

	Total distance (m)	> 6.99 km/h DC (m)	7-12.99 km/h DC (m)	13-17.99 km/h DC (m)	18 > km/h DC (m)
RT	8454 ± 832	3856 ± 346	2652 ± 622	1306 ± 443	644 ± 253
PC	8454 ± 832	3856 ± 346	2652 ± 622	1306 ± 443	644 ± 253
Pearson's *R*	1.00	1.00	1.00	1.00	1.00

RT: Real Time, PC: Post Competition, DC: Distance Covered.

Table 2. Comparison of heart rate data of real time and post competition.

	$\%HR_{max}$ 75-79 (min)	$\%HR_{max}$ 80-84 (min)	$\%HR_{max}$ 85-89 (min)	$\%HR_{max}$ 90-94 (min)	$\%HR_{max}$ 95-100 (min)	HR_{mean} (Beats/min)
RT	15 ± 6	19 ± 6	21 ± 5	21 ± 8	10 ± 9	166 ± 7
PC	15 ± 6	19 ± 6	21 ± 5	21 ± 8	10 ± 9	166 ± 7
Pearson's *R*	1.00	0.99	0.99	0.99	1.00	0.99

RT: Real Time, PC: Post Competition.

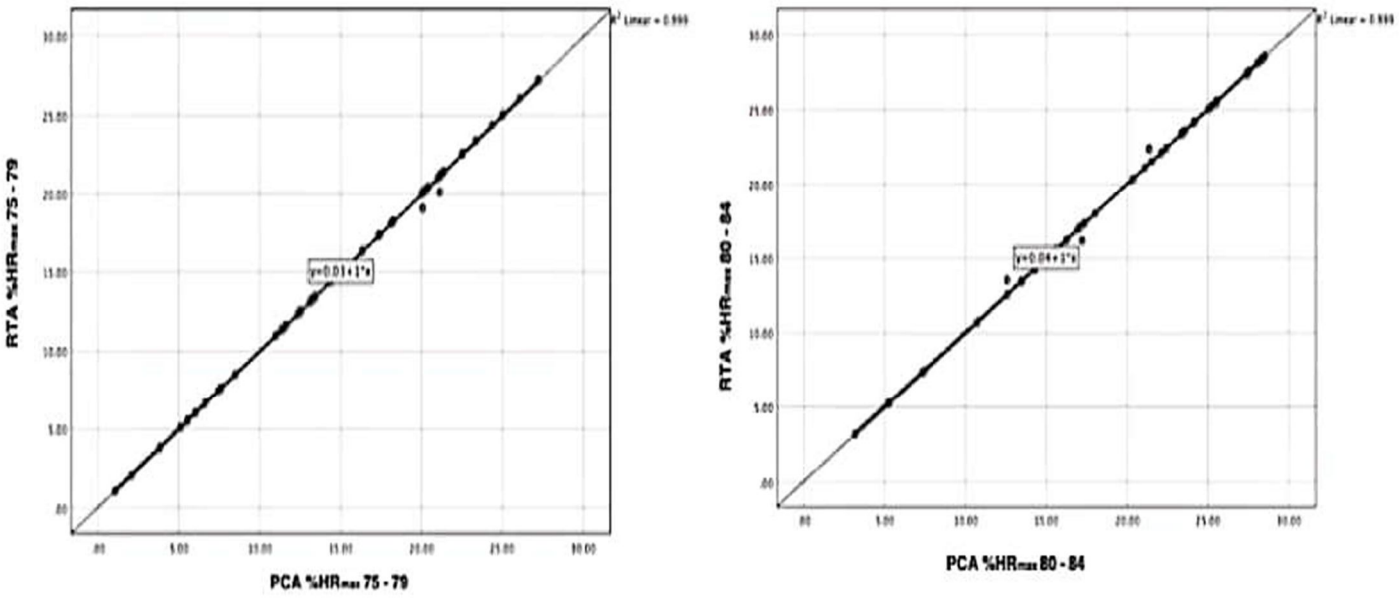

Figure 1. Scatter plot graphic showing the relationship related with the RTA and PCA data of the time spent in different percentages $\%HR_{max}$ 75 - 79 and $\%HR_{max}$ 80 - 84 of the heart rate (N = 60).

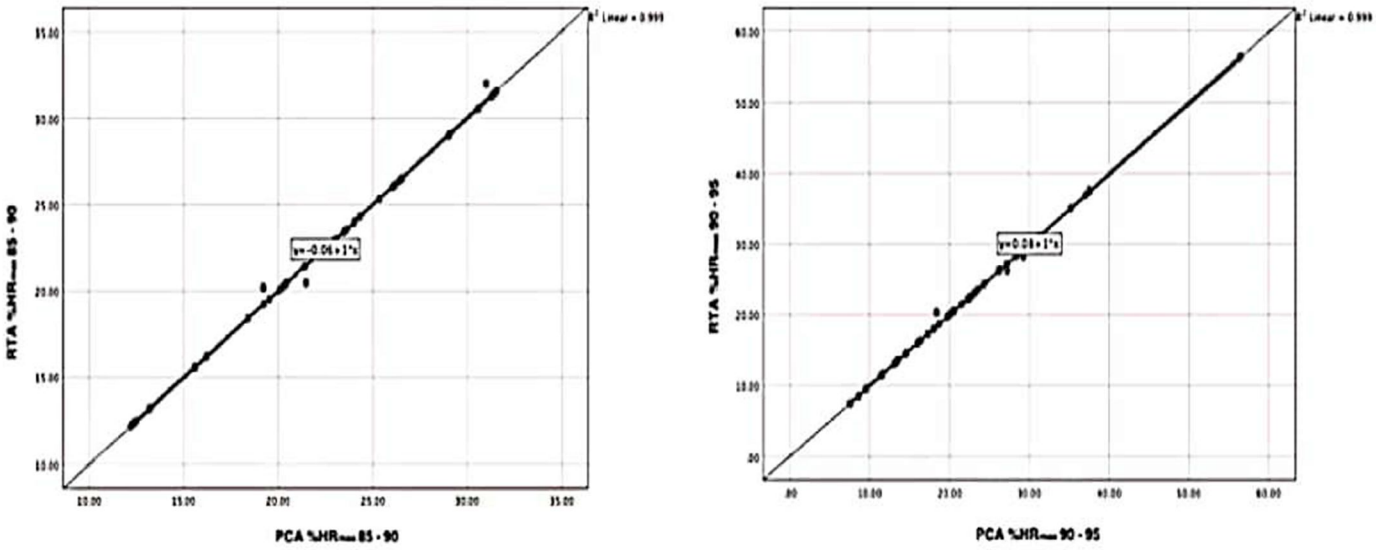

Figure 2. Scatter plot graphic showing the relationship related with the RTA and PCA data of the time spent in different percentages $\%HR_{max}$ 85 – 89 and $\%HR_{max}$ 90 - 94 of the heart rate (N = 60).

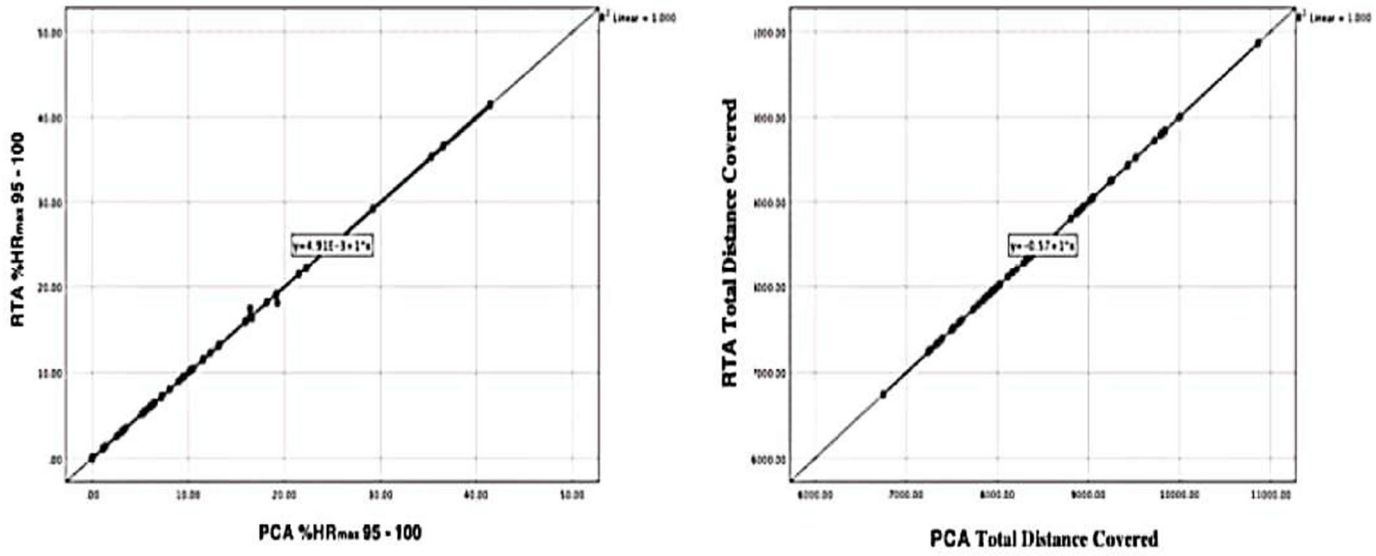

Figure 3. Scatter plot graphic showing the relationship related with the RTA and PCA data of the time spent in different percentages $\%HR_{max}$ 95 – 100 of the heart rate and total distance covered (N = 60).

DISCUSSION

In the study, the relationship between the RTA and PCA data of the distance covered in the speed ranges of <6.99 km/s, 7.00 to 12.99 km/s, 13.00 to 17.99 km/s, >18.00 km/s and heart rate 1st area time spent in %HRmax 75 to 79, 2nd area time spent in %HRmax 80 to 84, 3rd area time spent in %HRmax 85 to 89, 4th area time spent in %HRmax 90 to 94, 5th area time spent in %HRmax 95 to 100, and the average number of heart beats (HRmean beats/min) of the football players was evaluated. At the end of the study, it was determined that the RTA and PCA data of the Polar Team Pro GPS systems showed a high level of relationship statistically.

The use of GPS systems is often preferred by sports scientists and coaches as a guiding tool in planning and preventing injury (Buchheit and Simpson, 2017a; Martín-García et al., 2018). Considering the medical condition of the players and the training practices conducted by the data obtained, the consistency of the RTA and PCA

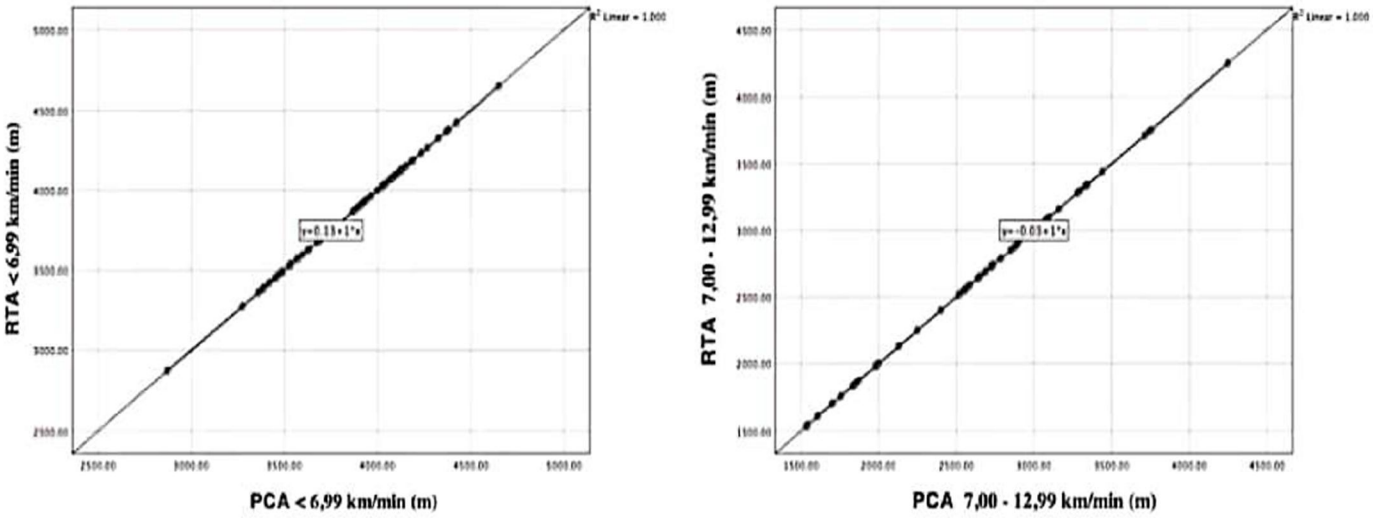

Figure 4. Scatter plot graphic showing the relationship related with the RTA and PCA data of <6.99 km/h, 7.00 to 12.99 km/h (N = 60).

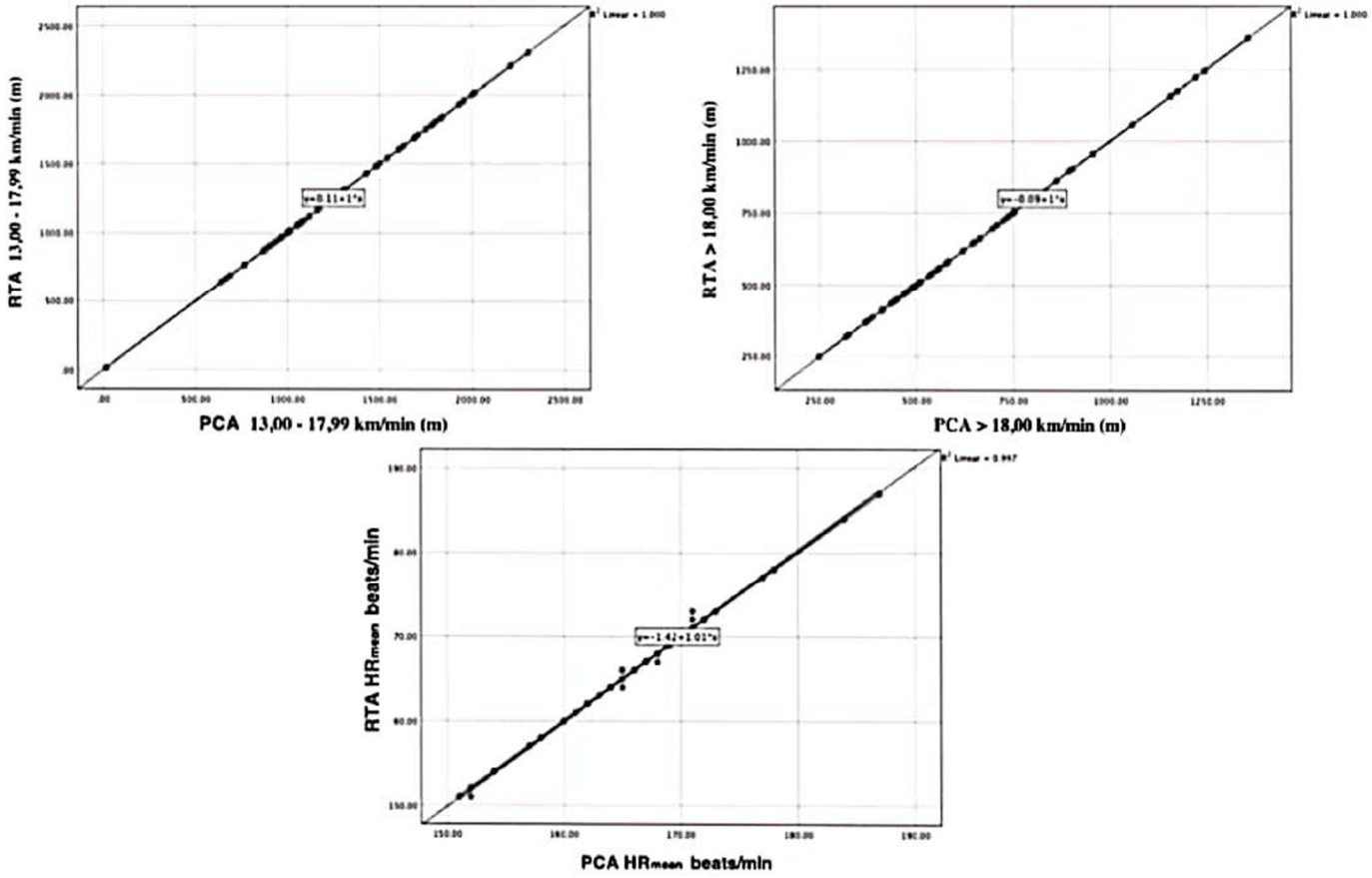

Figure 5. Scatter plot graphic showing the relationship related with the RTA and PCA data of 13.00 to 17.99 km/h, >18 km/h and HR average beat/min (N = 60).

parameters is very important (Aughey and Falloon, 2010; Barrett, 2017; Weaving et al., 2017). Although the number of studies examining the validity and reliability of GPS systems is quite high, the number of studies investigating the comparison of the RTA and PCA data obtained from GPS systems is quite limited (Aughey and

Falloon, 2010; Barrett, 2017; Weaving et al., 2017). The first study observing the comparison of the RTA and PCA data was carried out by Aughey and Falloon (2010). The data of only one competition of 12 Australian football players was investigated in the study. In the study conducted by Aughey and Falloon high speed travel distances were reported as 121 ± 110 m in real time and 98 ± 105 m after the competition. The results obtained in the study reported that sports scientists should be careful while examining the RTA and PCA data in high speed runs and sprint distances (Aughey and Falloon, 2010). However, since the time of the first study, the manufacturers of GPS systems, with the development of technology, have made both software and hardware improvements enabling them to measure their systems with higher accuracy (Bourdon et al., 2017; Buchheit et al., 2014). At the same time, a study by Aughey and Falloon sets out in the light of the parameters obtained from only one competition, and this low number of data is thought to affect the results of the study. In this study, contrary to the study conducted by Aughey and Falloon, a perfect correlation was found between the RTA and PCA data in all the parameters. It is thought that this was due to the use of the current software (Apple, iOS, 13.4) and hardware (Polar Team Pro 2.0.4 for iOS, Finland) as well as the amount of data obtained from the three competitions being higher contrary to the study carried out by Aughey and Falloon.

Similar results were obtained with this study in the study of the RTA and PCA data on football players (Barrett, 2017). In another study in the literature, the results supporting this study were obtained when the RTA and PCA data of the GPS data were examined (Weaving et al., 2017). Considering the studies in the literature, this is the first study examining the relationship of the RTA and the PCA data of HR data. These parameters showed a high level of relationship that can be used by sports scientists and coaches. According to the findings obtained from this study, the RTA and PCA data showed a close relationship, but Buchheit et al. stated that the versions of the software have misleading effects on the data, and users should be very careful when considering the updates made to the software when interpreting the parameters obtained from the software (Buchheit et al., 2014).

RECOMMENDATIONS

The findings from this study reveal that the Polar Team Pro GPS systems have a high level of correlation with the RTA and PCA data. However, it was assumed that the differences in the GPS systems used by sports scientists and coaches due to software, hardware, brand, and usage may cause variations in the data (Aughey and Falloon, 2010; Barrett, 2017; Buchheit et al., 2014; Weaving et al., 2017). Therefore, users are expected to validate the RTA and PCA data from their GPS systems using this study and the research methods from previous studies (Aughey and Falloon, 2010; Barrett, 2017; Weaving et al., 2017).

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