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ORIGINAL SCIENTIFIC ARTICLE

VALIDITY AND RELIABILITY OF POLAR V800 SMART WATCH TO MEASURE CRICKET-SPECIFIC MOVEMENTS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

The study purpose was to assess the reliability and validity of Polar V800 smart watch in measuring various cricket-specific movements.

Materials and methods. Only one trained male volunteer was selected to perform all the cricket specific movements to minimize individual error and eliminate between-subject variability. Polar V800 obtained distances were compared with real field markings.

Results. Split-half Reliability Statistical method has been used and 'r' score for the measurements taken has been found to be 0.93. 95% confidence intervals also express a good reliability score. The criterion validity method was used to determine the validity of the dataset. The Pearson correlations (r) have been found ranging from 0.86 to 0.99. Predicted best fit line of linear regression has been found as y = 0.9722 X + 0.0046 (where y = observed value, X = real field distance). One way ANOVA followed by Tukey's post hoc test on observed 10m sprint, 20m sprint and run-a-three movements show maximum significant difference with other cricket-specific movements. The mean percentage of bias for all cricket-specific movements has been found to be -2.20 ± 13.17.

Conclusions. The study reveals that Polar V800 smart watch has an acceptable accuracy, reliability, and validity for measuring various cricket specific movements with certain limitations.

Keywords: Polar V800, GPS, reliability, validity, cricket-specific movements.

Introduction

Quantification of movement patterns using smart watch based global positioning system (GPS) monitors are rapidly increasing. Keeping in pace with the changing and developing technology world, the application of GPS has been started in sports science as an alternative way of time motion analysis (Dobson & Keogh, 2007). According to the available literature, Australian Football League first used a GPS monitoring system to quantify game demands in field-based team sports and gradually infiltrated to other team sports (Aughey, 2011). Initially, GPS trackers were available in the form of innerwear; thereafter Polar Electro Oy manufactured a GPS compatible heart rate monitor. That became the Polar V800 smart watch (May 2014). In the meantime, several manufacturing companies launched GPS enabled smart watches such as Garmin Forerunner 910XT (Jan-Apr 2012), Suunto Ambit2 (May 2013). Out of all available GPS smart watches, Polar V800 smart watch is a robust, compact and reliable GPS receiver module, based on SiRFstarIV architecture which provides an accuracy of ±2% in distance measurement and accuracy of ±2 km/h in speed measurement for any outdoor sport (Polar Electro Oy [PEO]. 2013, p. 97). It has a 1Hz positional updating rate in high accuracy mode and has an internal accelerometer also that measures cadence from hand movement (Hernández-Vicente, Santos-Lozano, De, & Garatachea, 2016).

Cricket is one of the most popular team sports nowadays. Despite its' popularity there are only a few detailed works carried out in the field of cricket. Nowadays, due to peer pressure coaches, trainers as well as players take the initiative to learn about the game specific fitness requirements, game demands. Now, researchers are focusing on analyzing actual game demands by some typical methods such as time-motion analysis. Global Positioning System (GPS) technology has taken a prominent role to quantify player movements in terms of time-motion analysis (Dobson & Keogh, 2007) and for that specific purpose Polar V800 seems to be the right choice. However, there is no such study expressing validity and reliability of polar V800 smart watch to measure various cricket-specific movements. Therefore, the present study has been undertaken to assess the reliability and validity of the polar V800 smart watch in measuring various short-format cricket-specific movements.

Materials and methods

Study participants

In the current study, only one trained male volunteer having age, height and body mass as 21 years, 176 cm, and 64 kg, respectively, was engaged to minimize individual error and eliminate between subject variability (Jennings, Cormack, Coutts, Boyd, & Aughey, 2010; Petersen, Pyne, Portus, & Dawson, 2009).

The volunteer was informed about the study content and written consent was taken. He was verbally instructed to follow the marked line as closely as possible and was familiarized with the test protocol. He wore the smart watch on his left hand with the dial facing up and started the trial after a two-minute stabilization period. Higher GPS accuracy mode was selected for the test (PEO, 2013, p. 97). The study was approved by the Ethical Committee of Ramakrishna Mission Vivekananda Educational and Research Institute.

Study organization

Short-Format cricket-specific movements are categorized as follows: standing (< 0.5 m/s), walking (0.5-2.0 m/s), jogging (2.0-3.5 m/s), running or striding (3.5-5.0 m/s), sprinting (> 5.0 m/s), trigger step out and run, run-a-three and curve running (Coutts & Duffield, 2010; Jennings, Cormack, Coutts, Boyd, & Aughey, 2010; Petersen, Pyne, Portus, & Dawson, 2009).

To measure the static error of the device, the volunteer was asked to stand still for a period of 60 seconds. The volunteer was instructed to perform all the movements listed in Table 1 separately, 30 times.

During the run-a-three trial the volunteer was instructed to cover real field distance (instead of touch and go). A circuit of 180.00 m (Figure 1) was designed to replicate all the cricket-specific mvements in a single bout (Coutts & Duffield, 2010; Jennings, Cormack, Coutts, Boyd, & Aughey, 2010).

Table 1. Marked cricket specific movements patterns

Cricket specific movement patterns	Measuring marked distance (m)	Speed (km/h)	Remarks
Standing position	0.00	>1.80	Stand still
Walking	10.00 and 20.00	1.80-7.20	Straight line
Jogging	10.00 and 20.00	7.20-12.60	Straight line
Running/Striding	10.00 and 20.00	12.60-18.00	Straight line
Sprinting	10.00 and 20.00	< 18.00	Straight line
Trigger, step out & run	10.00	Self selected pace	Diagonal and straight
Curve running	20.00	Self selected pace	Arc of a circle (r=27.43m)
Run-a-three	17.68 m* 3 times	Self selected pace	To and fro
Circuit (figure 1)	180.00	Instructed pace	Mixed movements

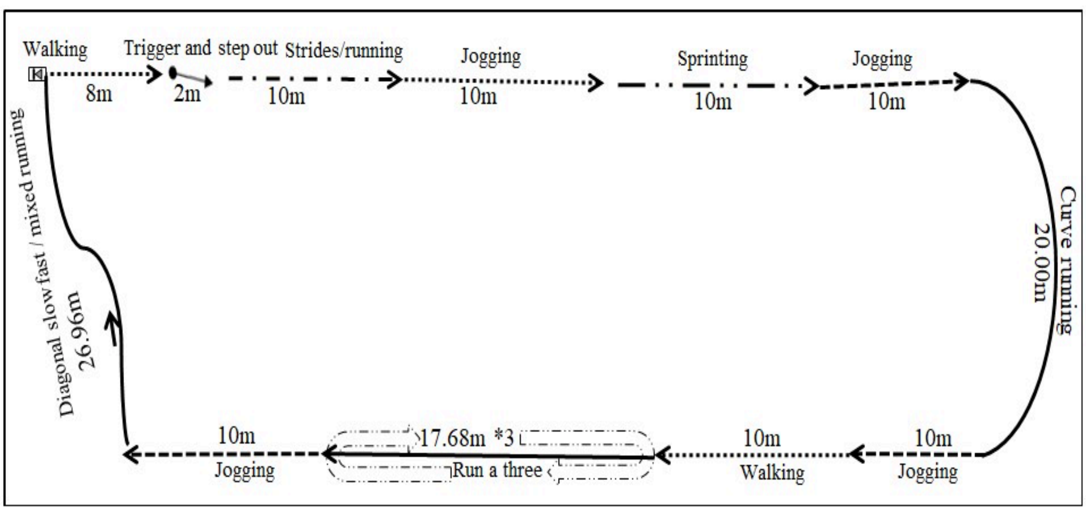

Figure 1. Circuit diagram of cricket specific movements

The experiment was done on a cricket ground between 3:30 pm to 5:00 pm and according to the local weather report, environment temperature, precipitation, humidity and wind speed has been found to be 31°C-37 °C, 0%, 57%-78% and 6-11 km/h respectively. There are no big trees, buildings or any other obstructions surrounding the ground, which helped to minimize the satellite response error of the watch (Benjamin, 2018). One certified timekeeper of the West Bengal Athletics Association assisted to track the time laps of each movement. The actual distance was measured by using a standard measuring tape and speed was monitored using a specific lap time value of known distance. Total distance covered and average speed data were collected concurrently. Obtained distance data were compared with real field marking and speed was calculated using the distance covered by the time elapse formula.

Statistical analysis

The hypotheses of normality and homogeneity of the variance were analyzed via Anderson-Darling test. Data were also cross-checked using Shapiro-Francia test to confirm the assumption of normality and homogeneity of variances. Most of the data were found to be normally distributed, so parametric analysis was performed.

The reliability of measurements was evaluated through the Split-half Reliability Statistical method which was used to measure the consistency of the scores of a test (Frey, 2018; Stephanie, 2016). The intra-class correlation coefficient (ICC) was also measured to understand reproducibility or consistency of the data measuring the same distance repeatedly (Garnacho-Castaño et al., 2021). The standard error of the estimate (SEE) and coefficient of variation (CV) were measured to understand the accuracy of predictions (Jennings, Cormack, Coutts, Boyd, & Aughey, 2010; Petersen, Pyne, Portus, & Dawson, 2009). The 95% confidence level was used to determine the precision of estimated difference. Bias and the percentage of errors (% of error) were also calculated to figure out error estimates as well as to report accuracy of measurement (Stephanie, 2013; Petersen, Pyne, Portus, & Dawson, 2009). The correlation coefficient (r) and regression technique were used to evaluate the linear association and strength of a relation between two sets of observations. The Bland-Altman plot (B&A plot) was used to quantify intervals of an agreement by constructing limits of agreement (Giavarina, 2015) as well as observing whether real field distance and polar V800 obtained distance gave different results or not. The B&A plot has also been designed to evaluate the bias in mean differences and to estimate an agreement of confidence limits, within 95% of the differences of polar V800 smart watch, compared to real field distance. The validity of the test was assessed using the Real field Validity method. The data were converted into percentile scores and a one-way single factor ANOVA followed by Tukey's post hoc test was performed to uncover specific differences among groups. The numerical value of accuracy of all short format cricket-specific movement patterns was also measured to examine the closeness of observed value to the real field distance. The least significant difference and Cohen's D effect sizes were intended to understand the magnitude of differences (Williams, & Abdi, 2010; Lakens, 2013). The level of significant for this study has been chosen as $\alpha \leq 0.05$.

Data sorting, statistical analysis and graphical representation were done using MapSphere GPS Track Editor v.1.15 beta (build 141), Gnumeric Spreadsheet 1.10.16, and Polar FlowSync.

Results

The reliability of the data set was measured through the Split-half Reliability Statistical method. The adjusted r score (estimated by Pearson product moment correlation coefficient followed by Spearman-Brown prophecy formula) was found to be 0.93 in odd-even method and 0.82 in halfway method. The ICC has been found 0.997 which indicates a very low quartile range meaning a high tendency to resemble interclass data. The SEE, CV and % of error of short format cricket-specific locomotive movements have been displayed in Table 2.

Table 2. Alternative validity and reliability measures of cricket specific movement patterns

Movement patterns	Distance (m)	SEE	CV	% of error
Walking	10.00	0.16	0.09	-0.03
	20.00	0.44	0.11	0.10
Jogging	10.00	0.24	0.14	-0.02
	20.00	0.42	0.11	0.10
Striding/Running	10.00	0.19	0.11	-0.06
	20.00	0.37	0.11	-0.07
Sprinting	10.00	0.21	0.13	-0.10
	20.00	0.61	0.19	-0.12
Trigger, step out and run	10.00	0.29	0.15	0.07
Curve running	20.0	0.26	0.07	-0.03
Run-a-three	17.68*3times	0.52	0.06	-0.09
Circuit	180.00	0.94	0.03	-0.02

The Pearson correlations (r) for real field distance and all measured cricket specific movements have been found to be ranging from 0.86 to 0.99 and with pooled data r has been found 0.998. Predicted best fit line of linear regression has been found as $y = 0.9722 X + 0.0046$ (where y = observed value, X = real field distance). The coefficient of determination ($R^2 = 0.996$) indicates homoscedasticity by nature, which indicates that as the number of measurements increase, only trivial measurement differences arise. The percentage of mean differences of observed pooled data against real field distances has been found to be -2.20 ± 13.17m in B&A plot (Figure 2).

The data suggest that on average polar V800 smart watches underestimate by 2.20% for the distance than the real field measurements. The limits of agreement mean ±1.96 SD has been found -23.61 m to 28.01 m. From figure 2 it could be understood that a major portion of pooled data lies between the confidence limits, only a few data points lay outside the limits. As more than 95% (approx.) data were lying inside of the limit, it indicates that there is a strong agreement between the tests. All the data converted in percentile

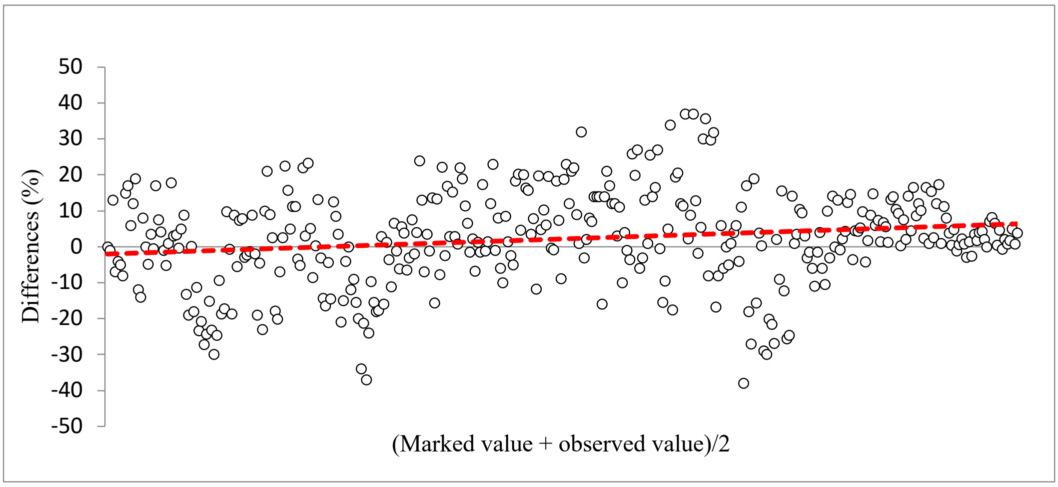

Figure 2. The Bland-Altman Plot

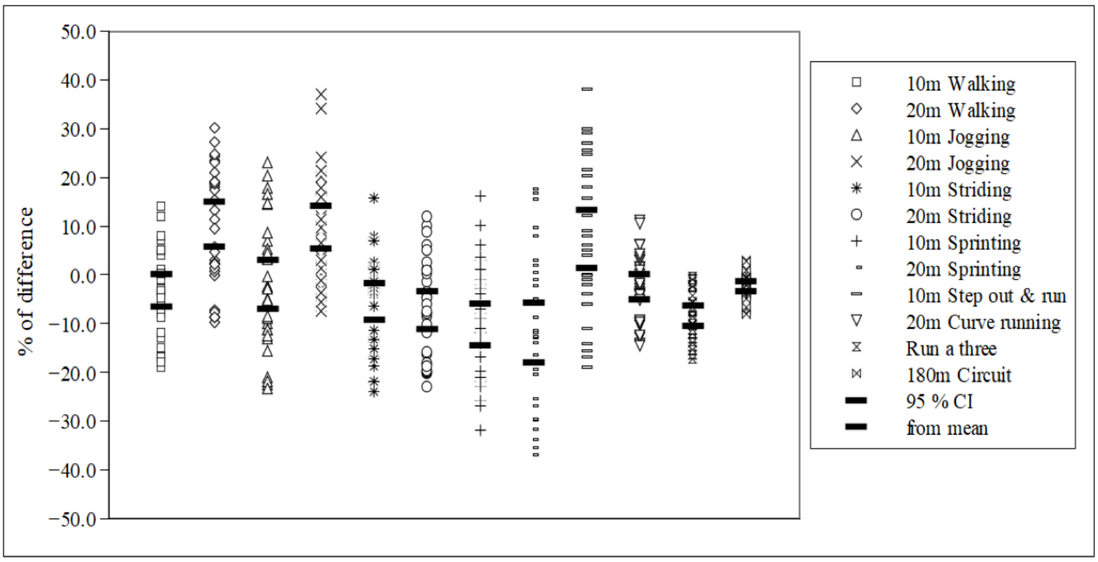

Figure 3. Graphical representration of bias with 95% confidence intervals

score and one way single factor ANOVA followed by Tucky's post hoc test were performed to uncover specific differences among groups.

The observed 20m walking, 20m jogging, 10m sprinting, 20m sprinting and run a three movements shows maximum significance difference with others observed movements but medium magnitude of differences (-0.43, -0.42, 0.44 and 0.36 respectively) has been observed with real field distance. The percentage of least significant difference has been observed 5.49 and the majority of the data set did not display significant difference with real field distance.

Bias was determined by subtracting the real field distance from the GPS estimated distance and evidence of bias has been observed in Figure 3.

The 95% CI of bias for all movements has been found to range from -3.15 to 14.84. All the data were pooled and compared with real field distance and no significant difference has been observed. Mean with SD, SEE and 95% CI for pooled data has been found to be 97.80 ± 13.17, 0.69, 96.44-99.17 respectively. The distribution pattern of the data clearly exposes random errors which come from an internal and external property of GPS, polar V800 smart watch and human locomotion error.

Discussion

One minute standing position was monitored to understand the static error of the smart watch. Due to natural error of GPS readings or inherent property of polar V800 a mild displacement (> 1.0 m/min, maximum speed > 0.9 km/h) has been found. Polar V800 smart watch has the ability to update the distance calculation in real time along with tracking a wide variety of activities (PEO, 2013, p. 56 & 97-98). There is an inherent error in the GPS location calculation, but under optimal conditions, the error can be minimized. Errors happen due to clock drift of the satellites and signal propagation delay in the upper atmosphere (Benjamin, 2018). Another source of error is a multipath delay, which occurs when the signal bounces off objects (building, big tree) before arriving at the receiver (Aughey, 2011; Benjamin, 2018). During low intensity activities such as walking, jogging a tendency of overestimating distance covered has been observed. This finding also supports the finding of Benjamin Bennett (2018), four alternative methods used to explore observed data such as raw GPS data, GPS speed data, average GPS data and line of best fit. Both raw GPS data and line of best fit methods overestimate the total distance with low variance. With a high variance, GPS speed method misjudged the total distance traveled for all types of activity. During trigger-step out and run movement a tendency of overestimation real field distance has been observed might be due to across step out by the volunteer. As the speed increases a clear picture of underestimation of real field distances has been observed in the study. This finding was also supported by Coutts and Duffield (2010); and Jennings, Cormack, Coutts, Boyd, and Aughey (2010). In real time experience during walking and jogging one second backlog time has been found in exported data but as the speed increases backlog time also increases up to four seconds. So it can be misleading to measure speed. During low and moderate intensity activity speed can be measured through exported data but when speed increases it could be quite complex to measure accurate data because of the limitation of 1Hz GPS monitor. Cricket specific run-a-three movements also underestimate real field distance (Petersen, Pyne, Portus, & Dawson, 2009), due to quick changes of direction (>1 sec) the watch is unable to estimate real position. During run-a-three movement conditions, the volunteer runs in a slight curvilinear pathway instead of straight line that means the volunteer covered more than real field distance but observed data did not exhibit this. A small quartile range has been observed in the 180m cricket specific circuit which clearly indicates as the distance increases the reliability also increases to measure specific distance. Polar V800 smartwatch updates latitude and longitude in every second and sets distance accordingly. So as the duration of time and distance increases the accuracy of measurement also increases but when it's about speed the coaching expert should focus on the number of high intensity bouts instead of maximum speed (distance covered/ time) and train accordingly. The reliability of polar V800 to measure locomotion patterns was found better in longer distances and larger time periods. As the locomotion speed increases the reliability decreases. This outcome is a replica (reduced reliability with increased movement velocities) finding of Benjamin (2018); Coutts and Duffield (2010) and Petersen, Pyne, Portus, & Dawson (2009). Although a good reliability score was observed in cricket specific movement circuits. As per the theoretical agreement of Polar V800 manual, the smart watch demonstrated a good level of accuracy for the actual measured distance in various movement patterns (GAGPORW, 2018; PEO, 2013, p. 97). Some error has been observed between actual and measured distance and that is also supported by previous research (Benjamin, 2018; Coutts & Duffield, 2010; Petersen, Pyne, Portus & Dawson, 2009). A good overall significant intra-model reliability has been observed in distance measure through split-half reliability methods. The B&A plot, CV and 95% CI also reflect the statement. It also found, as the distance decreases and speed increases the SEE and CV become relatively larger. A limitation of this study is peak speed was not directly measured. As we know, cricket is an intermittent sport, long periods of low-moderate intensity activity (standing, walking, jogging) interspersed with short bursts of high-intensity (striding, sprinting) activity with brief maximal accelerations. The sampling rate of Polar V800 smart was at 1-Hz which may not provide accurate information regarding speed trails (high-intensity activities) in nonlinear pathways, but as the inherent property of the smart watch it could give quite accurate distance measurement.

Effective training schedules largely depend on physiological demands and movement patterns of certain sports (Aughey, 2011). From this point of view, effective evaluation of cricket specific movements is important to prescribe fitness and condition programs. The accuracy of polar V800 has been observed -3.8 to 3.1 for measuring real field distance which also indicates random errors. A major finding of this investigation is to underestimate the distance covered in short sprint effort as well as run-a-three movements. The magnitude of errors associated with random errors should be clearly understood because no consistency of positive or negative errors has been observed in measuring true value. Sometimes it underestimates the true value and sometimes overestimates. Although when it is about precision (95% CI) then we can observe it includes true value or very close to true value. A tendency of under-reporting of high-intensity activity and the over reporting of low-intensity activity has been observed. The range of typical error has been observed 0.63 to 3.65 and relatively high typical error has been observed in circuits followed by run-a-three and short high intensity movement patterns.

Theoretically, it is possible because the number of GPS signals is lower during shorter sprints (GPS Accuracy, n.d.), so the distance of these sprints is underestimated and has reduced reliability. One study (Jennings, Cormack, Coutts, Boyd & Aughey, 2010) reported validity results for measured distance at lower intensity activity same as our current results (typical errors 1.51 ± 0.87). They found typical errors increased with short duration and high-intensity efforts. GPS monitoring is useful to track cricket specific movement patterns both in game situations and practice sessions to modify type of physical activity, duration of training and intensity of conditioning sessions. The reliability of estimating longer distances is acceptable for game and training applications. However, the underestimation bias displayed with the GPS units studied here during sprinting may mean that total game sprint distance is underreported, whereas the total game distance may represent true distance with a little change. So, coaches should focus on variations in game to game total distance cover and high intensity workload should be prescribed according to the number of high intensity efforts.

Conclusions

The study reveals that Polar V800 smart watch has an acceptable accuracy, reliability and validity for measuring basic locomotion and cricket specific movements. Although due to the inherent property of polar V800 smart watch (maximum sample rate 1Hz in high accuracy mode) it has a tendency to underestimate speed but due to continuous latitude and longitudinal update it can measure distance effectively. From this point of view, we can conclude that, although there are some certain limitations to measured speed oriented specific movements but when we wish to measure distance of all crickets specific movement patterns together then Polar V800 smart watch may be a good choice.

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Conflict of interest

The authors declare no conflict of interest.

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ТЕХНІЧНА ПРИДАТНІСТЬ І НАДІЙНІСТЬ СМАРТ-ГОДИННИКА POLAR V800 ДЛЯ ВИМІРЮВАННЯ ПРИТАМАННИХ КРИКЕТУ РУХІВ

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Метою дослідження було проведення оцінки надійності та технічної придатності смарт-годинника Polar V800 у процесі вимірювання різних притаманних крикету рухів.

Матеріали та методи. З метою скорочення до мінімуму індивідуальної похибки та усунення міжсуб'єктної варіабельності для виконання всіх притаманних крикету рухів було відібрано лише одного тренованого чоловіка-волонтера. Показники відстані, одержані за допомогою Polar V800, порівнювали з фактичними відмітками на полі.

Результати. Використовували статистичний метод перевірки надійності тесту шляхом співставлення окремих його частин, і було встановлено, що показник «r» для здійснених вимірювань дорівнює 0,93. Довірчі інтервали 95% також відбивають досить високий показник достовірності. Для визначення валідності цього набору даних використовували метод критеріальної валідності. Було встановлено, що коефіцієнти кореляції Пірсона (r) перебувають у діапазоні від 0,86 до 0,99. Було встановлено, що прогнозована найкраща емпірична крива лінійної регресії описується формулою y = 0,9722 X + 0,0046 (де y = виміряне значення, X = фактична відстань на полі). Однофакторний дисперсійний аналіз із наступним апостеріорним тестом Тьюкі, проведені стосовно виміряних значень рухів бігу на 10 м, бігу на 20 м та потрійного бігу вздовж усього пітча з двома поворотами на 180°, показують максимальну статистично значущу різницю з іншими притаманними крикету рухами. Установлено, що середня відсоткова похибка вимірювання стосовно всіх притаманних крикету рухів становить -2,20 ± 13,17.

Висновки. Результати дослідження показують, що смарт-годинник Polar V800 має прийнятну точність, надійність і технічну придатність для вимірювання різних притаманних крикету рухів із певними обмеженнями.

Ключові слова: Polar V800, GPS, надійність, технічна придатність, притаманні крикету рухи.

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