ASSESSING TEST-RETEST RELIABILITY OF THE PORTABLE BROWER SPEED TRAP II TESTING SYSTEM

Shaher A. I. Shalfawi[1], Eystein Enoksen[2], Espen Tønnessen[1] and Jørgen Ingebrigtsen[3]

[1]*Norwegian Olympic Sport Centre, Department of Physical Training, Oslo, Norway*
[2]*The Norwegian School of Sport Sciences, Department of Physical Performance, Oslo, Norway*
[3]*University of Nordland, Department of Physical Performance,*
Center for Practical Knowledge, Bodø, Norway

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Abstract:

The aim of the present study was to assess the test-retest reliability of the Brower Speed Trap II running speed timing system. The test-retest reliability of the system was assessed by testing 52 physical education students aged (±SD) 21.4 (±8.9) years. All participants were tested on 30-m sprint with 10-m, 20-m and 30-m split times. All measurements were obtained on two subsequent days. The results from this investigation indicate that the variations in the students' performance between test day one and test day two was small and the intra-class correlation indicates a high repeatability. In the examination of the system reliability, the system did not show any marked systematic bias ($p<.05$) assessed by the paired sample *t*-test. However, the systematic bias and the random variation found indicate that the Brower Speed Trap II running speed timing system was a reliable testing instrument to be used in testing physical education students, and a useful instrument for measuring running speed. However, in future studies it would be interesting to examine if the system were able to monitor the small changes in running speed that could result from increasing the training of an already elite athlete. Furthermore, we concluded that if comparison of overall values of running speed is intended, it is advisable to use the same testing system, because different systems give different results based on the errors associated with it.

Key words: *running speed, heteroscedastic, limits of agreement*

Introduction

Sprint performance and the repeated sprint ability have been extensively described in male and female elite and non-elite athletes in different sports, as well as other healthy populations (Aziz, Chia, & Teh, 2000; Aziz, Mukherjee, Chia, & Teh, 2007; Blazevich, 2000; Ebben, 2008; Ebben, Davies, & Clewien, 2008; McMillan, Helgerud, Macdonald, & Hoff, 2005; Taskin, 2008; Wadley & Le Rossignol, 1998; Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004). Several measurement systems and methods have been introduced, such as shuttle runs, straight forward acceleration, sprinting and treadmill testing (Aziz, et al., 2007; Glaister, Howatson, Pattison, & McInnes, 2008; McMillan, et al., 2005; Oliver, Armstrong, & Williams, 2009; Wisloff, et al., 2004). The majority of studies have used photocells as the preferred testing equipment. One of the systems used in assessing sprint time is the portable and wireless Brower Speed Trap II running speed timing system. The use of this system is well documented in literature (e.g. Caldwell & Peters, 2009; Coh, Milanovic, & Kampmiller, 2001; Ebben, 2008; Ebben, et al., 2008; Wisloff, et al., 2004). Nevertheless, its reliability has yet to be verified.

In sport science, the data should be supported by evidence of how reliable the measured variables are (Morrow & Jackson, 1993). Reliability has been defined as the "consistency of measurements" or "absence of measurement error" (Atkinson & Nevill, 1998; Enoksen, Tonnessen, & Shalfawi, 2009). A basic requirement of any test is therefore that repeated measurements yield consistent results (Nevill & Atkinson, 1997). Reliability refers to the reproducibility of a measurement; measures should be reproducible with neither marked systematic (learning, motivation, fatigue) nor random (sampling) variation (Enoksen, et al., 2009; Hopkins, 2000). Reliability affects the ability to track changes in measurements in clinical or experimental studies and thus defines whether the testing systems can be used to track athlete performance development, and to what degree the eventual measurement errors can be accepted for practical use (Atkinson &

Nevill, 1998; Enoksen, et al., 2009; Hopkins, 2000). Furthermore, the assessment of reliability is an important aspect of studying alternative methods of measurements and measuring systems (Altman & Bland, 1983). Several methods of assessing reliability have been introduced, such as "within-subject random variation, systematic change in the mean, retest correlation" and the "typical error" which is best presented as a coefficient of variation (Hopkins, 2000). Another method of assessing reliability was introduced by Altman and Bland (1983), namely, the 95% limits of agreement where the researcher can separate between systematic variation (learning, motivation or fatigue) and random variation (associated with sampling errors). Therefore, the aim of this study was to report and assess the reliability (repeatability) of the wireless Brower Speed Trap II running speed timing system.

Methods

Participants

Fifty-two healthy male and female physical education students, aged (±SD) 21.4 (±8.9) years, body mass 73.1 (±10.4) kg and stature 175 (±0.08) cm, agreed to take part in this study. Written consent was obtained from all participants, and the study was approved by the institutional ethics committee of the Nordland University (UIN).

Materials and procedure

Body mass (kg) was obtained using an electronic scale (A & D Company Limited, Tokyo, Japan), and stature was measured using a wall-mounted stadiometer (KaWe Medizintecknik, Asperg, Germany). The Brower Speed Trap II timing system (Brower Timing Systems, Utah, USA) consists of a handheld coach monitor (CML5MEM) and four infrared beam/transmitter sets. Each set consists of an infrared sender (IRD-T175) and an infrared emitter (IRE) with antennas mounted on tripods. Data are sent directly from the beam sets to the handheld coach monitor. Both are battery driven. The Brower Speed Trap II timing system radio frequency is given by the manufacturer to be 27.145 MHz. The measurement accuracy of the Brower Speed Trap II timing system is given by the manufacturer to be 1/100 s.

Procedures

Participants initially completed a 15-minute general warm-up, consisting of running at 60-70% of maximum heart rate. Participants were then asked to do three near maximal 30-m sprints as a specific part of the warm-up. After a 5-minute break, participants were then asked to perform three maximum attempts at 30-m sprint with a minimum of three minutes recovery between attempts (McCartney, et al., 1986; Spencer, Bishop, Dawson, & Goodman, 2005). The time was measured for 10-m, 20-m and 30-m sprints, in order to examine if the errors would differ with the distance. The participants started from a standing position placing the front foot on a starting line 30 cm behind the first photocell. When the test leader gave the signal, the participant started the sprint, attempting to cover the 30-m distance in the shortest possible time. The time started automatically when the participant broke the beam from the first gate (time zero), and stopped when the participant passed the photocells at 10, 20 and 30 metres. All photocells were assessed by aligning the wireless photocells with the distance corresponding to the distances being measured. Each tripod with wireless laser beams was placed directly above the distance indicated by the roll meter (KaWe Medizintecknik, Asperg, Germany). To control this set up, a cross-line self-levelling laser (Bosch PCL 1, Germany) was used. All photocells were 50 cm above the ground, as recommended by the Norwegian Olympic Federation. All tests were carried out in an indoor hall with a 45-m running track. The criteria for accepting the trials were: performing the trials as described in the procedure (Participant) and accepted Brower Speed Trap II photocells registration (Instrument). When these two criteria were fulfilled, the best result was retained for analysis. All measurements were performed on two consecutive days at the same place and time of day, and with the same settings and configurations.

Statistical analyses

Raw data were transferred to SPSS 13.0 for Windows and Analyse-it for Microsoft Excel (version 2.11). To assess the reliability of the student's performance, a two-way mixed intra-class correlation (ICC) reliability and the coefficient of variation (CV) between test day one and test day two were obtained following the guidelines provided by Hopkins (2000) for all measures. All data were then examined by a scatterplot, and a Pearson's r correlation coefficient was computed to determine the strength of the relationships between the paired variables from test day one and test day two. If the correlation was found to be strong, a linear regression was drawn to the scatterplot and the shared variance (R^2) and the equation of the predicted variable calculated.

To assess the reliability of the testing system, data were plotted using Bland and Altman's 95% limits of agreement as described by Atkinson and Nevill (1998). A paired *t*-test was used to assess the hypothesis of zero bias. Pearson r was calculated to examine the heteroscedasticity between the absolute differences and individual means. If heteroscedasticity (the differences depend on the magnitude of the mean) was suspected, or if the data were not normally distributed, a logarithmic (natural) transformation of the data was assessed before calculating the bias and limits of agreement. The data were then presented after an antilog had been performed and a paired *t*-test had been applied to the log-transformed data. The .05 level of significance was adopted for all the statistical tests. To determine whether the examined timing systems can be of practical use, analytical goals regarding the system reliability were set based on our use of the systems at the University. Therefore, our analytical goals were set to a total error (systematic bias and random error) not exceeding ±0.15 s.

Results

The between-test-day-one and test-day-two reliability for 0–10-m sprint time was intra-class correlated (ICC)=.91 with a CV of 2.3%, for 0–20-m sprint time was ICC=.91 with a CV of 2.9%, and for 0–30-m sprint time was ICC=.99 with a CV of 0.9%.

A linear regression analysis was conducted to determine the relationship, the shared variance and the linear regression equation between test day one and test day two. Results are presented for 0–10-m sprint time (Figure 1), 0–20-m sprint time (Figure 2) and 0–30-m sprint time (Figure 3).

The test-day-one and test-day-two reliability did not show any marked systematic bias (Table 1). Heteroscedasticity was suspected in 0–20-m sprint time after examining the data with a histogram (Figure 4). Furthermore, examination by the Bland and Altman plot showed an outlier (Figure 5). Removing this outlier and examining the data once again with a histogram of the difference showed that the data followed a normal distribution, and heteroscedasticity was removed (Figure 6).

Table 1 shows the results in seconds. The systematic variation is presented as bias and the random variation is presented as 95% limits of agreement.

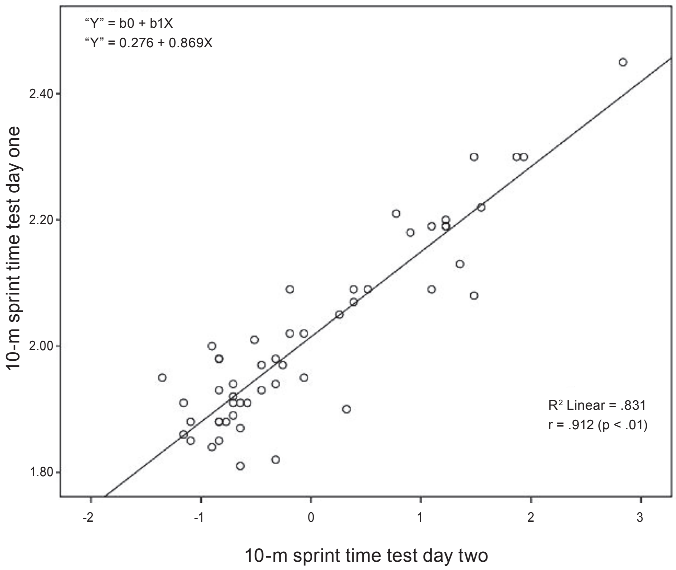

Figure 1. R^2, Pearson's r correlation cofficeint, p-value and linear regression equation between the results of the 10-m sprint time test day one and 10-m sprint time test day two.

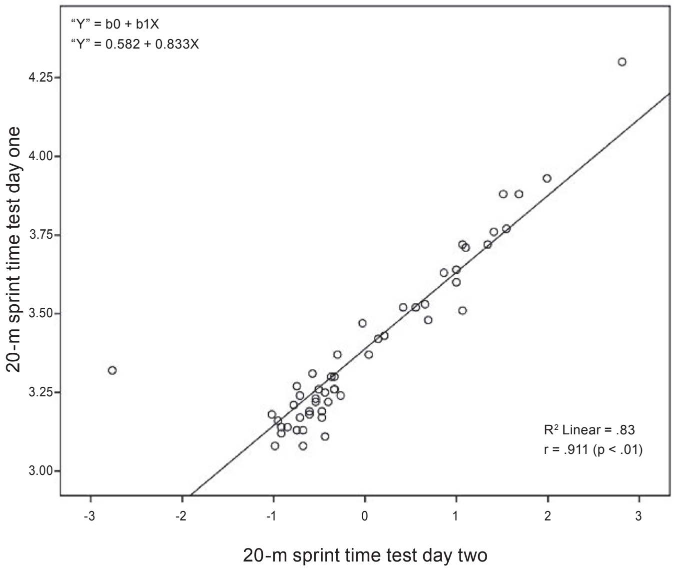

Figure 2. R^2, Pearson's r correlation coefficient, p-value and linear regression equation between the results of the 20-m sprint time test day one and 20-m sprint time test day two.

Table 1. Reliability measures of the Brower Speed Trap II

	Test day one	Test day two	Bias (SD)	95% limits of agreement	Paired *t*-test (p-value)
0–10-m sprint (s)	2.02 ±0.15	2.00 ±0.16	0.02 (0.06)	-0.11 to 0.14	.102
0–20-m sprint (s)	3.39 ±0.27	3.38 ±0.27	0.01 (0.06)	-0.11 to 0.13	.492
0–30-m sprint (s)	4.73 ±0.41	4.73 ±0.41	0.00 (0.06)	-0.13 to 0.12	.667
Pearson r between the absolute difference and the average mean was: 0–10-m sprint (r = – .11, n = 52, p = .42), 0–20-m sprint (r = –.03, n = 51, p = .83) and 0–30-m sprint (r = –.01, n = 52, p = .96).					

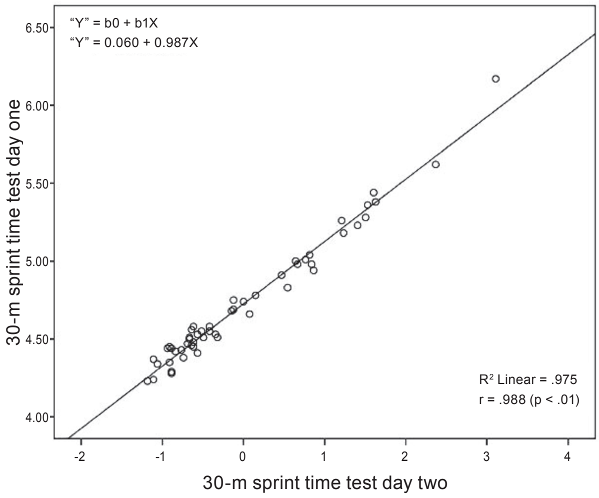

Figure 3. R^2, Pearson's r correlation coefficient, p-value and linear regression equation between the results of the 30-m sprint time test day one and 30-m sprint time test day two.

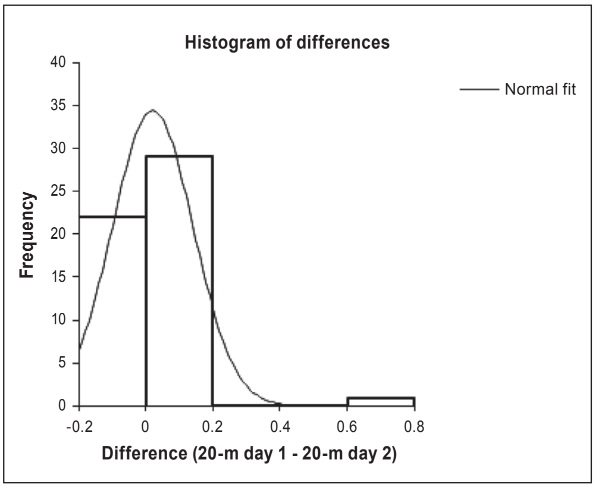

Figure 4. Histogram of the differences for test-retest of 20-m sprint for the Brower Speed Trap II.

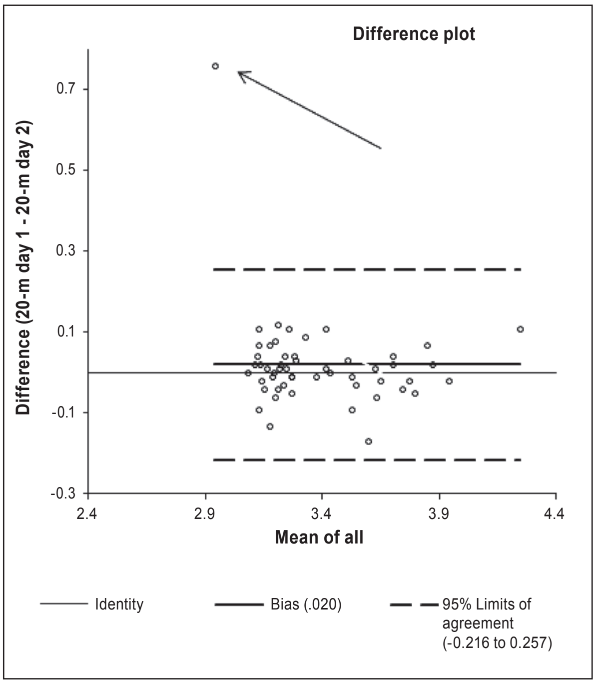

Figure 5. Bland-Altman plot with bias and limits between Brower Speed Trap II test-retest for the measures of 20-m running speed.

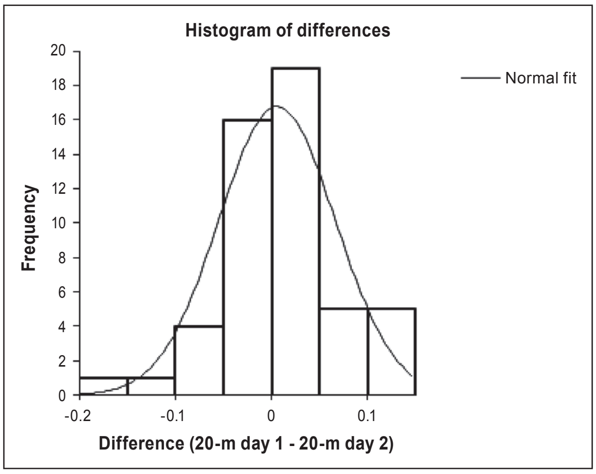

Figure 6. Histogram of the differences for test-retest of 20-m sprint for the Brower Speed Trap II after eliminating the outlier.

Discussion and conclusions

A high-performance repeatability indicated by a high ICC was found in the examination of performance reliability between test day one and test day two. The variations between performance in test day one and test day two for all measures were small and less than 5% (Hopkins, 2000). However, this was expected as it has been found that test-retest performance reliability in sprint can be achieved without the need for familiarization sessions (Glaister, et al., 2009; Moir, et al., 2004). Furthermore, when assessing the correlation coefficient (*r*), the results indicate that all the relationships between the measures from test day one and test day two were strong ($p<.01$), indicating a close to linear relationship (Hopkins, 2000). Based on the strength of this relationship between test pairs, we can assume that an accurate prediction of the Y value from the X value could be achieved by applying the regression equation provided (Figures 1, 2 and 3).

In the examination of the reliability of the Brower Speed Trap II testing system, we suspected heteroscedasticity in the 0–20-m sprint time measure obtained by the system (Figure 4). Further examination using a Bland and Altman plot revealed an outlier shown in the plot (Figure 5). However, after removing the outlier from the data and examining the data with both the Bland and Altman plot and a histogram of the difference (Figure 6), the data showed a normal distribution. Furthermore, in the examination of heteroscedasticity, Nevill and Atkinson found that if the correlation between the absolute differences and the individuals mean is positive but not necessarily significant in a set of data, it is usually beneficial to take logarithmic values when calculating the limits of agreement (Atkinson & Nevill, 1998; Nevill & Atkinson, 1997). In the present data, the correlation coefficient was tested against the null hypothesis of r=0 on all measures for a formal test of independency, and no positive relationship was found that might indicate a tendency for the amount of variations to change with the magnitude of the measurements (Table 1). Therefore, no log-transformation was applied.

The results indicate that the mean (±SD) difference (errors) between measurements on the first (day one) and second (day two) occasion were 0.02 s (±0.06 s) for 0–10-m sprint time, 0.01 s (±0.06 s) for 0–20 m sprint time and 0.00 s (±0.06 s) for 0–30-m sprint time. The results did not show any significant bias assessed by the paired sample *t*-test (Table 1). Furthermore, assuming the differences are normally distributed, 95% of the differences should lie between the limits 0.02 s (±0.13 s) for 0–10-m sprint time, 0.01 s (±0.12 s) for 0–20-m sprint time and 0.00 s (±0.13 s) for 0–30-m sprint time, regardless of the subjects mean performance. Based on the results of this study, we can conclude that this system can be a useful tool to be used in testing physical education students as it appears to measure the improvements that such subjects may make following a training intervention. This is supported by several previous studies where the improvements observed were between 0.10 s to 0.22 s in untrained subjects (Christou, et al., 2006; Dawson, et al., 1998; Kotzamanidis, Chatzopoulos, Michailidis, Papaiakovou, & Patikas, 2005; Ross, et al., 2009).

Based on a comparison between several studies on elite athletes and our analytical goal of 0.15 s, the system has not been found usable since the total measurement error exceeded our analytical goal. This could be due to the participants in this study being physical education students and not elite athletes. Furthermore, studies have shown only marginal changes after training interventions for speed improvements in both professional soccer players (-0.05 s) and semi-professional soccer players (-0.01 s to -0.03 s) (Bravo, et al., 2008; Ronnestad, Kvamme, Sunde, & Raastad, 2008; Thomas, French, & Hayes, 2009). However, this suggests that different results could be found if the study were to be repeated with well trained subjects since the system did not show any marked systematic bias.

In this study, the Brower Speed Trap II measuring system was found to be a useful instrument in estimating running speed. Furthermore, the measurement errors associated with the system indicate that the system is useful in testing physical education students. However, we recommend that the present study could be repeated using the same system but with already trained athletes in order to examine whether the system is able to detect the small changes in performance resulting from training of an already well-trained athlete. Furthermore, if a comparison of the overall values of running speed is intended, it is advisable to use the same testing system, as different systems give different results based on the errors associated with it.

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UTVRĐIVANJE TEST-RETEST POUZDANOSTI PRIJENOSNOG MJERNOG SUSTAVA BROWER SPEED TRAP II

Cilj je ovog istraživanja bilo utvrđivanje pouzdanosti sustava za mjerenje brzine trčanja Brower Speed Trap II metodom test-retest. Test-retest pouzdanost sustava bila je utvrđena testiranjem 52 studenta kineziologije, u dobi od 21,4±8,9 godina. Svi ispitanici bili su testirani testom *sprint na 30 metara* s prolaznim vremenima zabilježenima na 10, 20 i 30 metara. Sva mjerenja su provedena tijekom dva uzastopna dana. Rezultati istraživanja pokazali su malu varijabilnost rezultata u testovima provedenima prvi i drugi dan, a intraklasna korelacija između rezultata dobivenih prvi i drugi dan pokazuje visok stupanj ponovljivosti. Primijenjeni *t*-testa za zavisne uzorke pokazao je da ne postoji značajna sistematska pogreška mjerenja (p<.05). Ipak, dobivena sistematska pogreška i utvrđena slučajna varijacija potvrđuju da je sustav za mjerenje brzine trčanja Brower Speed Trap II pouzdan mjerni instrument za mjerenje populacije studenata kineziologije te koristan mjerni instrument za mjerenje brzine trčanja. Ipak, u budućim istraživanjima bilo bi zanimljivo istražiti može li sustav zabilježiti male promjene u brzini trčanja koje mogu biti rezultat treninga vrhunskih sportaša. Nadalje, zaključili smo da ako je namjera uspoređivati rezultate mjerenja brzine trčanja, korisno je koristiti isti mjerni sustav, budući da različiti mjerni sustavi daju različite rezultate s obzirom na različite pogreške koje sustavi imaju.

Ključne riječi: *brzina trčanja, heteroskedastičnost, granice podudarnosti*

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Correspondence to:
Shaher A. I. Shalfawi
Norwegian Olympic Sport Centre
Department of Physical Training
P.O. Box 4003, Ullevål Stadion, 0806 Oslo, Norway
Phone: +47 45 66 06 60
Fax: +47 24 07 57 50
E-mail: shaher.shalfawi@me.com