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The validity and reliability of a novel mobile app to measure agility performance in the physically active youth population

Juan A. Escobar-Alvarez[1], Rocío Carrasco-Zahínos[2], Pedro R. Olivares[3], Sebastián Feu[4], Robinson Ramírez-Vélez[5], Miguel Angel Pérez-Sousa[6]*

1. *Faculty of Higher Education, South Essex College University Centre, Southend on the Sea, UK*
2. *Facultad de Educación, Universidad de Extremadura, 06006 Badajoz, Spain*
3. *Facultad de Educación, Psicología y Ciencias del Deporte, Universidad de Huelva, Spain, Instituto de Actividad Física y Salud, Universidad Autónoma de Chile, Chile*
4. *Facultad de Educación, Universidad de Extremadura, 06006 Badajoz, Spain*
5. *Navarrabiomed-Universidad Pública de Navarra (UPNA), Complejo Hospitalario de Navarra (CHN), Instituto de Investigación Sanitaria de Navarra (IdiSNA), Pamplona, Navarra, Spain; CIBER of Frailty and Healthy Aging (CIBERFES), Instituto de Salud Carlos III, Pamplona, Navarra, Spain*
6. *Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain; Epidemiology of Physical Activity and Fitness Across Lifespan research group, University of Seville, Seville, Spain*

*Correspondence: (Miguel A. Pérez-Sousa) perezsousa@gmail.com

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Abstract: Agility is a key component of physical fitness in adolescents. However, the measurement of this variable is usually complex, requiring high cost instruments and complex software. To test the validity and reliability of a novel iPhone app (Lap Tracker Auto-timer) to measure agility performance among adolescents. Twenty-four physically active adolescents (15.7 ± 2.3 years old) participated in two testing sessions (separated by 7 days). They performed three 4 x 10 m agility test trials measured by Photocell or the iPhone app. The correlation analysis revealed high validity (r = .92; 95% confidence interval [CI] = .88 – .95), with a standard error of the estimate of 0.56 s ($p < 0.001$). The coefficient of variation (CV; 0.09) and intraclass correlation coefficient (ICC; .93; 95% CI = .85 – .97) showed an acceptable reliability. This study demonstrated that the iPhone App Lap Tracker Auto-timer could be a valid, reliable and low-cost tool to evaluate agility performance in adolescents. However, more studies are required to guarantee the utility of this app.

Keywords: app, valid, reliable, performance, agility

1. Introduction

Agility can be defined as the ability to perform a rapid whole-body movement given a change in velocity or direction in response to a stimulus (Sheppard & Young, 2006). This ability is integrated in athletic performance, especially in team sports, where continuous accelerations, decelerations, and change of direction (COD) or speed are required during a match. For example, agility is suggested to be a key performance indicator in soccer (Lloyd et al. 2015), basketball (Scanlan, Tucker, and Dalbo 2014) and rugby (Freitas et al. 2018). In fact, agility is one of the components of health-related physical fitness, and several studies have shown that agility contributes to better health (Ortega et al. 2008) and quality of life (Perez-Sousa et al. 2019).

Agility is widely examined using several protocols (Ruiz et al., 2011; Sheppard et al., 2014). The aforementioned evaluations are characterised by having to complete a trajectory of previously planned directional changes as fast as possible. These timed events can be measured by several tools, including stopwatches (Ruiz et al. 2011), radar guns (Samozino et al. 2016) and mobile apps. However, the gold standard method within this field are the photoelectric timer gates devices (Samozino et al. 2016; Vicente-Rodríguez et al. 2011). Most of these tests provide more accurate and reliable (intraclass correlation coefficient [ICC] > .70) information when they are performed with high-cost devices that are of limited use under laboratory conditions. In addition, these instruments usually require specific and complex software to interpret the obtained data.

In the past 5–10 years, there has been increasing research on the use of mobile phones (including smartphones) for measuring athletic performance (Peart, Balsalobre-Fernández, and Shaw 2017). The use of this wearable and low-cost technology facilitates the analysis of human movement for several professionals in this field (physical education teachers, coaches, physicians, physiotherapists, researchers, etc.). Mobile applications also offer a potential solution to provide support for sports settings in general because mobile phones are commonly accessible (Muntaner-Mas et al. 2019).

Although not all mobile apps have been subjected to empirical testing, previous research have analysed the validity and reliability of commercial apps for the measurement of physical parameters, including vertical jump in different populations (Balsalobre-Fernández et al. 2015; Cruvinel-Cabral et al. 2018), sprinting ability (Romero-Franco et al. 2017; Stanton et al. 2016) and more recently COD (Balsalobre-Fernández et al. 2019). Therefore, further studies are warranted to determine the utility of commercial apps for objectively and remotely assess agility performance. Thus, this study aimed to determine the validity and reliability of an application for iOS (Lap Tracker Auto-timer) to measure agility performance in physically active adolescents.

2. Materials and Methods

Subjects

Twenty-four physically active participants volunteered for this study (18 males and 4 females). Participants' characteristics were: 14–18 years old (15.7 ± 2.3 years), 163.9 ± 6.4 cm tall and 64.4 ± 6.5 kg. Criteria to be included were: i) did not suffer from any disease or injury that would limit their performance; ii) between 14 and 18 years; iii) provided informed consent. Also a question of physical activity was conducted as follow: (i) "Have you regularly exercised, such as jogging or dancing, or performed rigorous physical activity as football, hockey...etc. at least three times a week?". Participants were considered physically active if they responded affirmatively. Additionally, written informed consent was obtained from their parents or legal tutors after being informed of the benefits and risks of the research. This study was approved by the ethics board at South Essex College (ID 3526AL) and performed in agreement with the Declaration of Helsinki.

Methodology

Kit Racetime2 Light Radio (Micro Gate) - Kit Racetime 2 (Microgate, Bolzano, Italy) are photocells that transmits data via radio. It is designed to measure total or intermediate times accurately and reliably. Previous studies have considered this device to be the 'gold standard' for measuring times and split times in different sports performance test, such as speed/agility, course ship, sprints, etc (Bond et al. 2017; García López et al. 2012). The photocells were aligned with the reflectors, following the manufacturer's instructions, during each participant's trial.

Lap Tracker Auto-timer app - Lap Tracker Auto-timer (version 4.0) is a motion-detection-based lap timer that can be used to track different athletes in distinct tests performance. The camera view has up to four adjustable detection zones (see Figure 1) that detect the movement when an object or person passes in front of the camera of the mobile device where it is installed. For this study, the app was used on an iPhone® 8 that was running iOS 12.2 (Apple Inc., USA), although it is also available for iPad and iPod. The app was configured to stop on the fourth round of the test, and the data were recorded on an Excel sheet for its subsequent analysis.

Testing protocol - All the participants were asked to meet in the morning of the study. Body mass was measured using a scale (Seca model 711, Hamburg, Germany), and height was estimated with an aluminium stadiometer (Seca model 220, Postfach, Germany), according to the recommended procedures in the body composition assessment protocol (Norton et al. 1996).
Participants performed a standardised warm-up that comprised 8 min of moderate jogging and 5 min of dynamic stretching. At the end of the warm-up and after explaining the test, each subject performed two familiarisation during the testing day. No physical limitations or musculoskeletal injuries that could affect testing were reported.
The 4 x 10 m shuttle run test has been used for assessing speed/agility and coordination in previous studies (Artero et al. 2009; Moliner-Urdiales et al. 2011). It is especially recommended for children and adolescents (Ruiz et al. 2011). Two parallel lines were marked on a slip-proof floor (10 m apart) with a yellow-coloured spray, and three sponge blocks were placed behind the marked lines (one behind the starting line and two behind the opposite line). Participants were instructed to run back and forth as fast as possible and cross each line with both feet. Each time the participants crossed any of the lines, they had to pick up (the first time) or exchange (second and third time) a sponge block. The app and the photocells were stopped when the adolescent crossed the end line and thus completed the total 40 m (4 x 10 m). The iPhone 8 was placed on a fixed tripod (same position as the photocells) and aligned with the beam of the photocell with a laser to ensure that both instruments automatically collected the data at the same time (Figure 2).

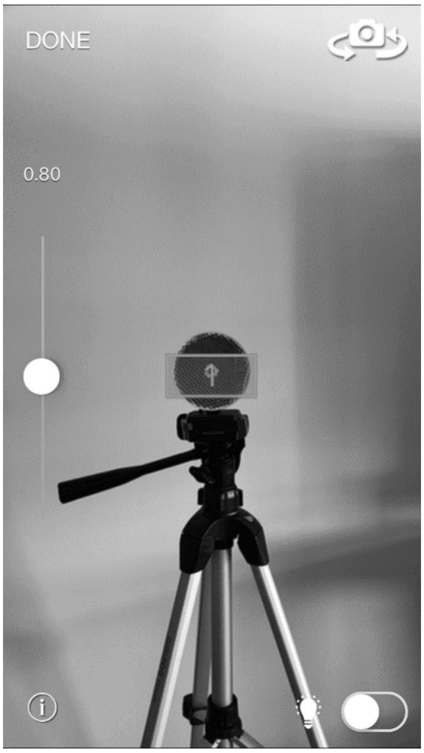

Figure 1. Screenshots of iPhone 8 showing the calibration of the detection zone of the Lap Tracker Auto-timer app for movement detection.

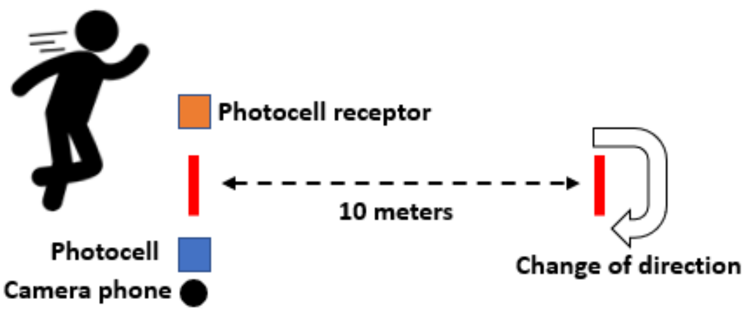

Figure 2. Representation of the 4 x 10 m shuttle run test. The camera phone was placed just below of Photocell and the detection zone configured to detect movement to the height of photocell receptor

The aforementioned protocol was performed three times (with 7 days between each trial). For the first trial, the times for the agility performance test were collected with both devices to observe the validity of the app in comparison with the photocells. For the second and third trials, only the app was used, in order to analyse the absolute and relative reliability of it. Participants always performed the task at the same time of day, a consideration that controlled for potential biological-contaminating variables (e.g., circadian rhythms) that can influence the results (Valdez-Ramírez et al. 2009).

Statistical Analysis

Descriptive analyses were performed for the dataset obtained with the photocells and the app. The Shapiro-Wilk test was used to examine whether each analysed variable was normally distributed. The course of normality and the capacity improvement process of Box-Cox (Nachtsheim et al. 2004) were also examined to ensure data uniformity and the ability to use parametric statistical tests.

The validity of the app was analysed using a Pearson correlation with the data obtained for each device. The chosen criterion to interpret the magnitude of the correlation (r) was: ≤ 0.1 = trivial, > .1 to .3 = small, > .3 to .5 = moderate, > .5 to .7 = large, > .7 to .9 = very large, > .9 to 1.0 = almost perfect (Hopkins et al., 2009).

The relative and absolute reliability, besides the magnitude of the change was analysed using Excel (with a datasheet provided by Hopkins) for validity and reliability studies (Hopkins, 2015). The relative reliability was assessed using ICC with 95% confidence interval (CI). An ICC ≥.70 was considered to be acceptable (Koo and Li 2016; Weir 2005). To examine the absolute reliability, we first calculated the change in the mean between sets and the typical error of the measure expressed as coefficient of variation (CV) (in per cent). A CV < 5% was set as the reliability criterion (Hopkins et al., 2009). Finally, the magnitude of the change between tests was calculated using Cohen's effect size (ES). The criterion for interpreting this magnitude was < 0.2 = trivial, 0.2–0.6 = small, 0.6–1.2 = moderate and > 1.2 = large (Hopkins et al., 2009). Reliability was also assessed according to the Bland-Altman method. This analysis measures bias as estimated from mean differences, the 95% confidence interval for bias, the limits of agreement and ± 1.96 standard deviation (SD) of the difference. All data were analyzed using MedCalc Statistical Software version 18.2 (MedCalc Software BVBA, Ostend, Belgium). Figures were designed using GraphPad Prism 6.0 (GraphPad Software Inc., California, USA).

3. Results

Mean ± standard deviation values for time performance (s) for the 4 x 10 m test with the photocells and the Lap Tracker Auto-timer app are shown in Table 1. Pearson correlation analysis is also shown in Table 1. There was a very large correlation (r = .92; p < .001) between the devices.

The ICC was .93, a value that indicated almost perfect reliability between test-retest, while the CV for the absolute reliability analysis was 0.09%. Finally, the magnitude of the test-retest change provided a Cohen's ES of 0.1, a value indicative of a trivial effect (Table 2).

Finally, the Bland-Altman plots are depicted in Figure 3. Graphical analysis showed a noticeable and similar concordance between the photocells and app for average time measurements, as shown by the low bias value (SD of bias = 0.30) and narrow confidence interval (range: -0.53 to 0.63%).

Table 1: Mean ± standard deviation and correlation analysis of the 4 x 10 m shuttle run test performance (s) for the photocells and the app *Lap Tracker Auto-timer*.

Photocells	App	*r*	95% CI	SEE	R^2	*P*	Inference
11.2 ± 0.6	11.3 ± 0.7	.92	(.88, .95)	0.56	.86	< .001	Very large

Note: 95% Confidence interval. SEE : standard error estimate

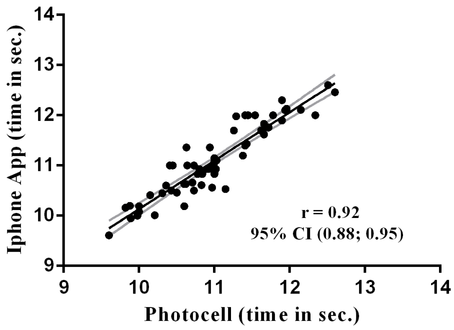

Figure 3. Correlation plot between Photocell and the app Lap tracker Auto-timer for the measurement of the total time in 4x10 shuttle run test.

parameters due to the use of automatic detection of movement. While other valid and reliable apps are based on video-analysis, they require importing and manipulating high-speed videos of the participant's performance by manual selection of the appropriated frame (Balsalobre-Fernández et al. 2015; Romero-Franco et al. 2017). In recent years, different smartphone apps have been developed to collect several types of vertical jumps (countermovement jump, squat jump, etc.) (Balsalobre-Fernández et al. 2015), sprint performance (Romero-Franco et al. 2017) and COD (Balsalobre-Fernández et al. 2019), among others (Peart et al. 2017). A recent study by study by Balsalobre-Fernández et al (2019) reported good validity and reliability for a smartphone app for the measurement of COD performance, although they used the 5+5 test (Nimphius et al. 2018) while our results are based on the 4 x 10 m shuttle run test (Ruiz et al. 2011).

Table 2. Mean ± standard deviation values for test-retest, intraclass correlation (ICC), coefficient of variability (CV) and effect size (ES).

Test	Retest	ICC	95% CI	%CV	95% CI	ES	95% CI	Inference
10.7 ± 0.9	10.6 ± 0.9	0.93	(0.85 – 0.97)	0.09	(0.0 – 1.4)	0.1	(0.69 – 0.49)	Trivial

Note: 95% Confidence interval.

4. Discussion

The purpose of this study was to examine the validity and reliability of the mobile app *Lap Tracker Auto-timer* for the measurement of agility performance. Our results showed that the app provided valid and reproducible data when compared with the photocells. The data obtained during the validity assessment process reflected a very large correlation ($r = .92$, $p < .001$) between the times obtained with both devices (Hopkins et al., 2009). Previous research have suggested that when seeking to replace an existing measurement instrument on the other, due to easy handling or lower costs, the correlation index must be greater than 0.8 (Lamprea and Gómez-Restrepo 2007), as was the case of this study. Regarding the reliability of the app, the results obtained for the test-retest display almost perfect reliability (ICC = .93) (Koo and Li 2016), with a coefficient of variation of 0.09 and a trivial ES (0.1) for the test-retest comparison (Hopkins et al., 2009). Therefore, the aforementioned results suggested that the app provides reliable data.

To the best of our knowledge, this study is the first to observe the validity and reliability of the app *Lap Tracker Auto-timer* for testing agility performance. This app differs from others for testing physical

Considering the rise of smartphone technology for the measurement of sport performance and physical testing (Peart et al. 2017), this study provides relevant information about the accuracy of an app with a novel design. This app could be used by sport scientists, researchers, strength and conditioning coaches or even practitioners to measure performance without post-video-analysis. To optimise the use of this app and obtain more accurate data, we recommend: i) using a tripod, ii) the height of the device (iPhone, iPad or iPod) should be between 80 cm and 1 m (to ensure the mobile camera captures the area from the hip to the chest) and iii) the space where the trigger point is very sensitive to movement and therefore must be free of elements.

There are several limitations to this study that must be discussed. First, the sample size was small. Future studies involving larger samples are needed. Another limitation of this study was experienced during data collection. The camera is sensitive to any movement within the image frame. In this way, if the app detects movement, the timer starts its account, so it is necessary to limit this image frame as much as possible. Furthermore, *Lap Tracker Auto-timer* can be used for some other tests that measure speed/agility as 5-0-5, Illinois (Sheppard & Young, 2006), Arrowhead, 5-10-5 and T-tests (Walker 2016), besides tests where the participants starts from a point to which they must return to finish it.

In conclusion, our findings suggest that the app *Lap Tracker Auto-timer* for iOS devices could be a valid, reliable and low-cost alternative to measure speed/agility in the 4 x 10 m test. In particular, we identified empirical validation that the *Lap Tracker Auto-timer* offers an acceptable remotely assess speed/agility as a complementary tool to traditional methods in the fitness and sports settings.

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