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Research article

A Self-Paced Intermittent Protocol on a Non-Motorised Treadmill: A Reliable Alternative to Assessing Team-Sport Running Performance

Paul J. Tofari [1]✉, Blake D. McLean [1,2], Justin Kemp [1] and Stuart Cormack [1]
[1] School of Exercise Science, Australian Catholic University, Melbourne, Australia
[2] Sport Science Department, Collingwood Football Club, Melbourne, Australia

Abstract
This study assessed the reliability of a 'self-paced' 30-min, team-sport running protocol on a Woodway Curve 3.0 non-motorised treadmill (NMT). Ten male team-sport athletes (20.3 ± 1.2 y, 74.4 ± 9.7 kg, VO_{2peak} 57.1 ± 4.5 ml·kg^{-1}·min^{-1}) attended five sessions (VO_{2peak} testing + familiarisation; four reliability trials). The 30-min protocol consisted of three identical 10-min activity blocks, with visual and audible commands directing locomotor activity; however, actual speeds were self-selected by participants. Reliability of variables was estimated using typical error ± 90% confidence limits expressed as a percentage [coefficient of variation (CV)] and intraclass correlation coefficient. The smallest worthwhile change (SWC) was calculated as 0.2 × between participant standard deviation. Peak/mean speed and distance variables assessed across the 30-min protocol exhibited a CV < 5%, and < 6% for each 10-min activity block. All power variables exhibited a CV < 7.5%, except walking (CV 8.3-10.1%). The most reliable variables were maximum and mean sprint speed (CV < 2%). All variables produced a CV% greater than the SWC. A self-paced, team-sport running protocol performed on a NMT produces reliable speed/distance and power data. Importantly, a single familiarisation session allowed for adequate test-retest reliability. The self-paced design provides an ecologically-valid alternative to externally-paced team-sport running simulations.

Key words: Exercise test, athletic performance, running, reproducibility of results.

Introduction

Running performance in team sports has been shown to influence overall team success (Gabbett et al., 2013; Manzi et al., 2014; Mooney et al., 2011). The activity profile within team sports consists of periods of high intensity running, interspersed with lower intensity activity and/or complete rest (Brewer et al., 2010). Therefore, the physiological determinants of team-sport running performance differ somewhat from traditional endurance exercise. As an alternative to more traditional endurance tests, a number of high-intensity intermittent performance tests have been developed to assess running performance specific to team sports (Bangsbo et al., 2008). While these tests provide greater specificity when testing team-sport athletes, most do not incorporate the wide range of locomotor activities experienced in team-sport competition (i.e., walking to sprinting). Furthermore, the majority of current high-intensity, intermittent running performance tests are externally paced (e.g. shuttle speeds guided by sound, running speeds guided by visual feedback), whereas locomotor speeds during team-sport competition are determined by the individual athlete, dependent on game situations. The use of non-motorised treadmills (NMT) (Lakomy, 1987) has allowed for the development of simulated team-sport running protocols that mimic team-sport running (i.e., rapid speed changes) in a controlled environment in which different performance variables (e.g., speed, distance, power) can be systematically measured (Highton et al., 2012). Assessing the reliability of these protocols is an important consideration for researchers and practitioners in determining the smallest practically important change that may be detected following training interventions (Pyne, 2003; Sirotic and Coutts, 2008). Original NMT models (e.g., Woodway Force, Woodway, USA) require runners to wear a tether belt around the waist and be anchored behind, allowing them to overcome the inertia of the treadmill belt to perform locomotor activities. Recently, a curved NMT has been manufactured (Woodway Curve 3.0., Woodway, USA) allowing participants to complete locomotor tasks without being anchored via a waist tether. Additionally, the curved NMT has shown good reliability and validity during short duration (30 s) sprint testing (Gonzalez et al., 2013; Mangine et al., 2014). While this technology provides a promising tool to assess team-sport specific running performance, the reliability of these measures collected on a Woodway Curve 3.0 NMT has not been reported. To date, all published, treadmill-based team-sport running simulation protocols (Sirotic And Coutts, 2007; 2008) use externally-paced movement velocities (e.g., percentage of maximal sprinting speed), or a very small portion of self-selected velocity (2.7% of total activity) (Aldous et al., 2014), in order to assess team-sport specific running performance. As the self-paced nature of team-sports may have a significant impact on movement strategies adopted throughout a game (Aughey, 2010), internally paced performance tests may provide a more ecologically valid assessment tool than externally paced alternatives. Although some partial or completely self-paced, field-based team-sport running tests exist (Ali et al., 2013; Williams et al., 2010), these do not allow for the detailed measurement of variables such as power output. Therefore, the purpose of this study was to assess the reliability of a self-paced team-sport running protocol on the Woodway Curve 3.0 NMT. A secondary purpose was to assess the number of familiarisation sessions needed to produce reliable data.

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Methods

Ten amateur team-sport athletes (20.3±1.2 y, 74.4±9.7 kg, VO_{2peak} 57.1±4.5 ml·kg^{-1}·min^{-1}) were recruited to participate in this study. All participants were required to have an aerobic capacity (VO_{2peak}) ≥ 50 ml·kg^{-1}·min^{-1} (tested during the initial laboratory visit) and be currently competing or training in team sports [e.g., soccer, Australian football, rugby, field hockey] at least three times per week. Participants were required to attend five testing sessions, involving an initial pre-test and familiarisation session, followed by four team-sport running simulations (trials 1-4), each separated by one week. Prior to each laboratory visit, participants completed a 48-h food diary and were asked to refrain from any strenuous physical activity preceding the testing day. Participants were asked to follow the same diet (as recorded in initial food diary) and exercise routine for 48-h prior to subsequent laboratory visits. Laboratory conditions were constant (21.4 ± 0.7 °C; 44.6 ± 2.9% relative humidity) and each individual was tested at the same time of day to limit diurnal fluctuations in performance.

Non-motorised treadmill model

The treadmill used in the present study was a curved, non-motorised design (Woodway Curve 3.0, Woodway, USA). Unlike previous NMTs, the curved design allows for untethered running (Sirotic and Coutts, 2008). The static incline of the treadmill surface was set at 140 mm and 90 mm (distance from floor to the frame of the NMT) for the front and rear feet, respectively, per manufacturer specifications. The Curve 3.0 contains four load cells (on the left and right side at the front and rear of the treadmill belt) that measure vertical ground reaction force at 200 Hz, while treadmill belt speed is measured via photomicrosensors (Omron EE-SX670, Omron Corporation, Osaka, Japan) mounted on the running drum shaft. All data are collected and analysed through the manufacturer's software (Pacer Performance System, Innervations, Australia). The aforementioned software package calculates horizontal force using the formula: horizontal force = acceleration * (body mass * belt friction), and power output was calculated via the product of horizontal force and horizontal displacement. Data were then exported to Microsoft Excel for detailed analysis of specific speed zones.

Protocol Development

Previous NMT-based team-sport running simulations have been developed to replicate time-motion profiles of a number of team sports (e.g., soccer, rugby league, rugby union, Australian football) (Sirotic and Coutts, 2007). These protocols achieve the desired activity profiles by prescribing running speeds based on percentage of maximal sprinting speed, requiring participants to match these speeds via visual feedback cues (Sirotic and Coutts, 2007; 2008).

In contrast, the protocol in the current study used visual and audible commands to direct participant locomotor speed (i.e., 'Stand Still', 'Walk', 'Jog', 'Run', 'Sprint'), however, actual locomotor speeds were self-selected. Before commencing the protocol, participants were asked to follow visual and audible commands (as above) and were instructed that during 'run' periods they should be performing a 'hard run, as if attempting to reach the next contest within a game' and to 'sprint maximally' during 'sprint' periods. This initial guidance was provided to assist participants in differentiating between the discrete speed categories. During the sprint periods, standardised verbal encouragement was provided by the investigator. No other encouragement or feedback was provided. Our performance protocol was designed to achieve mean running velocities above the Australian football game mean (~125 m·min^{-1}) (Wisbey et al., 2011), with the goal of creating significant physiological stress. Figure 1 shows a 10-min portion of the team-sport running protocol, which was repeated three times during each trial to form a 30-min performance test. Table 1 defines the time spent in each speed category for a 10-min block. Each 10-min block was made up of 8 min of simulated 'on-field' activity and a 2-min period of low activity, to mimic an Australian football interchange when the player is removed from the field of play. During these low activity periods, participants were permitted to consume water ad libitum. This duration of on-field activity and interchange period is typical of current Australian football practices (Coutts et al., 2010). The three identical 10-min blocks allow for the assessment of changes during specific time points of the activity. Furthermore, the 30-min duration of the performance test (approximately a quarter of an Australian football match, typically 4 x 30-min quarters) was deemed appropriate to assess changes in team-sport specific running performance, and has been utilised for a previous team-sport running protocol (Sirotic and Coutts, 2008).

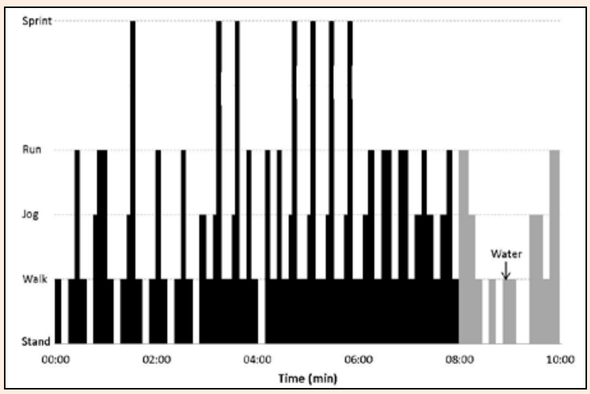

Figure 1. A ten-minute portion of the self-paced match-simulation protocol. This 10-min period was repeated three times to make up the complete 30-min protocol. Participants self-selected their chosen running speeds. The area highlighted in grey depicts a period of 'low' activity, simulating a rest period (interchange) common in Australian Football. Participants were permitted to consume water during this period.

Testing sessions

Visit 1 (pre-testing and familiarisation): Upon reporting to the laboratory, all participants underwent a standardised warm up, which involved 3 min of self-selected submaximal running on a NMT (Woodway Curve 3.0, Woodway, USA) before completing a sequence of dynamic stretches of the major muscle groups of the lower limbs. Participants then completed an incremental motorised-treadmill (Pulsar 3p, HP Cosmos, Nussdorf-Traunstein, Germany) run to exhaustion while being monitored via open-circuit spirometry (TrueOne 2400, Parvo Medics, Utah, USA) for assessment of VO_{2peak}. The incremental test involved two 3-min stages at 8 and 12 km·h^{-1} with a grade of 0%. Thereafter, speed was increased by 1 km·h^{-1} every min to 18 km·h^{-1}, at which point speed remained constant and grade was increased by 2% every minute until volitional exhaustion. After completing the run to exhaustion, participants rested for ~10 min before returning to the NMT to complete an initial familiarisation of the 30-min team-sport running simulation

Visits 2-5 (reliability trials 1-4): Before completing trials 1-4, participants underwent the same standardised warm up as described above before performing a 3-min portion of the team-sport simulation, which included one sub-maximal sprint. Participants then rested for 5 min, towel dried and obtained body mass (PW-200KGL, A&D Weighing, Kensington, Australia) wearing shorts only, before commencing the 30-min team-sport running simulation.

Data analysis

All variables were log transformed to reduce bias because of non-uniformity of error, and analysis was performed using a custom spreadsheet (Hopkins, 2011). Data were separated into locomotor zones for analysis of reliability, as defined by the speed commands described earlier, with designated standing periods removed from analysis. The inter-trial (e.g., Trial 1 v Trial 2) reliability of mean speed, mean/total distance and mean power output in all speed zones was estimated using the intra-class correlation coefficient and typical error ± 90% confidence limits (CL) expressed as a percentage [coefficient of variation (CV)]. The smallest worthwhile change (SWC), defined as the smallest change of practical importance, was calculated as 0.2 × the between participant standard deviation (SD). Variables were considered capable of detecting the SWC if CV% ≤ SWC (Pyne, 2003). Reliability was also calculated for total, maximum, and mean distance, speed, and power output per zone, and between 10-min blocks.

Results

Tables 1 and 2 display mean ±SD, SWC, CV% ± 90% CL, and percentage change in mean for distance and speed covered across each trial (Trials 1-4) and separated for 10-min blocks, respectively. All variables produced a CV% greater than the SWC.

Speed and distance reliability

The most reliable variables were maximum speed and mean sprint speed for the entire trial (CV 1.8% and 1.9%, respectively). The least reliable of all variables was the inter-trial jogging distance/mean speed of Block 3 (CV 5.7%). The range of CV% for all variables between trials 2-1 was 1.8 to 6.8%, similar to trials 3-2 (CV 1.8 to 4.9%) and 4-3 (CV 2.1 to 5.7%).

Power reliability

Overall, mean power output during sprint periods was the most reliable power measure (CV 2.7%). Mean and between block power output during walking were the least reliable measures (range CV 8.3 – 10.1%). All other power output variables displayed a CV% < 7.5% (Table 3).

Discussion

To our knowledge, this is the first study to assess the reliability of entirely self-paced team-sport running, incorporating a spectrum of running intensities, on a Woodway Curve 3.0 NMT. Previous treadmill-based team-sport running protocols utilise external pacing, by asking participants to achieve a prescribed percentage of maximal sprinting speed (Aldous et al., 2014; Nedelec et al., 2013; Sirotic and Coutts, 2008) or a speed relating to a percentage of VO_{2max} (Nicholas et al., 2000). Some externally-paced team-sport running simulations have been performed on motorised treadmills and, thus, are limited by the maximal speed of the treadmill (generally 25 km·h^{-1}) and the inability for the treadmill to change speed quickly (Drust et al., 2000; Greig et al., 2006). The use of NMTs allows for more rapid speed changes and a maximal speed limited only by the athlete's ability. For this reason, research using NMTs has gained popularity to better emulate team-sport running (Aldous et al., 2014; Nedelec et al., 2014; Oliver et al., 2007; Sirotic, 2008). Previous investigations have shown good reliability for distance covered in all speed bands (CV ~2-5%) (Aldous et al., 2014; Sirotic, 2008) during NMT team-sport running protocols. However, all speeds were externally paced; therefore, good reliability for distance covered is not unexpected. In the present work with a self-paced running protocol, we report similar reliability for the distance variables (see table 3, mean CV < 6%), highlighting the ability for athletes to repeatedly 'self-select' a consistent locomotor pace based on simple instruction. A recent study which incorporated periods of variable running distance (i.e., self-paced) during a soccer-specific NMT simulation (Aldous et al., 2014) reported better reliability (CV 1.4%) in comparison to the 'running' periods of our study (mean CV 4.4%). However, the variable running distance accounted for only 2.7% of the entire protocol, while the entire team-sport running simulation in the present study was self-paced.

Although previous research using team-sport running simulation protocols on a NMT recommends a minimum of two familiarisation sessions (Aldous et al., 2014; Nedelec et al., 2013; Sirotic, 2008), our data indicate that participants were familiarised following trial 1, with CV < 5% across all speed/distance variables (Table 2) between trials 1 and 2. Mean CV% for maximal and mean sprint speed, potentially the most difficult movement speed to complete on the NMT, was the lowest for any variable measured (CV 1.8% and 1.9%, respectively). This compares well with other externally paced team-sport running simulations performed on a NMT, which present maximal sprinting speed reliability of CV ~1.3% (Sirotic, 2008), and CV 4.5% (Aldous et al., 2014).

Table 1. The speed commands (W = walk, St = stand, R = run, J = jog, Sp = sprint) and time spent (s) in each speed band for a ten-minute portion of the self-paced team-sport running simulation. This 10-min period was repeated three times, comprising the complete 30-min protocol.

W	St	W	R	W	St	J	R	W	St	W	J	Sp	W	St	W	R	W	St	W	R	W	St	J	W	J	Sp	W	J	Sp	W	R	W	St	R	W	R	W
8	8	8	6	8	8	4	12	8	8	8	4	6	8	8	8	6	8	8	8	6	8	8	8	8	4	6	12	4	6	8	6	8	8	6	8	6	8
J	Sp	W	J	Sp	W	J	Sp	W	J	Sp	W	J	R	W	R	W	R	W	J	R	J	W	J	R	W	R	J	W	St	W	St	W	St	J	W	R	
4	6	12	4	6	12	4	6	12	4	6	12	6	8	8	12	8	12	8	8	6	8	8	8	6	8	12	8	8	8	8	8	16	16	16	8	12	

Table 2. Reliability of distance (and speeds) across team-sport simulation trials and activity blocks within trials.

	Trial 1	Trial 2	Trial 3	Trial 4	Mean Distance (m)	Mean Speed (m·s^{-1})	CV [(%) 90 CL] 2-1	CV [(%) 90 CL] 3-2	CV [(%) 90 CL] 4-3	Mean CV (%)	Avg. % Change in Mean	Avg. SWC (%)	Avg. ICC [(%) 90 CL]
	Sprint Distance (m)												
Block 1	249 ± 14	251 ± 13	258 ± 17	260 ± 15	254 ± 15	6.1 ± 0.4	3.2 (2.3-5.3)	2.5 (1.8-4.2)	2.8 (2.0-5.6)	2.8 (2.3-3.8)	0.30	1.2	0.81 (0.62-0.93)
Block 2	247 ± 13	253 ± 11	258 ± 16	259 ± 17	254 ± 15	6.1 ± 0.3	1.8 (1.3-2.9)	2.4 (1.8-4.0)	2.1 (1.5-3.5)	2.1 (1.7-2.9)	0.36	1.2	0.90 (0.78-0.96)
Block 3	245 ± 14	249 ± 16	255 ± 17	258 ± 15	252 ± 16	6.0 ± 0.4	3.8 (2.8-6.3)	2.1 (1.5-3.4)	2.4 (1.7-3.9)	2.8 (2.3-3.8)	0.31	1.2	0.83 (0.66-0.94)
	Running Distance (m)												
Block 1	401 ± 60	384 ± 58	382 ± 66	386 ± 66	388 ± 63	3.3 ± 0.5	3.1 (2.2-5.1)	4.7 (3.4-7.8)	4.3 (3.1-7.1)	4.1 (3.2-5.5)	-0.10	3.3	0.95 (0.89-0.98)
Block 2	387 ± 53	371 ± 66	372 ± 60	373 ± 67	376 ± 64	3.2 ± 0.5	6.1 (4.4-10.3)	5.8 (4.2-9.7)	5.7 (4.1-9.6)	5.9 (4.7-8.0)	-0.09	3.5	0.91 (0.80-0.97)
Block 3	371 ± 57	354 ± 64	364 ± 56	367 ± 58	364 ± 59	3.1 ± 0.5	6.8 (4.9-11.5)	5.9 (4.3-9.9)	3.7 (2.7-6.2)	5.6 (4.5-7.7)	-0.03	3.5	0.91 (0.81-0.97)
	Jogging Distance (m)												
Block 1	236 ± 27	233 ± 29	237 ± 28	230 ± 25	234 ± 28	2.5 ± 0.3	3.5 (2.6-5.9)	5.1 (3.7-8.5)	4.8 (3.5-8.0)	4.5 (3.6-6.1)	-0.08	2.4	0.89 (0.76-0.96)
Block 2	228 ± 24	226 ± 31	230 ± 27	225 ± 24	227 ± 28	2.4 ± 0.3	4.4 (3.2-7.4)	4.3 (3.1-7.2)	5.1 (3.7-8.5)	4.6 (3.7-6.3)	-0.05	2.5	0.89 (0.76-0.96)
Block 3	223 ± 34	220 ± 35	224 ± 30	220 ± 22	222 ± 29	2.4 ± 0.3	5.0 (3.6-8.4)	6.6 (4.8-11.1)	5.4 (3.9-9.0)	5.7 (4.6-7.8)	-0.02	2.9	0.87 (0.73-0.95)
	Walk Distance (m)												
Block 1	462 ± 49	449 ± 53	443 ± 53	435 ± 54	448 ± 54	1.7 ± 0.2	5.7 (4.1-9.5)	3.5 (2.6-5.9)	2.9 (2.1-4.8)	4.2 (3.4-5.7)	-0.19	2.5	0.91 (0.80-0.97)
Block 2	444 ± 56	429 ± 57	427 ± 54	411 ± 50	428 ± 54	1.6 ± 0.2	4.2 (3.0-6.9)	3.2 (2.4-5.4)	3.2 (2.3-5.3)	3.6 (2.8-4.8)	-0.21	2.8	0.95 (0.88-0.98)
Block 3	422 ± 53	403 ± 59	409 ± 60	401 ± 62	409 ± 60	1.6 ± 0.2	5.8 (4.2-9.7)	5.2 (3.8-8.8)	4.6 (3.3-7.7)	5.2 (4.2-7.1)	-0.14	3.2	0.91 (0.80-0.97)

Data presented are mean ± SD for all variables, CV (90% CL) for both distance and speed, average percent change in mean, average SWC, and average ICC (90% CL). Also presented are mean ± SD speeds for each block. CV: coefficient of variation; CL: confidence limit; SWC: smallest worthwhile change; ICC: intraclass correlation coefficient.

Furthermore, the reliability obtained in a specific repeat sprint test ranged from CV 0.8 to 1.5% (Spencer et al., 2006), which also compares well to the present work.

All speed/distance variables assessed in this study demonstrated high reliability, exhibiting CVs < 6%. All power output variables, except walking, returned CVs <7.5%. However, all CV% were greater than the SWC, and therefore were not capable of detecting the SWC. Our analysis also shows high reliability for total distance (CV 2.7%). In comparison, a 60-min self-paced test on a motorised treadmill with trained runners presented similar reliability for total distance (CV 2.7%) (Schabort et al., 1998). Similarly, trained female cyclists performing a 60-min cycle-ergometer test demonstrated a CV of 2.7% for mean power output across the whole test (Bishop, 1997). As speed is not generally measured during ergometer cycling, power output in this instance provides a surrogate for speed, as the two are very closely related in a controlled environment (Pugh, 1974). Importantly, these two comparative studies did not require changes in speed as demanded in the present study. This indicates that, even with changes in speed during a self-paced team-sport running simulation protocol, athletes are able to consistently repeat their performance across testing sessions.

The CV for mean power output (2.7%) across the 6-s sprints within the team-sport running protocol was the most reliable power measure, while peak power output, and mean running/jogging and peak sprint power were all similar (CV ~6%). Previous research assessing peak power reliability on an NMT has reported CVs of 7.9% (Oliver et al., 2007) and 9.0% (Sirotic and Coutts, 2008). However, the latter study analysed sprinting reliability via a separate peak sprint test, while the former, as in the present study, assessed sprinting reliability throughout the entire protocol. The CV%, coupled with the SWC, can be used to estimate sample sizes required for prospective studies using the equation proposed by Hopkins: (Hopkins, 2000) $N \approx 8 \times CV^2/d^2$ where d = SWC. For example, to detect a SWC of 2% in total sprint distance requires a sample size of 23, while peak power output (SWC = 2.27%) would require 60 participants. Previous research using an externally paced protocol on an NMT (Oliver et al., 2007) calculated required sample sizes of 13 and 56 for the above variables, respectively, using the same methods.

The intraclass correlation coefficient (ICC), (see tables 2 and 3), was high (greater than 0.8) at all speeds and distances. This is similar to externally paced team-sport running simulations on a flat NMT (Aldous et al., 2014; Sirotic and Coutts, 2008). Power output displayed lower ICCs (0.37 to 0.76) compared to other NMT literature (Gonzalez et al., 2013; Sirotic and Coutts, 2008). However, as previously mentioned, these studies assessed reliability from sprinting in isolation, not during a long intermittent team-sport simulation. Furthermore, these lower ICCs may be a reflection of the homogeneity of the participant group rather than error in the measurement (Weir, 2005).

This curved NMT belt differs from the flat belt, tethered version in previous team-sport running simulations (Woodway Force, Woodway, USA) (Aldous et al., 2014; Nedelec et al., 2013; Sirotic and Coutts, 2008), and may alter running ergonomics when compared to overground running. However, to date, no research has assessed potential changes in running ergonomics on the Woodway Curve 3.0 NMT. A further limitation to the current protocol is the lack of team-sport specific actions (i.e., jumping, changing direction, kicking, etc.) (Magalhães et al., 2010; Nedelec et al., 2014).

Conclusion

This work shows that a team-sport running simulation protocol that is entirely self-paced presents reliability similar to that of externally-paced team-sport running similar to that of externally-paced team-sport running simulations. Moreover, with as little as one familiarisation session on the Woodway Curve NMT, team-sport athletes can reliably reproduce self-selected distances/speeds across a range of locomotor commands. Given the self-paced nature of the protocol in the present study, this and similar self-paced curved NMT protocols may provide a more ecologically valid, laboratory-based performance test than externally-paced alternatives. However, as the CV% exceeds the SWC, small but meaningful changes may not be detected with this test. As a result, practitioners should ensure changes exceed the CV% to declare a meaningful change.

Table 3. Reliability of mean power output across team-sport simulation trials and activity blocks within trials.

	Trial 1	Trial 2	Trial 3	Trial 4	Mean Power (W)	CV [(%) 90 CL] 2-1	3-2	4-3	Mean CV%	Avg. % Change in Mean	Avg. SWC (%)	Avg. ICC [(%) 90 CL]
	Mean Sprint Power (W)											
Block 1	297 ± 18	301 ± 20	296 ± 23	303 ± 14	299 ± 19	3.6 (2.6-6.0)	5.9 (4.3-9.9)	5.4 (3.9-9.1)	5.1 (4.1-6.9)	0.15	1.33	0.76 (0.61-1.02)
Block 2	290 ± 16	289 ± 24	288 ±17	291 ±17	290 ±19	4.7 (3.4-7.8)	4.6 (3.3-7.7)	4.6 (3.4-7.7)	4.6 (3.7-6.3)	0.06	1.33	0.69 (0.56-0.94)
Block 3	285 ±17	278 ±15	2865 ± 14	288 ± 24	284 ±18	4.3 (3.2-7.3)	4.8 (3.5-8.0)	3.2 (2.3-5.3)	4.2 (3.3-5.7)	0.22	1.29	0.64 (0.52-0.87)
	Mean Running Power (W)											
Block 1	146 ± 25	137 ± 23	133 ± 24	133 ± 24	137 ± 24	4.4 (3.2-7.3)	4.9 (3.5-8.1)	9.0 (6.5-15.2)	6.4 (5.1-8.7)	-0.21	3.61	0.37 (0.30-0.50)
Block 2	139 ± 21	133 ±26	128 ± 25	128 ± 25	132 ±24	7.1 (5.2-12.0)	7.2 (5.2-12.1)	7.1 (5.2-12.0)	7.1 (5.7-9.8)	-0.17	4.02	0.38 (0.30-0.51)
Block 3	133 ±24	125 ±26	125 ± 24	126 ±23	127 ± 24	7.5 (5.4-12.7)	7.4 (5.4-12.5)	5.1 (3.7-8.5)	6.8 (5.4-9.2)	-0.10	4.15	0.35 (0.28-0.47)
	Mean Jogging Power (W)											
Block 1	112 ±17	111 ±17	116 ± 18	110 ±14	112 ±17	4.6 (3.3-7.7)	6.4 (4.6-10.8)	8.0 (5.7-13.4)	6.5 (5.2-8.8)	-0.06	3.08	0.44 (0.35-0.59)
Block 2	109 ±14	111 ±19	112 ± 17	110 ±17	111 ±17	5.7 (4.1-9.5)	5.6 (4.0-9.4)	7.2 (5.2-12.1)	6.2 (4.9-8.4)	0.02	3.23	0.40 (0.32-0.54)
Block 3	107 ±18	109 ±20	110 ± 18	108 ±15	108 ±18	6.8 (4.9-11.5)	8.3 (6.0-14.1)	6.5 (4.7-10.9)	7.3 (5.8-9.9)	0.03	3.59	0.42 (0.34-0.57)
	Mean Walk Power (W)											
Block 1	41 ± 7	40 ± 7	40 ± 7	39 ± 6	40 ± 7	5.9 (4.3-9.8)	10.5 (7.5-17.8)	10.0 (7.2-17.0)	9.0 (7.2-2.3)	-0.12	3.80	0.49 (0.40-0.67)
Block 2	40 ± 7	39 ± 7	38 ± 6	37 ± 5	39 ± 6	5.4 (3.9-9.0)	10.6 (7.6-18.0)	10.9 (7.8-18.5)	9.3 (7.4-12.7)	-0.16	3.50	0.55 (0.44-0.74)
Block 3	38 ± 6	37 ± 7	36 ± 6	37 ± 6	37 ± 6	5.4 (3.9-9.1)	12.3 (8.8-21.0)	11.3 (8.1-19.3)	10.1 (8.0-13.8)	-0.08	3.83	0.55 (0.44-0.74)

Data presented are mean ± SD for all variables, CV (90% CL) for both distance and speed, average percent change in mean, average SWC, and average ICC (90% CL). CV: coefficient of variation; CL: confidence limit; SWC: smallest worthwhile change; ICC: intraclass correlation coefficient.

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Key points

- Self-paced team-sport running protocols on a curved NMT that closely match the locomotor demands of competition deliver reliable test-retest measures of speed, distance and power.
- Such protocols may be sensitive to changes in running profile following an intervention that may not be detectable during externally-paced protocols.
- One familiarisation session is adequate to ensure test-retest reliability.

AUTHORS BIOGRAPHY

Paul TOFARI
Employment
School of Exercise Science. Australian Catholic University, Melbourne, Australia.
Degree
BExSc (Hons)
Research interests
Exercise physiology, team sport, fatigue
E-mail: Ptofari@gmail.com

Blake MCLEAN
Employment
High Performance Department. Collingwood Football Club, Melbourne, Australia.
Degree
BExSc (Hons), MSc
Research interests
Exercise physiology, team sport, fatigue
E-mail: blake.d.mclean@gmail.com

Justin KEMP
Employment
School of Exercise Science. Australian Catholic University, Melbourne, Australia.
Degree
PhD
Research interests
Applied sports performance, nutritional ergogenics and muscle physiology
E-mail: Justin.Kemp@acu.edu.au

Stuart CORMACK
Employment
School of Exercise Science. Australian Catholic University, Melbourne, Australia.
Degree
PhD
Research interests
Athlete preparation, fatigue
E-mail: Stuart.Cormack@acu.edu.au

✉ **Paul Tofari**
Australian Catholic University, Locked Bag 4115, Fitzroy, MDC, Victoria, Australia, 3165