

YoYo App white paper

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Summary

The YoYo App is a native iPhone, Apple Watch, Android and web implementation of the Yo-Yo Intermittent Recovery Test Level 1, built by Stacksy. It runs the published protocol exactly, times every beep on the device's audio clock so a 28-minute test does not drift, and adds the things a tester needs on the day: a roster of athletes, one-tap warnings and drop-outs, and results with an estimated $\text{VO}_{2\text{max}}$ that copy straight into a spreadsheet.

This paper explains where the test comes from and what it measures, why hockey and the International Hockey Federation (FIH) use it, why a recording is a weak reference for a timed test, how the app keeps time, and how it is designed to be used. It also documents our measurement of the widely used 2016 reference video, which we found to run one second slow over the full test while the app matches the protocol exactly.

The Yo-Yo Intermittent Recovery Test

The Yo-Yo Intermittent Recovery Test was developed by the Danish physiologist Jens Bangsbo and first described in 1994 in *Fitness Training in Football: A Scientific Approach*. It adapts the 20 m shuttle run of Léger and Lambert by inserting a 10-second active recovery after every 2×20 m shuttle, so that the test resembles the stop-start pattern of team sports rather than the continuous running of a distance race ([Bangsbo, Iaia and Krstrup, 2008](#)).

Level 1 of the test starts at 10 km/h and increases the speed in steps, from level 5 to level 23 at 19 km/h, over 91 shuttles and 3,640 m. An athlete runs 20 m to a line, turns on the beep, runs back, and then walks or jogs for 10 seconds before the next shuttle. The first time the athlete fails to reach the line on the beep is a warning; the second failure ends the test, and the result is the distance covered.

What it measures is the ability to perform repeated bouts of intense exercise and to recover between them. In the validation study, heart rate and blood and muscle measurements showed that Level 1 drives the aerobic system to its maximum while also taxing the anaerobic system, and the test proved highly reproducible from one occasion to the next ([Krstrup et al., 2003](#)). The distance covered correlates with the amount of high-intensity running an athlete does in a match, and the higher the level of competition,

the further athletes run in the test. A rough estimate of maximal oxygen uptake can be derived from the distance: $VO_2\text{max (ml/kg/min)} \approx \text{distance (m)} \times 0.0084 + 36.4$ ([Bangsbo, Iaia and Krstrup, 2008](#)).

The reasons it spread far beyond football are practical. It needs only a 20 m strip, cones and an audio track; a whole squad can be tested at once; and it takes under half an hour.

Why hockey and the FIH use it

Hockey is an intermittent sport: short sprints, turns and recoveries for 60 minutes, for umpires as much as players. The International Hockey Federation makes the Yo-Yo Intermittent Recovery Test Level 1 one of the two fitness tests every international umpire must pass, chosen, in its words, because the tests "aim to mirror the conditions during matches as much as possible" ([FIH, Guidelines for Fitness of Umpires, October 2025](#)).

FIH requirement	Detail
Standard, women, all panels	1,120 m (level 16.1)
Standard, men, all panels	1,720 m (level 17.8)
Frequency, outdoor umpires	Three times a year: March, July, November
Paired test	Repeated Sprint Ability, 6 × 40 m (6.8 s women, 6.4 s men), timed by Stack's RSA Test app
Evidence	The test is video recorded with a witness and retained for six months
Scoring	The level of the last complete successful shuttle; a second infraction ends the test

The same guidelines define the infractions a witness must call: starting before the beep, failing to reach the 20 m line or return to the 0 m line before the beep, turning without touching the line, and not coming to a complete stop before the next shuttle. The first infraction is a warning; the second ends the test. National associations and clubs apply the same test to players, and it is used across football, rugby, basketball and the other intermittent sports, which is why norms exist for most levels of competition ([Bangsbo, Iaia and Krstrup, 2008](#)).

An umpire's international appointments depend on this result three times a year. That is the standard the timing has to meet.

The problem with a recording as the reference

The test is defined by a formula, but in practice it is administered from an audio recording. The FIH's Guidelines for Fitness of Umpires instruct umpires to "use the following YouTube version of the Yo-Yo Intermittent Recovery Test" and give one link: a video titled "yo yo Intermittent+recovery+test+Lvel1", uploaded on 21 January 2016 by a personal channel that is not operated by the FIH or any federation, with no description or provenance ([YouTube, xoRUOmm6XZY](#); [FIH, October 2025](#)). A test that decides whether an umpire is appointed to an international match deserves a better-defined clock than a nine-year-old upload the federation does not control.

Recordings carry timing errors that formulas do not. The audio clock of the device that made a recording, and the resampling a video goes through when it is produced and uploaded, each introduce small speed errors. They are far too small to hear on one shuttle but they accumulate over a 28-minute test.

We measured the 2016 video beep by beep. All 273 beeps were located by computer and grouped into the 91 shuttles by their 10-second recoveries, and the result was compared with the protocol shuttle by shuttle.

	2016 reference video	Protocol (and the YoYo App)
First start beep to last end beep	1,715.6 s	1,714.6 s
Mean recovery	10.006 s	10.000 s
Shuttle times, every level	0.003 to 0.011 s longer than the protocol	formula

The video follows the same speed table at every level, and every recovery is 10 seconds, but the whole recording plays 0.06 % slower than real time. The gap grows evenly, 0.1 s by shuttle 10, 0.5 s by shuttle 50, and 1.0 s by the last shuttle. That is the signature of playback speed rather than a different protocol, and it is the discrepancy a tester notices late in the test when the app and the video run side by side. The app's beeps are computed from the protocol and placed on a hardware clock, so its error over the same span is in the thousandths of a second. Our full measurement is available on request.

How the app keeps time

The YoYo App does not play a recording. It computes the test from the protocol and plays each beep at the computed instant.

One clock. When the tester starts the test, the app records a single start time. Every shuttle start, turn and finish is a fixed number of seconds after that instant, computed from the table: $\text{speed} = \text{level} \times 0.5 + 7.5 \text{ km/h}$, 40 m per shuttle, 10 s recovery. Nothing is timed relative to the previous beep, so there is nothing to accumulate. Pausing simply freezes the clock and resuming restarts it from the same point.

Beeps on the audio hardware. Each tone is handed to the device's audio system a fraction of a second early with an exact play time, and the audio hardware plays it at that time. The same mechanism keeps music in tune, and it is accurate to a fraction of a millisecond. The screen animates from the same clock, so what the tester sees and what the athletes hear never disagree.

The same engine everywhere. The timing engine exists three times, in Swift for iPhone and Apple Watch, in Kotlin for Android, and in JavaScript for the web, and each copy is locked to the same table by automated tests that check the first ten and last five shuttle times against independently computed values. On the Apple Watch the engine runs locally from the phone's start time, so the wrist taps are computed on the watch rather than relayed over Bluetooth.

Announcements as a tester would call them. At each new level the app says the level, the number of shuttles and the first shuttle code, for example "Level 12 · 3 shuttles · 12 point 1"; within a level it says just the code. At the end it says "The Yo-yo test is complete. Well done."

The result is a test whose timing is the protocol itself, on any device, with no dependence on a recording, a cable or a particular speaker.

How the app is designed to be used

The app is built around the way a test is actually run: one tester, a phone or tablet on the bench, a speaker, and a line of athletes.

Set up. On the home screen the tester chooses where to start (the full protocol from level 5, or a later level for a warm squad, with distance credited for the skipped shuttles), the lead-in of 10, 20 or 60 seconds, and whether voice calls and countdown ticks are on. Athletes are added by name and the roster is kept for next time.

Ready to go. Tapping *Ready to go* arms the test. The screen says READY, the athletes stand on the start line, and one tap on the field starts the lead-in. From then on the app runs the protocol to the end without further input.

Athletes and warnings. During the test each athlete has a tile. The tester taps a tile once when the athlete commits an infraction and it turns amber with a warning; a second tap records the athlete as out, with the last complete shuttle and the distance at that moment. This is the FIH's warning-then-out rule applied to each athlete individually, which

is what a witness has to do with a clipboard today. Undo reverses the last tap. The test ends by itself when every athlete is out, or when the tester stops it. With no roster, the app runs the timer alone and a single Warning button counts a lone runner's misses.

Results. At the end the app shows the final level, distance, an estimated VO_2max and duration for the group and for each athlete, marks who dropped out after a warning, and copies the whole table in a spreadsheet-ready form or shares it. Every test is kept in a history on the device. Nothing is sent anywhere; there is no account and no server.

Apple Watch. With the watch app open, the watch mirrors the phone's clock and taps the wearer's wrist at every start, turn and finish beep, records heart rate through the test as a Health workout, and captures recovery heart rate one minute after the finish. A runner feels the cue even when the speaker is 40 m away in the wind.

Helping athletes without making the test easier

A recording gives an athlete one thing: a beep. The YoYo App gives two more, and both are optional, because neither changes the protocol.

Countdown ticks. Three soft ticks sound at 3, 2 and 1 seconds before every shuttle start. An athlete standing at the line after the 10-second recovery knows exactly when the next run begins instead of tensing up guessing. The start beep itself is unchanged and lands at exactly the same instant it would in the recording; the ticks only forewarn it. They can be switched off for a test that must sound identical to the recording.

The visual field. The screen shows the shuttle as it runs: a green bar shrinking from left to right on the way out, a red bar growing on the way back, the shuttle code in large type, and a countdown between shuttles with the next level and speed. An athlete who can see the screen knows whether they are ahead of or behind the pace mid-shuttle and can adjust, rather than finding out at the line. With the phone on a tablet stand by the start line, or the app on an iPad or a laptop browser, the whole line can see it. Turn the screen away, or run the test from a watch or a speaker only, and the test is purely audio.

The philosophy is deliberate. The test is a test, and the speeds, the distances, the recoveries and the warning rule are exactly the protocol's. But the point of the test is to measure an athlete's capacity, not their ability to guess when a beep is coming, and an athlete who paces each shuttle well produces the truer number. The app removes the guesswork and leaves the physiology alone.

Availability

The app and its documentation live at yoyo.hockey, which also carries the support page and the privacy policy.

Platform	Where	Notes
iPhone and iPad	App Store: YoYo App	iOS 17 or later; free
Apple Watch	Included with the iPhone app	watchOS 10 or later; haptics and heart rate
Android	Google Play Store: YoYo App	Android 8.0 or higher
Any browser	yoyo.hockey/app	Runs offline once loaded; can be added to a home screen

The app is free, has no account, no advertising and no analytics, and keeps rosters and results only on the device. Heart rate is read from Apple Health on the watch and never leaves the wearer's own devices.

About Stacksy

The YoYo App is developed by [Stacksy](#), a software studio in Perth, Western Australia, that builds products for hockey and for the people who run it. Alongside this YoYo App, Stacksy makes [WhistleIQ](#), a platform for umpire and official appointments and development, and the Hockey Shootout App, which runs penalty shoot-outs to the rules. The same approach runs through all of them: take the rule or the protocol exactly as written, and build the tool around the way officials and coaches actually work on the day.

Questions about the app or this paper: contact@stacksy.com.au.

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