Indoor cycling trainer for measuring and improving cyclist sports performance

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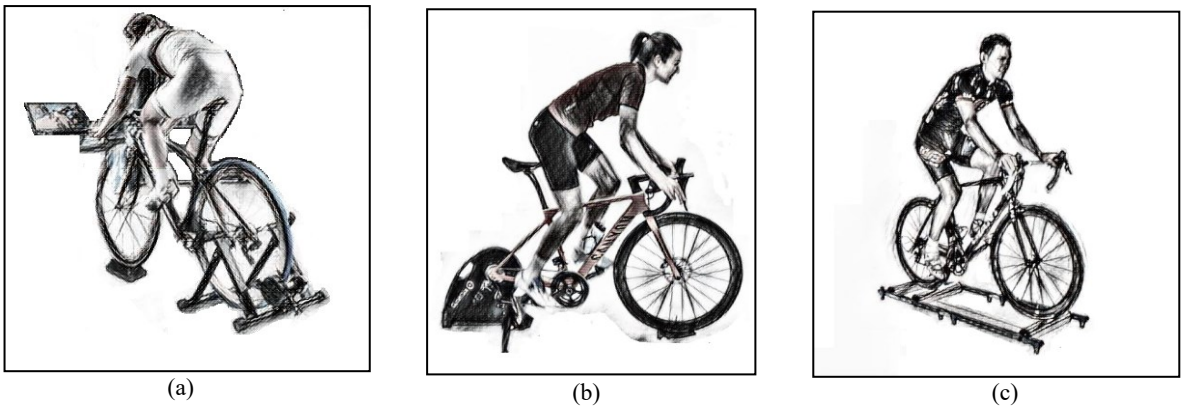
Abstract: The indoor trainer has been use by many either to maintain stamina during the winter or to prepare for professional tournament. The usage of indoor trainer shouldn't be limited for maintaining stamina and winter training. The purpose of this study is to investigate what is the method conduct by recent studies that utilized indoor trainer as a research tools. This study also covers different types of indoor trainer available and types of additional sensor available. The study learns that in order to conduct research in any contextual studies the suitable setting is either fixed time trial or control group methods; and the favorable indoor trainer tools are fluid and direct drive trainer.

1. Introduction

Indoor cycling trainer is a combination of using an indoor cycling setup paring with multiple sensors. Depends on its purpose the sensor may allowed user to monitor information such as speed, cadence, elevation of training and many more depends on the type of turbo trainer. There are few type of indoor trainer: basic turbo trainer or smart and interactive trainer. This study will investigate recent studies research method and overview types of trainer, selection of additional sensor and how does it contribute to research studies from preceding studies.

2. Indoor Trainer Concept

Indoor trainer is also known as turbo trainer; it is actually utilizing a real set of bicycle attach to a trainer mount. It is use as an alternative for winter training in order to maintain stamina and provide a comparative indoor training. The usage of turbo trainer increases muscle activities comparing the usage of treadmill [1]. There are two ways to set up the indoor trainer: Firstly, the rear wheel of personal bicycle is mounted to the device and secondly a basic trainer like rollers trainer might not require for bicycle to be mount to the trainer. There are 4 types of conventional trainer: Magnetic trainer, Fluid Trainer, Direct Drive Trainer and Rollers trainer. See Fig. 1 to compare indoor trainer setup between magnetic and fluid trainer, Direct Drive Trainer and Rollers trainer.



(a) (b) (c)

Fig. 1. (a) Magnetic and Fluid Trainer; (b) Direct Drive Trainer; (c) Rollers Trainer

Magnetic and fluid trainer engage the bicycle rear wheel to pressed against a motor controller which either uses magnetic motor resistance or fluid Motor resistance. The bicycle axle is mounted to the frame of the trainer and clamp to secure the bicycle to the trainer [2]. It provides basic build-in resistance control with a limited resistance selection thus provides cheaper selection. This however may be upgraded into smart trainer by connecting additional sensor to the bicycle. Table 1 shows the build-in sensors comparisons provided by the basic indoor trainer. The additional sensor will be discussed in section 3 of this article.

Table 1. Indoor trainer Comparison

	Resistance control	Power Meter	Stable	Realistic	Smart Trainer Pairing
Magnetic Trainer	✓	×	✓	×	✓
Fluid Trainer	✓	×	✓	✓	✓
Direct Drive	✓	✓	✓	✓	✓
Rollers Trainer	×	×	×	×	×

Direct drive trainer is similar to magnetic and fluid trainer; bicycle need to be mounted at the rear wheel of the bicycle. Instead of mounting it to the axle, direct drive replaces the rear wheel of the bicycle. The trainer is usually motorized and equipped with smart capabilities. This provides efficient, realistic, controllable and reliable training sessions.

Last in the list is the rollers trainer. Rollers trainer is a basic trainer which does not provide and resistance but are often use to keep fit or warming up before tournament. Differ from trainer mention above, the front and rear wheel is contacted to the rollers. The training sessions required higher focus for stability control. To upgrade additional independent sensors are required.

3. External Sensors and Smart Trainer

Additional sensors are important to maximize training result. Affordable indoor trainer such as magnetic trainer or fluid trainer comes only with basic build-in resistance setting. Unlike direct drive, it provides build-in sensor and connection to computer application for monitoring and training setup. In order to upgrade the basic indoor trainer into a smart and interactive trainer, sensors with Adaptive Network Topology (ANT+) and Fitness Equipment Control (FE-C) network protocol is required. Here are several optional sensors for indoor trainer upgrade:

3.1 Cadence and Speed Sensors

Cadence sensor allows to measure energy output as rotations per minute (RPM) of the bicycle crank arm; while, the speed sensors measure the speed and distance based on the circumference of the wheel. The newer version combines both cadence and speed sensors where speed depends on the RPM generated. The information from the cadence and speed sensors are often used to calculate power generated by rider's cycling session without having to install the power meter.

3.2 Power Meter

A power meter is a sensor to measure power output generates by the rider. Power meter is important as it allows for evaluation of performance development and Training load [3]. The power is measure with watts and it is angular with torque and velocity. Power meter can be place either at the wheel hubs, the crank arms, pedals, spindle or bottom brackets of the bicycle. The best and accurate power meter output depends on location of the power meter. Fig. 2 shows location of power meter placement to the bicycle. The best placing of the power meter is the wheel hubs of the bicycle, following with bottom brackets, crank arms, pedals and finally spindle.

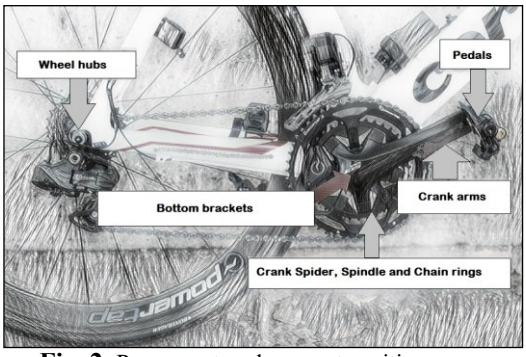


Fig. 2. Power meter placement positions

3.3 Heart Rate Monitor

Heart rate monitor device that measure physical activities There are few common styles of heart rate monitor such as chest straps and wrists band. The chest straps heart monitor provides with the most accurate heart rate reading. The information is often transmitted to fitness watch or mobile application for viewing. The mobile application for the straps provide a basic analytic information like HR max, VO_2 Max, duration of the activities, percentage of fat burned, the distance of the activities, average pace and live map location. The only disadvantage of the chest straps is, there is no display and only limited to heart rate monitoring.

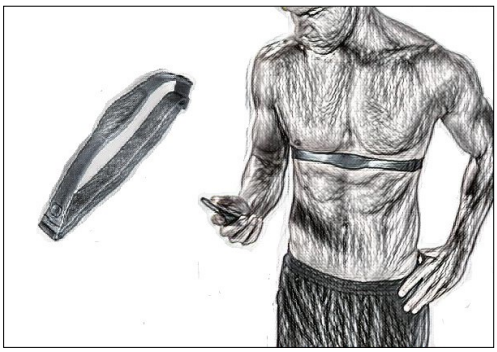


Fig. 3. Chest straps heart rate monitor

The wrist band is cheaper option that provides additional sensors such as pedometer, and sleep monitor. The mobile application isn't much different from chest band. It provides user better daily overview and comparison namely: calories burned, steps taken, deep sleep, light sleep, HR max and many more. Although the sensor is less accurate but for the purpose of creating personal records, wristband is much favorable choice. Additionally, wrist bands allow for easy setting such as type of activities with start and stop option directly from the wristband display. However, information like HR max, fat burned percentage, and pace are not available.

3.4 VO_2 Meter

VO_2 information is arguable not important in physical fitness. VO_2 information is volume of oxygen consumption of the body when physical activities are undergone. However; VO_2 information is important for understanding respiratory fitness, cardiovascular fitness and peripheral fitness. However, most of the current heart rate monitor device provide VO_2 max estimation instead of using VO_2 analyzer as shown in Figure 4.

Fig. 4. Example of portable VO2max analyzer

3.5 Smart Turbo Trainer

Smart trainer is an all-in-one cycling training software where training control and analytics information is provided in one software. Resistance and type of training is selectable for more realistic training. Analytics information are easily generated by the software. In order to use the software, all device listed above should use ANT+ and FE-C network protocol.

4. Recent Study Utilizing Turbo Trainer

The application of turbo trainer is not limited to training for sports event or maintaining stamina in the winter. More and more research utilizing the turbo trainer for research. The studies are not limited to improving tools for physical fitness but also focuses on kinematics, nutritional and sport performance improvement. Here are several type of studies and its setting for their research:

4.1 Kinematic

Dinsley et al (2012) studies the Q Factor is a pedal location [4]. In this studies, the rider was required to pedal at 90 RPM and 150 W for 3-minute, start with 5-minute warmup and separates the second body position with 3-minute rest. Data were collected from the second minute of each 3-minute trial. The two position is: first, standardized with the hands placed on top of the handlebars and second, mounted approximately 25 cm in front of the handlebars.

4.2 Nutritional

Wadley et al. studies the impact of high carbohydrate food and medium carbohydrate food to intensive training. The indoor trainer is use for performing 1-hour performance trial in all 9 days' period of intensified training for all participant. [5]. The study conclude that the carbohydrate intake does not affect intensified training.

4.3 Body Position

Study the effect of cyclist body position to the critical power output. The study compares between Break Lever Hoods (BLH) and Time Trail Position(TTP) where critical power output shows significant different in long fixed-duration trial: 3 Minute,6 minute and 12 minute [6]. The study concludes that the cycling position affects power output and critical power output.

Differ from the research above, the focus of the study is to visualize training video which shows 3 different expect of pedaling namely: force vectors, torque generation and directional deviation between torque and force vectors. For the data collection purpose the study request for riders to keep their cadence at of 90 rpm and at the same rime during the first interval they are expected to generate powers 7 times their body weight. In the second times they are expected to keep their cadence at 90 rpm but generating power as much as 10 times their body weight. Both at the duration on 30 seconds. For the final interval, it was expected for them to ride for a total of 10 seconds with maximal affords[7].

4.4 Training Effects

Heaney et al. (2018) studies the effects of intensified training toward free light chains in saliva which stresses oral health issues; it was conducted the studies with fix environment where the temperature is set at 20 ± 1 °C. In order to complete the task, the riders are required to ride all 1-hour time trial. In this study the information for external sensors are not require. The studies also conclude that intensified training affects oral health [8].

4.5 Tapering Effects

Tapering is a practice to reduce training before competition in sport that requires endurance and long distance training. Neary et al. conduct a 20km time trial research by using indoor training setup to investigate the effects of gradually reducing training volume. The 7 days' studies were divided into 3 groups where the training volume reduction: 30%, 50% and 80%. The studies conclude that the group which reduces their training volume up to 50% increase sports performance significantly on the 20k time trial[9].

5. Conclusion

Basic turbo trainer provides consistence stamina throughout rough weather and safe environment for training in major event. In order to increase productivity, it is advice for usage of additional sensor with ANT+ and FE-C network protocol. This paring allows for the usage for smart training software, where training is more realistic, resistance is predetermined and analytic information make it easier for planning. This setup also benefit for researcher as the analytic information is in real time and downloadable in CSV extension. Furthermore, based on research listed above, the only decision needed is to set up the method of the research, types of control group and types of preselected training.

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