



University of Verona,
School of Exercise and Sport Science,
Laurea magistrale in Scienze motorie preventive ed adattate
(Laurea magistrale in Scienze dello sport e della prestazione fisica)

Metodologia delle misure delle attività sportive

Wednesday 20/12/2017 8:30÷10

Luca P. Ardigò Ph.D.

SenseWear Armband in Athletic Populations

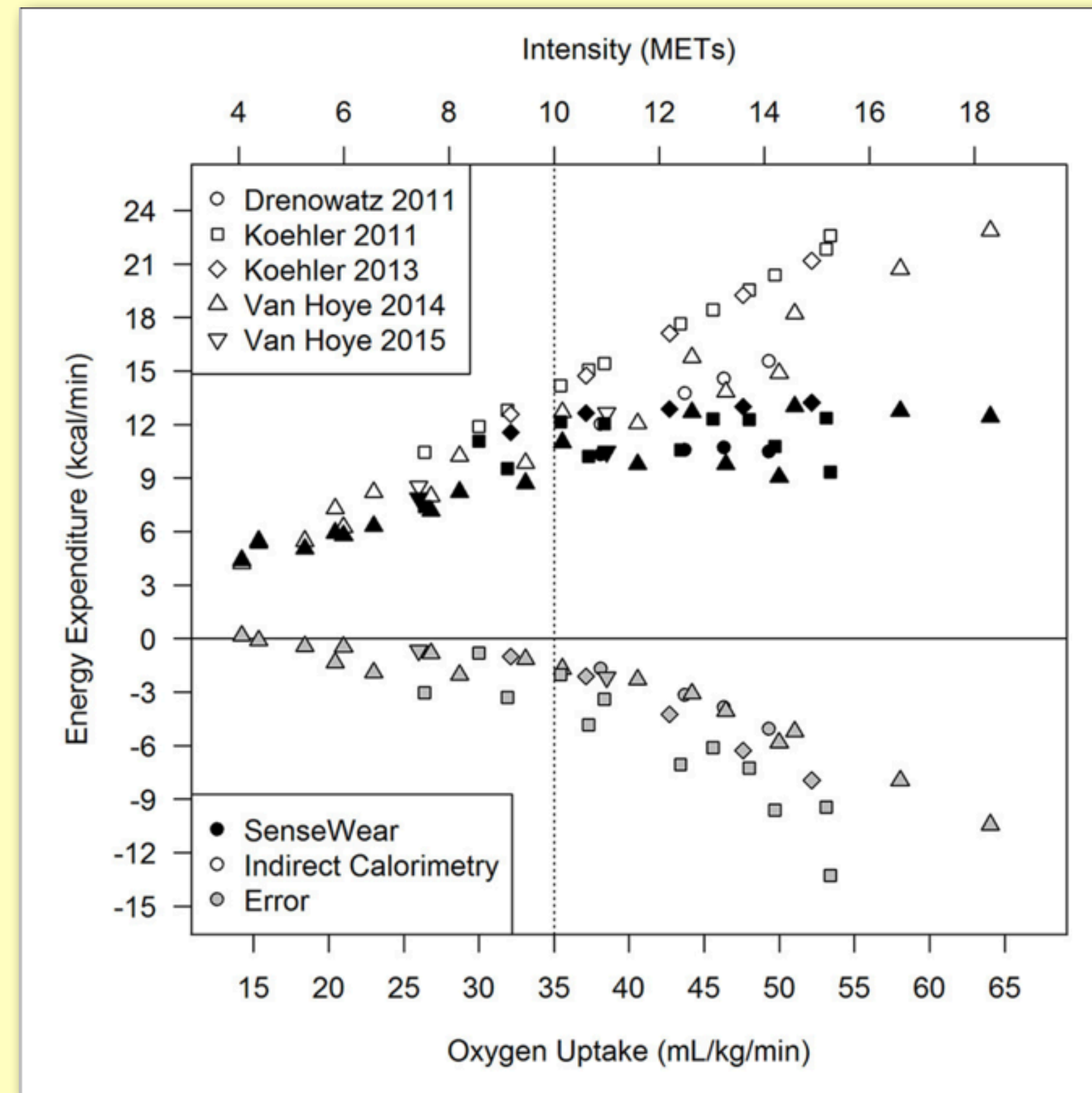


Figure 1. Custom-built platform for mounting GNSS devices and cameras on the roof rack of the car.



measures

Supej et al, 2014

Global Navigation Satellite System

measures

- 1) Smart phone: HTC Sensation HD (HTC Co., Taoyuan City, Taiwan)
- 2) Wrist watch: Garmin Forerunner 305 (Garmin International Inc., Kansas City, KS, USA)
- 3) Handheld device: Locosys Genie GT-31 (LOCOSYS Technology Inc., Taipei, Taiwan)
- 4) Professional system for testing engines and vehicles: Racelogic VBOX 20 SX (Racelogic Ltd., Buckingham, UK) with an external antenna B3G02G (Inpaq Technology Co., Ltd, Taipei, Taiwan)
- 5) High-end geodetic Leica RTK GNSS system (Leica Geosystems, Heerbrugg, Switzerland) consisting of a rover and a reference station, which had equal hardware components: RTK GNSS receivers (Leica GX1230GG), Leica survey antennae (GLONASS/GPS AX1202 GG) and Leica Sateline 3AS radio modems. The reference station was set up at the appropriate Leica tripod.

Table 1. Selected technical specifications of the GNSS devices. Legend: GNSS—Global Navigation Satellite System; GPS—Global Positioning System; GLONASS—Globalnaja Navigacionnaja Sputnikovaja System; A-GPS—Assisted GPS; SBAS—Satellite-Based Augmentation System; RTK—Real Time Kinematics.

Device	GNSS Satellites	Doppler Effect	Frequency	Processing Mode	Sampling Rate (Hz)	Receiver's Number of Channels	Latency (ms)	Antenna Type
HTC	GPS	No	L1	A-GPS	1	?	?	Internal
Garmin	GPS	No	L1	SBAS	1	12	?	Internal
Locosys	GPS	Yes	L1	SBAS	1	20	?	Internal
Racelogic	GPS	No	L1	SBAS	20	20	41.5	External
Leica	GPS + GLONASS	No	L1/L2	RTK	20	72	20	External

Figure 2. Laptop with the external analog-digital unit in the vehicle synchronously stored data from two GNSS systems and the vehicle speedometer.

measures



Figure 7. Bland Altman test of agreement between the Leica and other GNSS devices. On x axis is average speed of both compared devices; on y axis is difference in speed between both devices. The first row shows data for steady speed, the second for acceleration and the third deceleration. Full horizontal line represent the mean differences and the dash-dot line 1.96 SD (standard deviation) interval in each diagram. Note that the vertical scale change sometimes in order to improve the visibility of the diagrams.

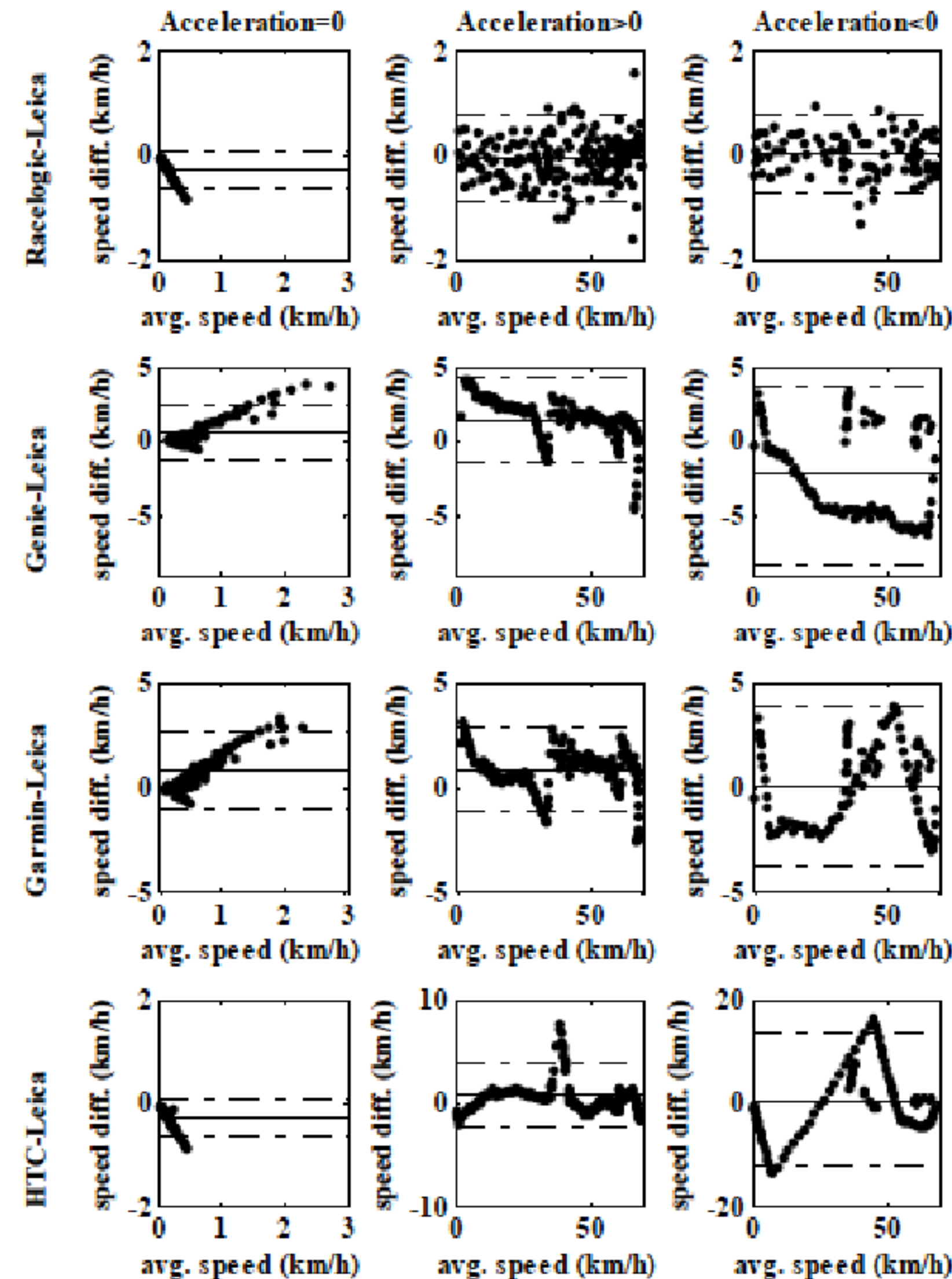
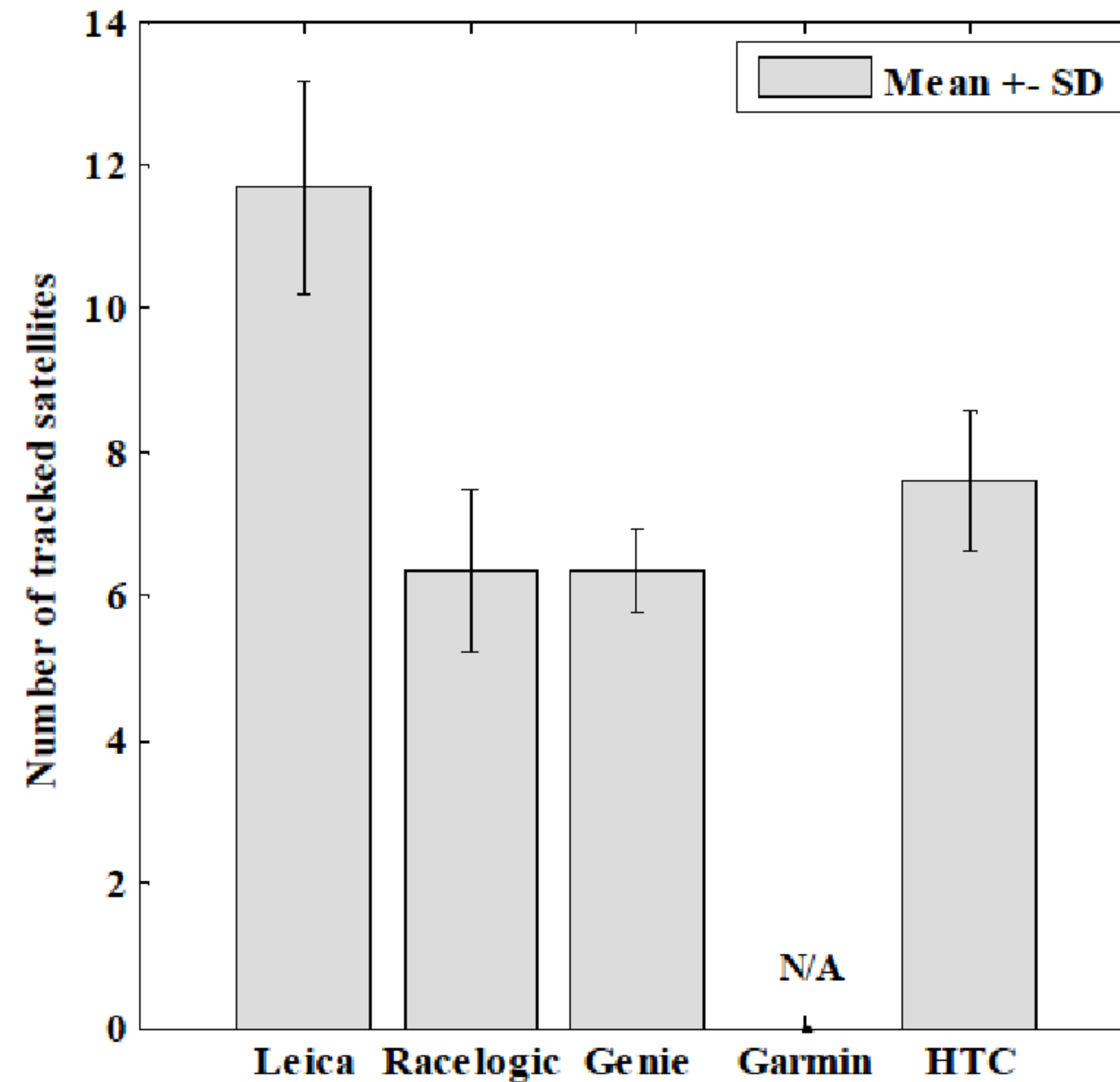


Figure 8. Mean number of tracked satellites (bars) for each GNSS device during the measurements and the corresponding standard deviations (SD) (error bars). Note that the number of tracked satellites for Garmin was not available (N/A).



Other issues

- Specially patients are aware of being measured (effect of reactivity or interference) and therefore the use of portable instruments to measure PA might prevent them to perform some activities (e.g., a device could be used during a sport but not while having a shower, this may prevent the person from doing that sport);
- multi-sensor portable devices (e.g., Zephyr BioHarness, Hidalgo equivital)



Other issues

- multi-sensor garments;

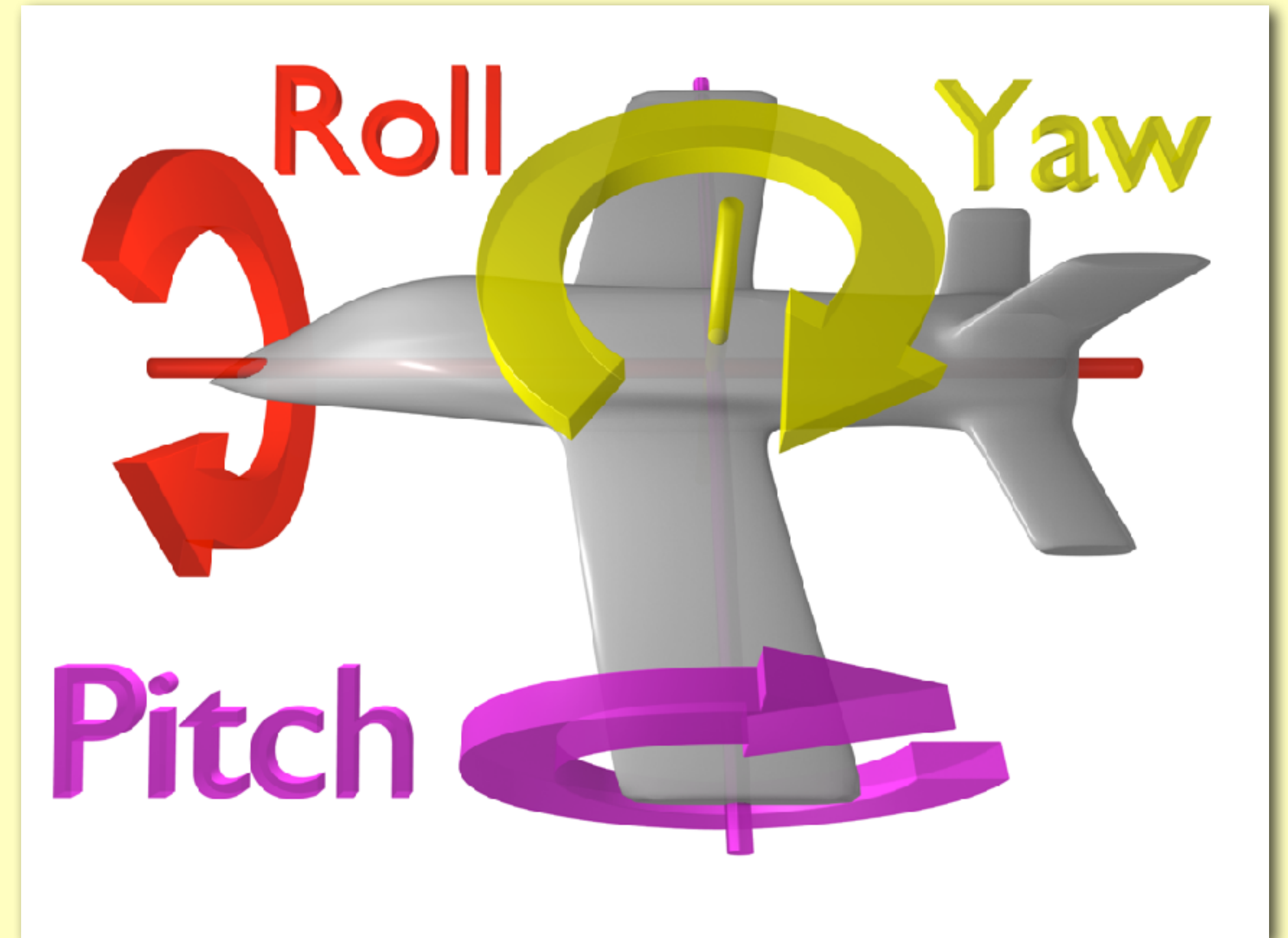


Other issues

- Inertial Measurement Units-based systems;
- IMU is an electronic device that measures and reports on a craft's (aircrafts, drones, missiles, spacecrafts, satellites, landers..., humans) speed, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. Recent developments allow for the production of IMU-enabled GPS devices. An IMU allows a GPS to work when GPS-signals are unavailable, such as in tunnels, inside buildings, or when electronic interference is present;
- data collected from the IMU's sensors allow a computer to track a craft's position, using a method known as dead reckoning;

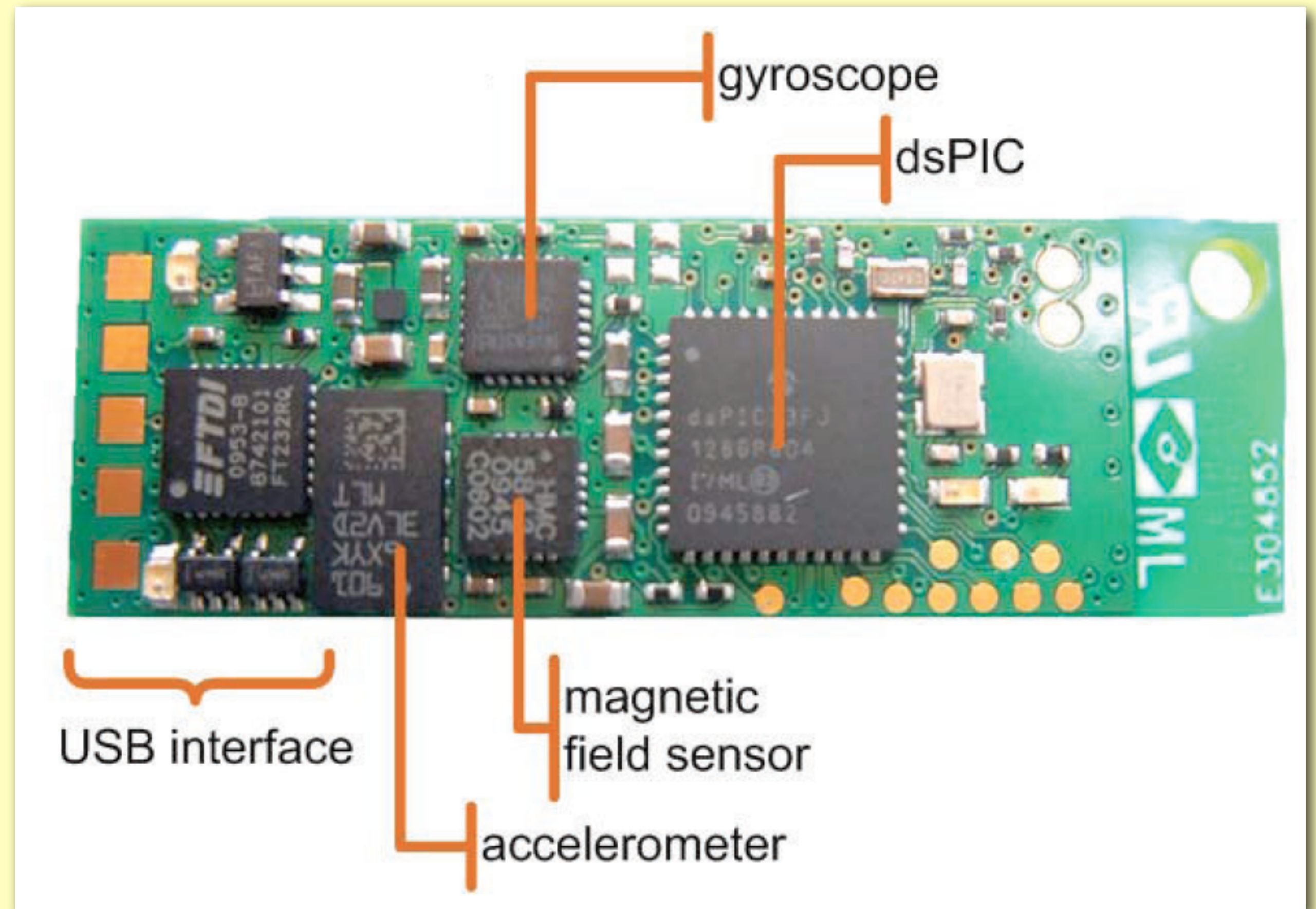
Other issues

- IMU works by detecting the current acceleration using one or more accelerometers, and detects changes in rotational attributes like pitch, roll and yaw using one or more gyroscopes. And some also include a magnetometer, mostly to assist calibrate against orientation drift;



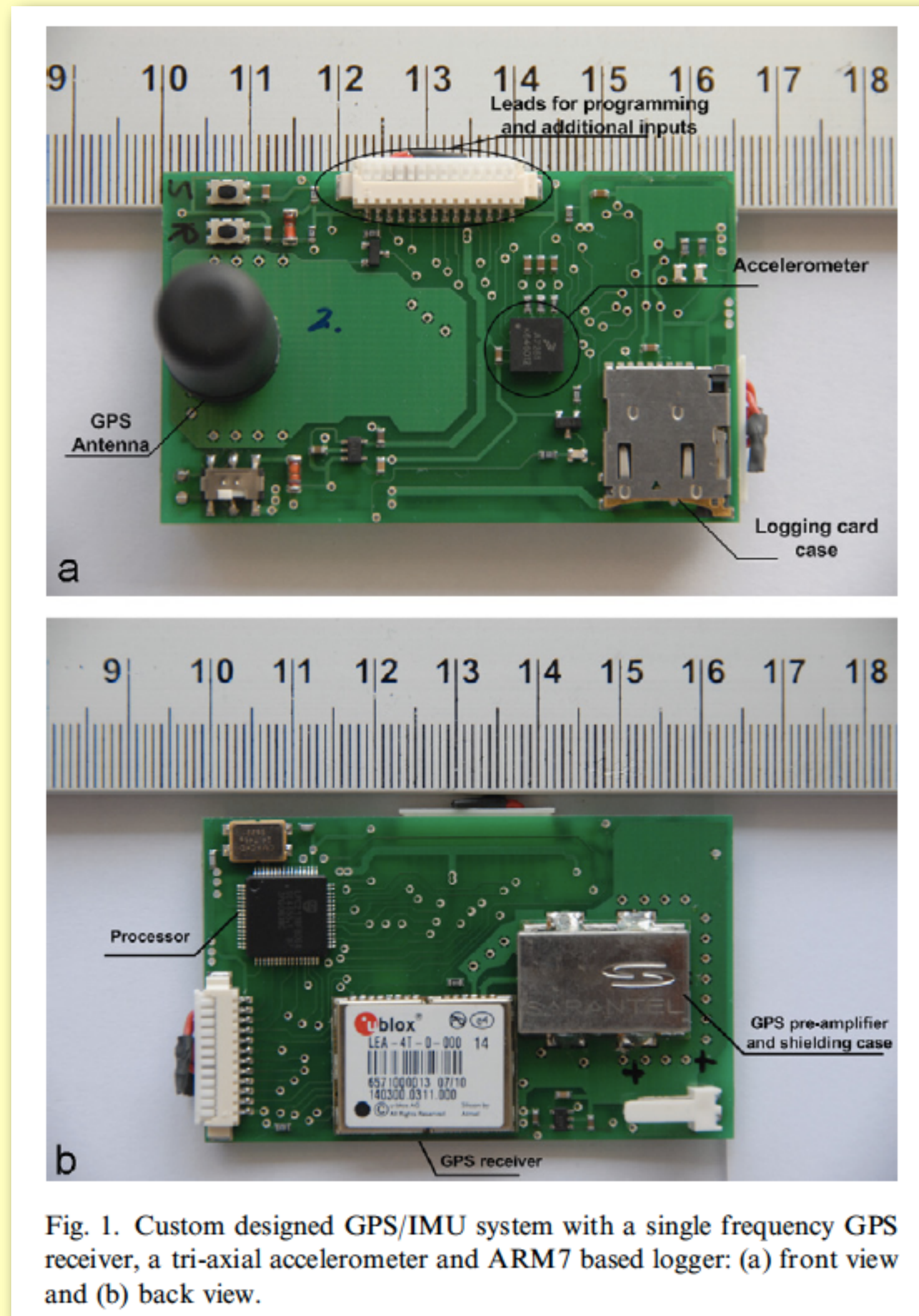
Other issues

- inertial guidance systems are now usually combined with satellite navigation systems through a digital filtering system. The inertial system provides short term data, while the satellite system corrects accumulated errors of the inertial system (an integration over time $\rightarrow$ s $\rightarrow$ s integration over time $\rightarrow$ position w/e);



Other issues

measures



Tan et al., 2008

Other issues

- IMU is often a box containing three accelerometers, three gyroscopes, optionally three magnetometers:
 - . three accelerometers are placed such that their measuring axes are orthogonal to each other. They measure acceleration;
 - . three gyroscopes are placed in a similar orthogonal pattern, measuring rotational position in reference to an arbitrarily chosen coordinate system;
 - . three magnetometers in IMUs allow better performance for dynamic orientation calculation;

Other issues



Fig. 5. Implementation of the sensor network: Three IMUs on the oars and the boat, indicated by red arrows.

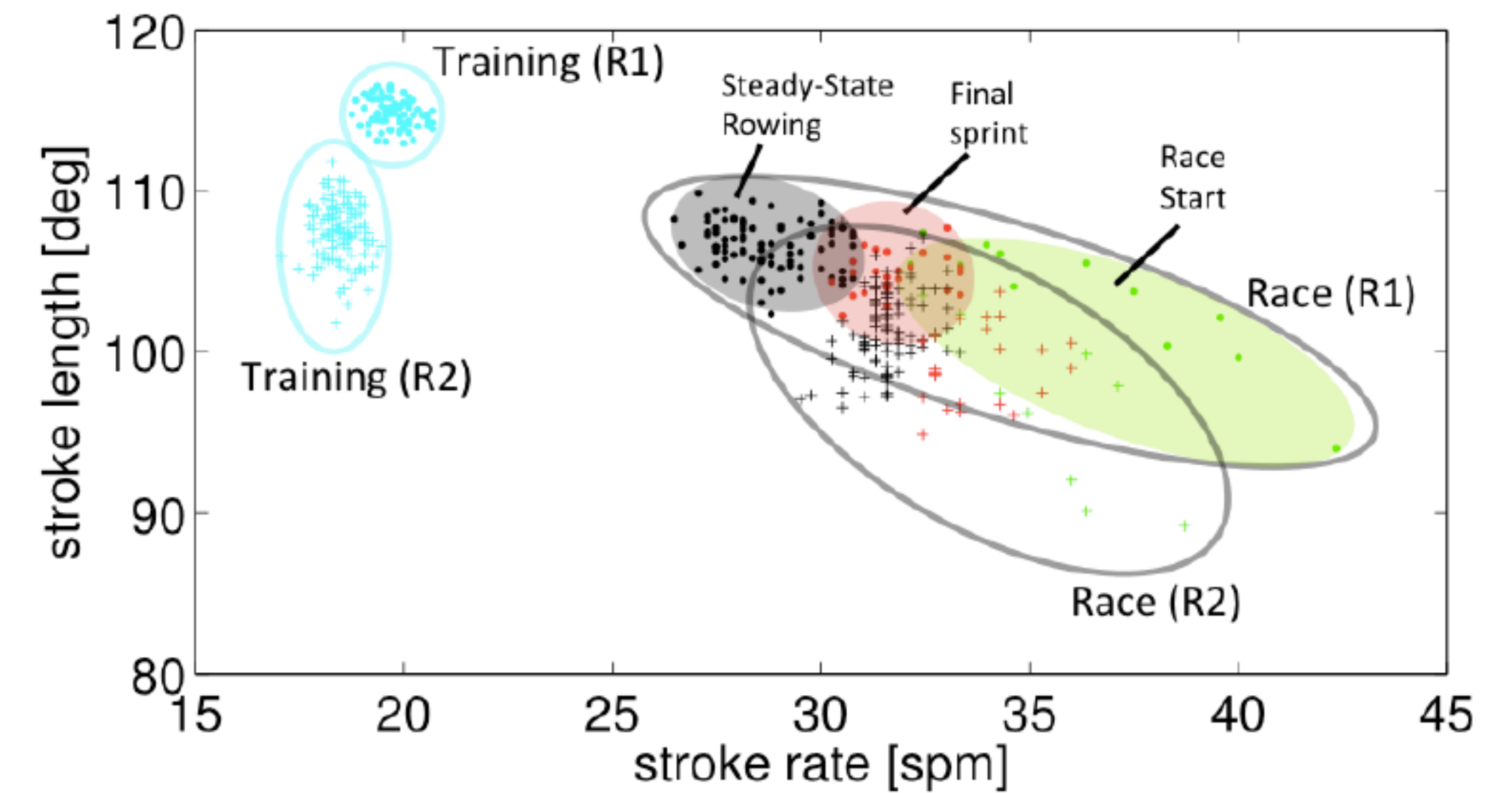


Fig. 7. Visualization of data of stroke length and stroke rate from two world-class rowers (R1 and R2) for training and racing sessions.

Other issues

measures



Other issues



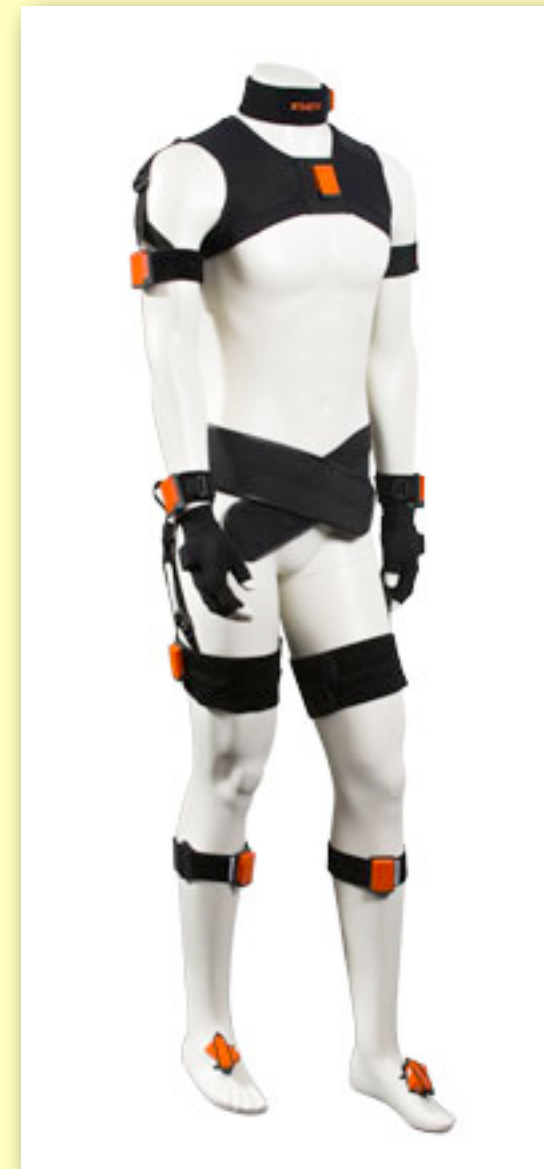
Other issues

– dead reckoning:

- . (also ded (for deduced) reckoning or DR) is the process of calculating one's current position by using a previously determined position, or fix, and advancing that position based upon known or estimated speeds over elapsed time, and course;
- . GPS receiver supports DR machine;
- . GPS receiver (e.g., parking garages, tunnels, urban canyons, forest, multipath propagation) & DR machine support each other;

Other issues

- Xsens products



Other issues

- Equinosis products



Other issues

- Wiva products



Other issues – stt products

measures

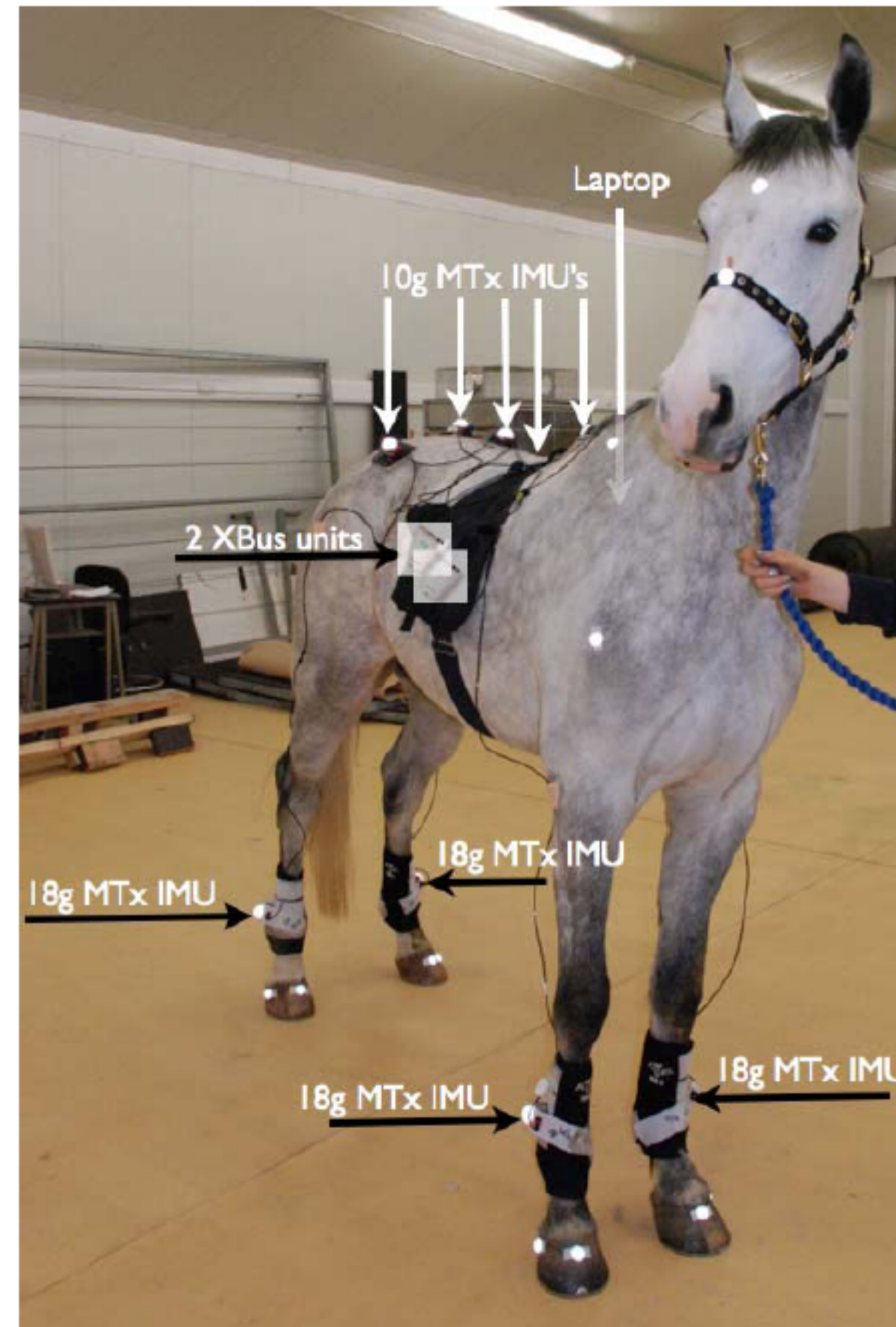


Other issues

- horse gait analysis;

measures

Figure 1. Distal limb mounted IMUs strapped onto a standard protective boot using Velcro. The IMUs are connected in series to two XBus Masters on the right side of the horse. The XBus Masters are plugged into a laptop mounted on the left side of the horse. Reflective markers are placed on the proximal dorsal and lateral hoof of each leg and on each of the IMUs.



Other issues

– horse gait
analysis;

measures



Fig. 1. Experimental setup: rider (MVN suit) and horse (acceleration sensor on the cannon bone) with the applied measurement systems: rotation axes of the riders' segments are shown as arrows: red arrows indicating Roll angles and green arrows indicating Pitch angles.

Other issues

- film industry;



Ted, 2012

Other issues

- infant trunk posture and arm movement assessment

measures

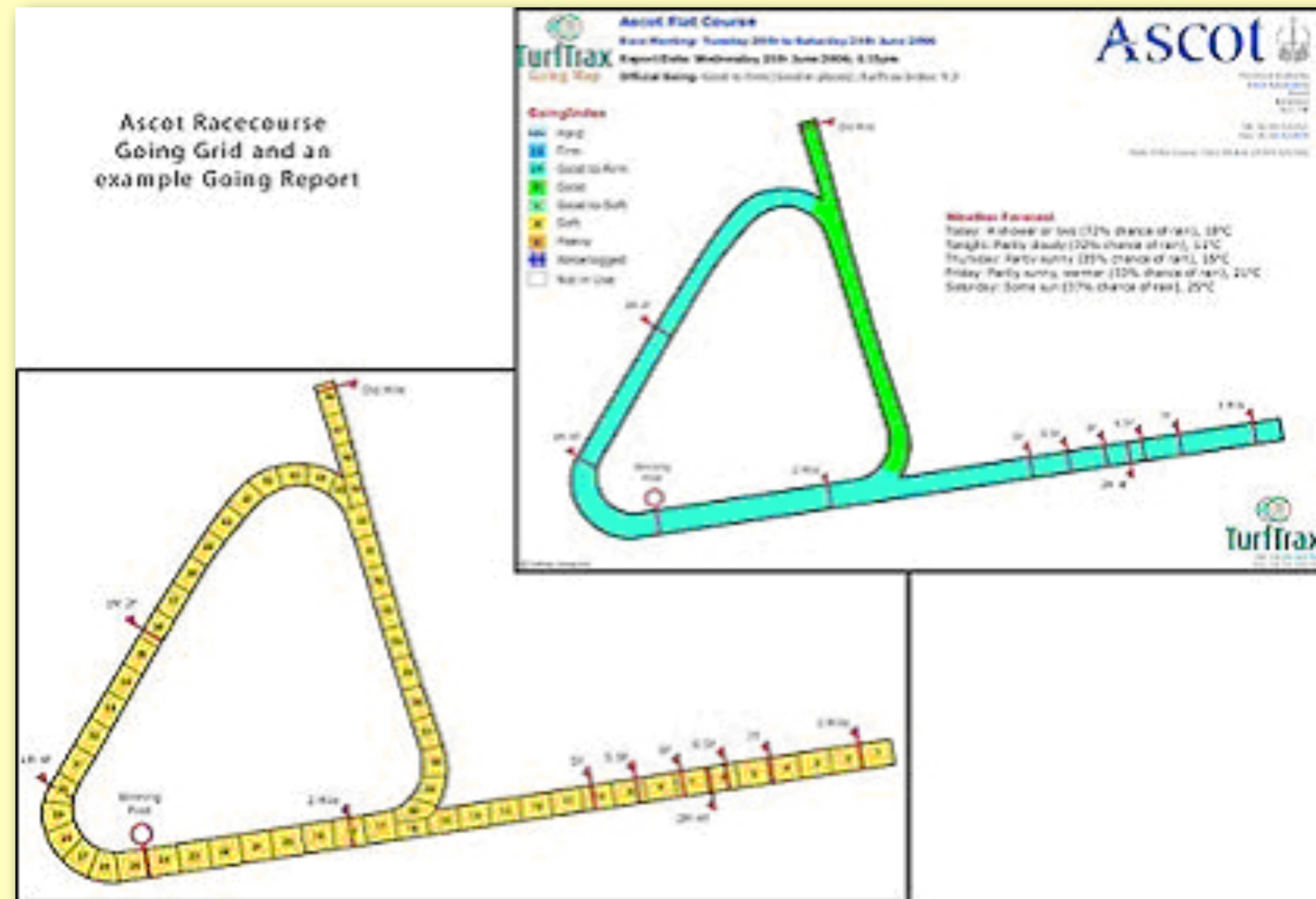


Figure 1 Experimental setup. Baby doll is positioned on top of two pressure mattresses, and equipped with five IMU bracelets (red ellipses), positioned one on baby doll's chest, one on each forearm, and one on each upper arm. Ten Optotrak markers (one on baby doll's forehead, one on each cheek, one on the frontal side of lower abdomen, one on the frontal side of each shoulder joint, one on the lateral side of each elbow joint, one on the dorsal side of each hand) serve as reference (white rectangles). Referential Optotrak and IMU coordinate system orientation is indicated in the lower right corner (white arrows).

Riharetal, 2014

Other issues

- TurfTrax wireless tracking system;



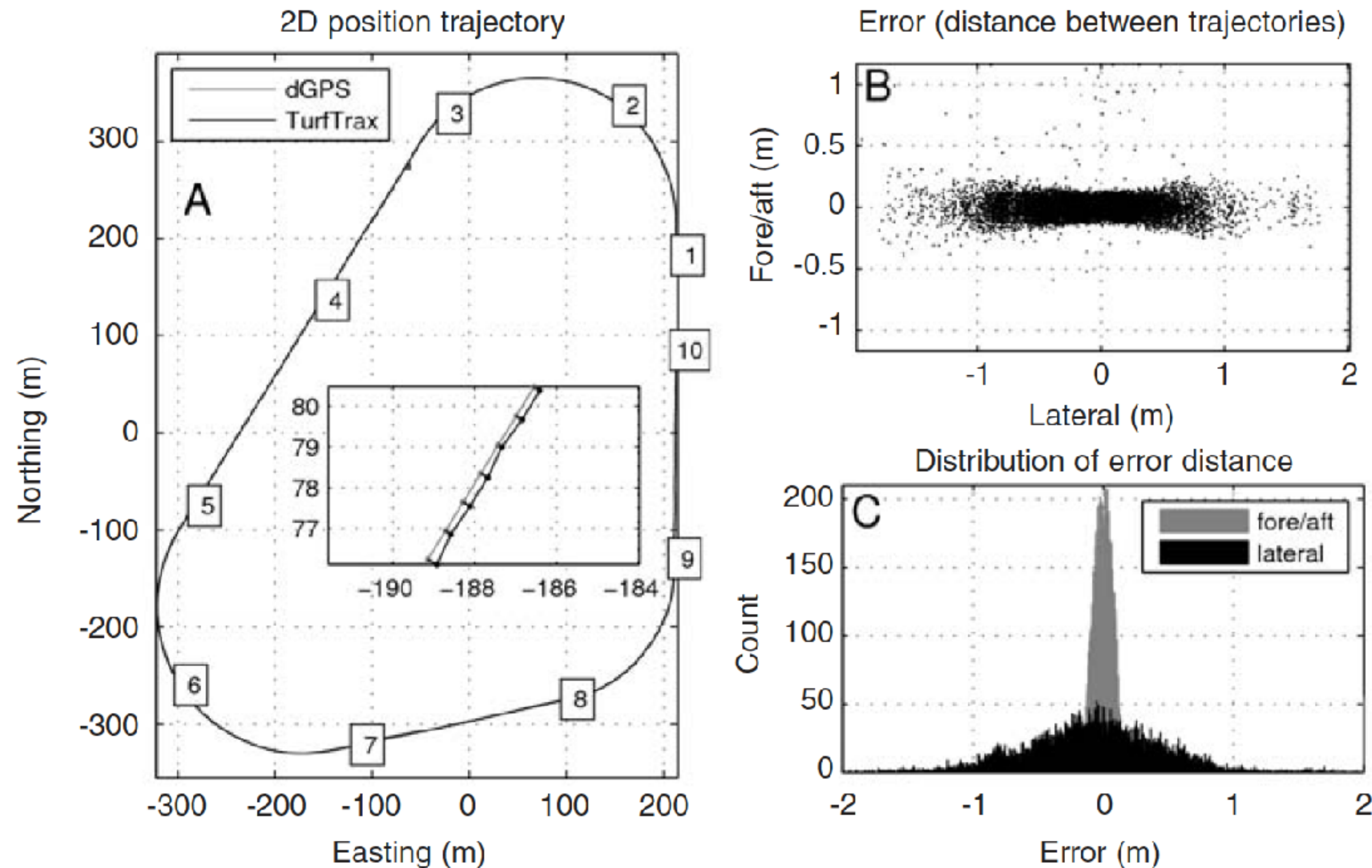


Fig 1: Comparison of position trajectories of the TurfTrax and DGPS systems. An overlay of trajectories provided by both systems for a 2 km run around Lingfield racecourse (A), the distance between the 2 trajectories at each GPS sample point (B), and the distributions of the difference between the trajectories (C). The mean $\pm$ s.d. difference between the systems was 2.2 ± 24 cm in the direction of travel and -8.9 ± 51 cm perpendicular to the direction of travel.

Other issues

measures

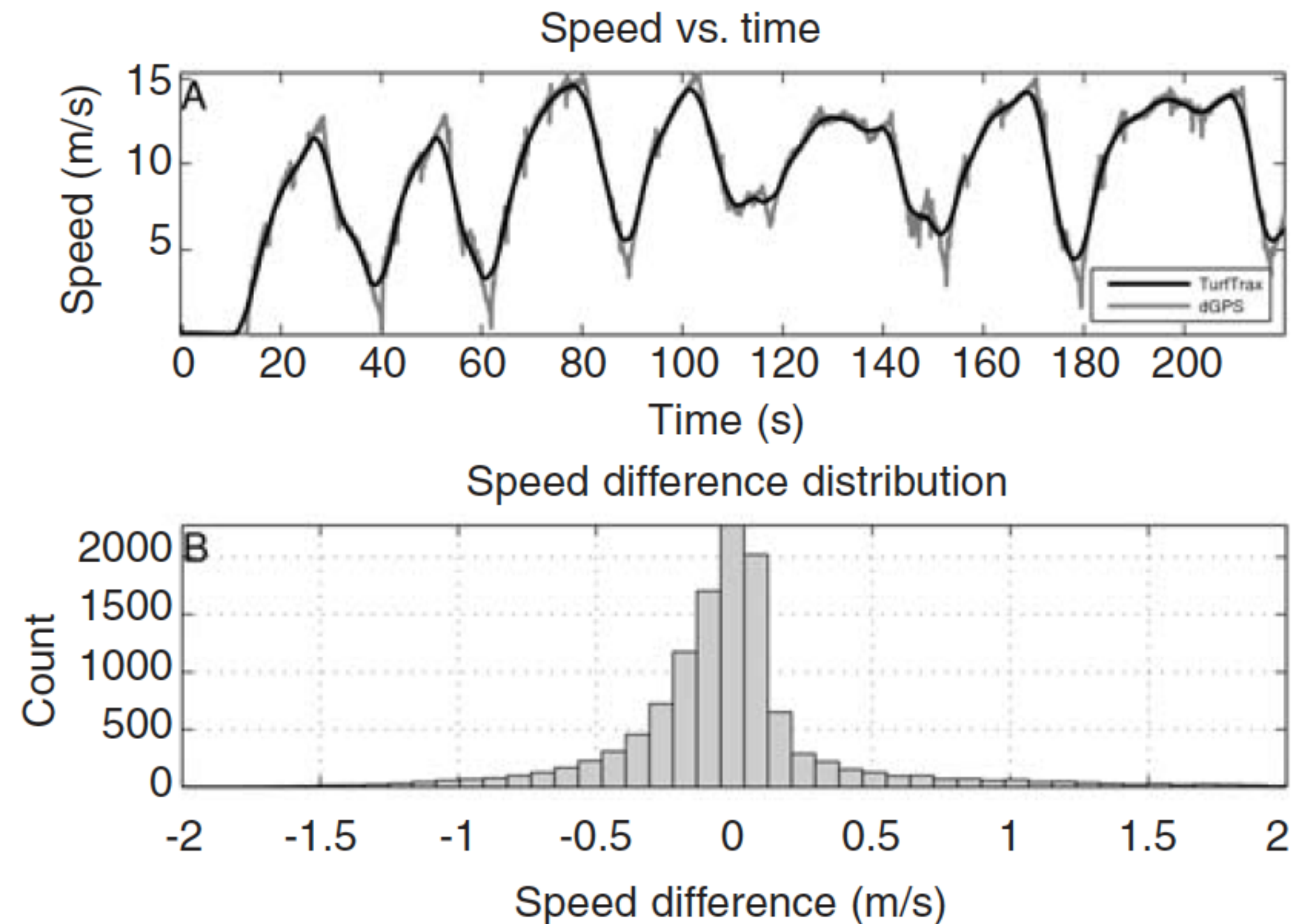
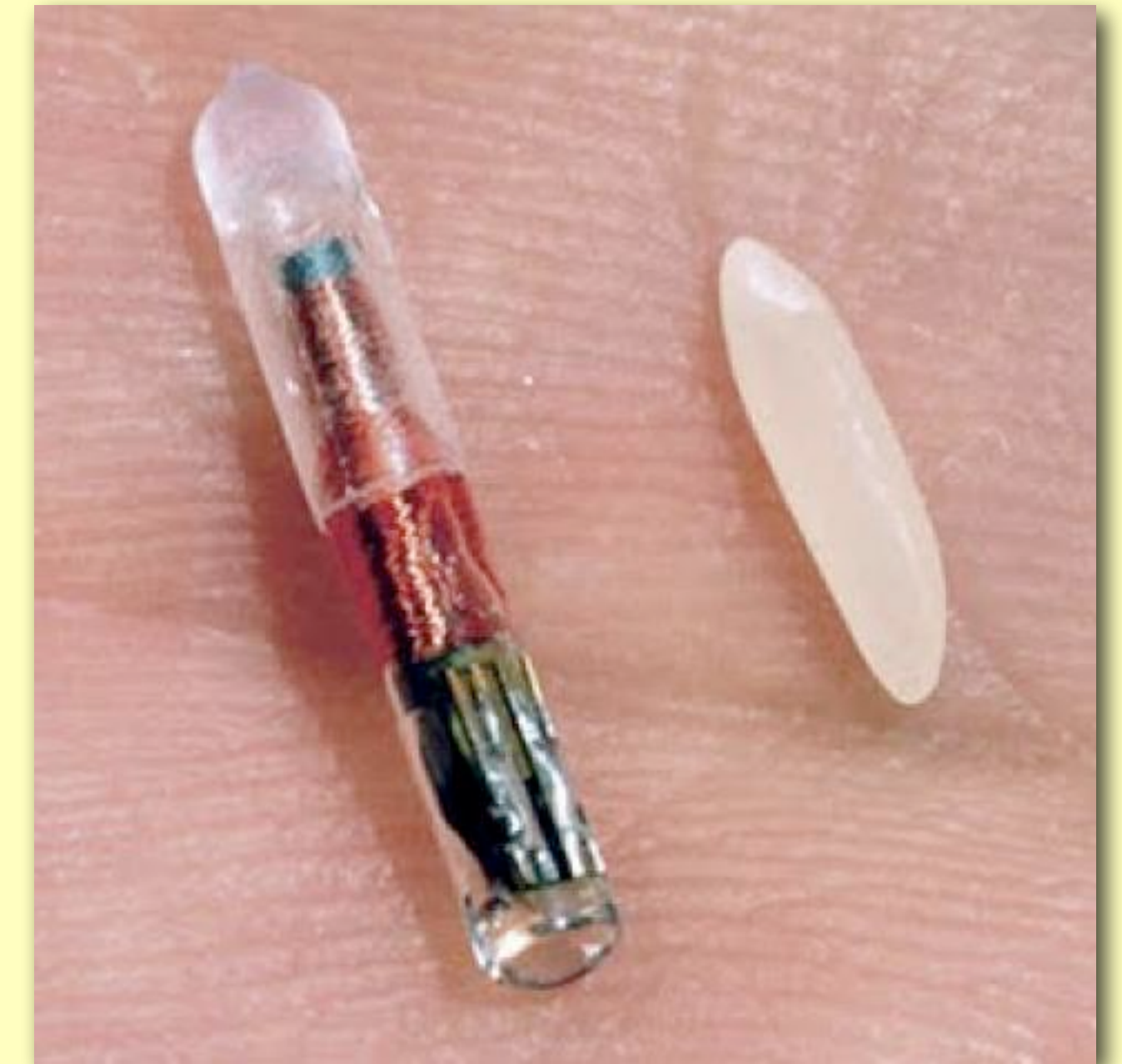


Fig 2: Comparison of the speed estimates of the TurfTrax and DGPS systems. Overlay of speed vs. time for both systems during run 2 (A), and the distribution of the difference between the speed estimates (B). The systems give very similar estimates of speed, with the TurfTrax system yielding smoother data. The long tails of the difference distribution are due to periods of high acceleration, where the 2 estimates diverge. For periods of low acceleration where the data are similar, the bulk of the data fall within 0.15 m/s of the mean value.

Other issues

- radio-frequency identification (RFID) chip;
- RFID is the wireless non-contact use of radio-frequency electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects;
- RFID tags contain electronically stored information;
- some tags are powered by and read at short ranges (a few meters) via magnetic fields (electromagnetic induction);
- others use a local power source such as a battery, or else have no battery but collect energy from the interrogating EM field, and then act as a passive transponder to emit microwaves or UHF radio waves (i.e., electromagnetic radiation at high frequencies);
- battery powered tags may operate at hundreds of meters;
- unlike a bar code, the tag does not necessarily need to be within line of sight of the reader, and may be embedded in the tracked object



Other issues

measures



– RFID for timing races;

173

Other issues

measures



Other issues



Road cycling



MTB



Running



Triathlon

Other issues

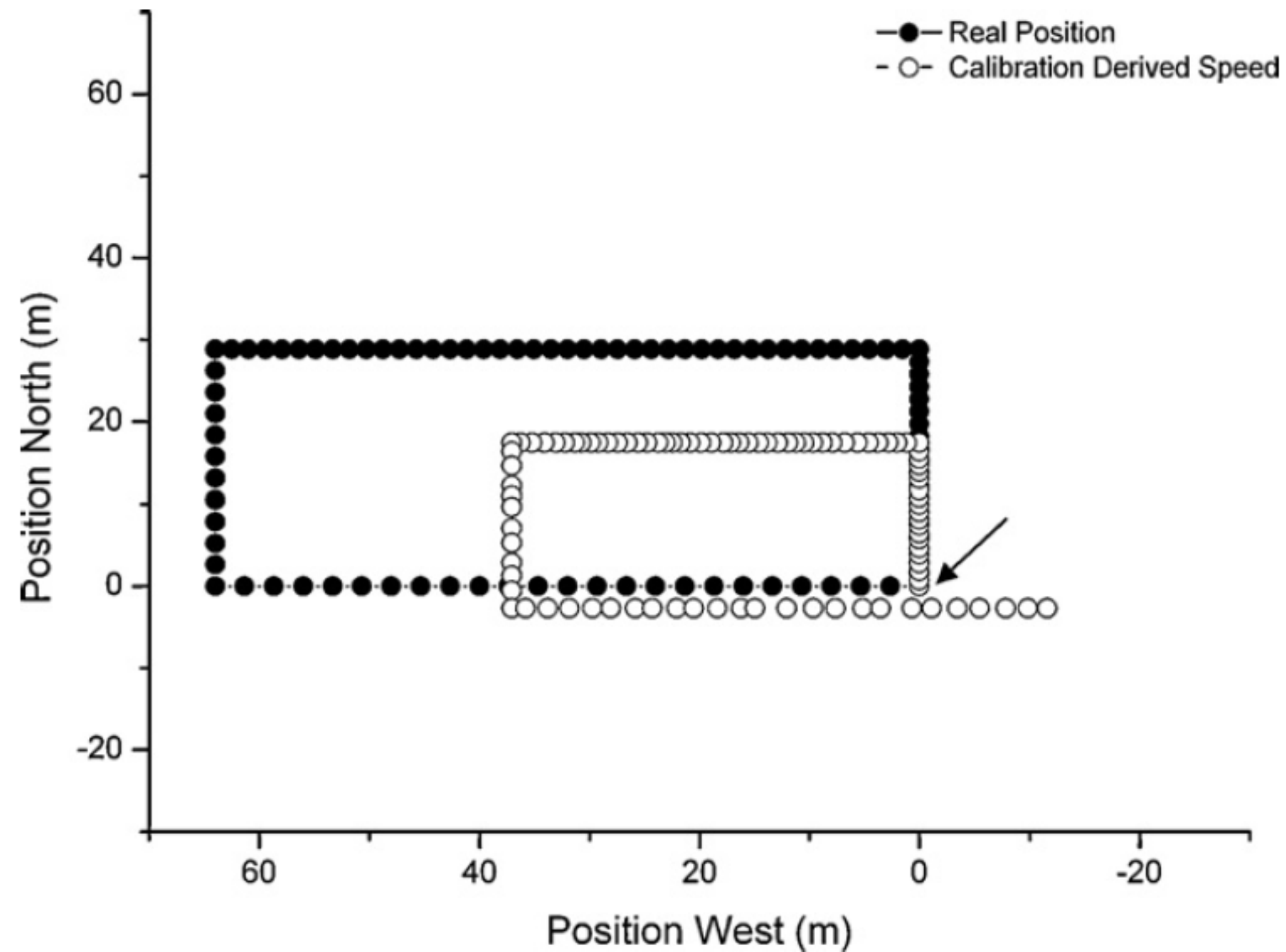


Fig. 4. Comparison of dead-reckoned tracks derived from the real position and the calibration-derived speed. The track begins at the point marked by the arrow moving anti-clockwise.

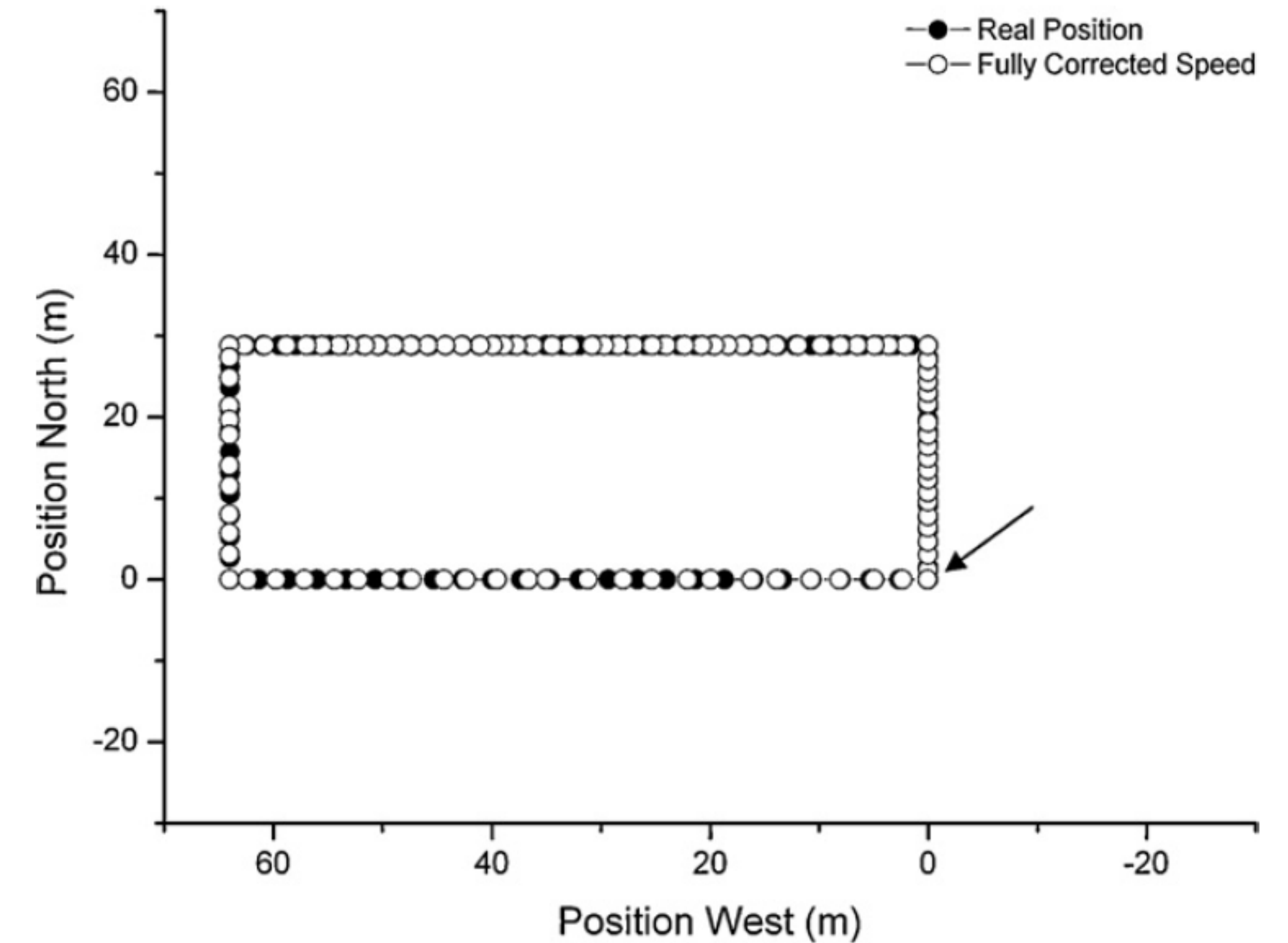
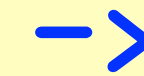


Fig. 5. Comparison of dead-reckoned tracks derived from the real position and the fully corrected speed. The track begins at the point marked by the arrow moving anti-clockwise. Initially, the gradient for the regression of speed against ODBA from the treadmill calibration had been 2.3796. After the correction it was set at 3.928 for legs 1 and 2, 3.990 for leg 3, and 3.521 for leg 4.

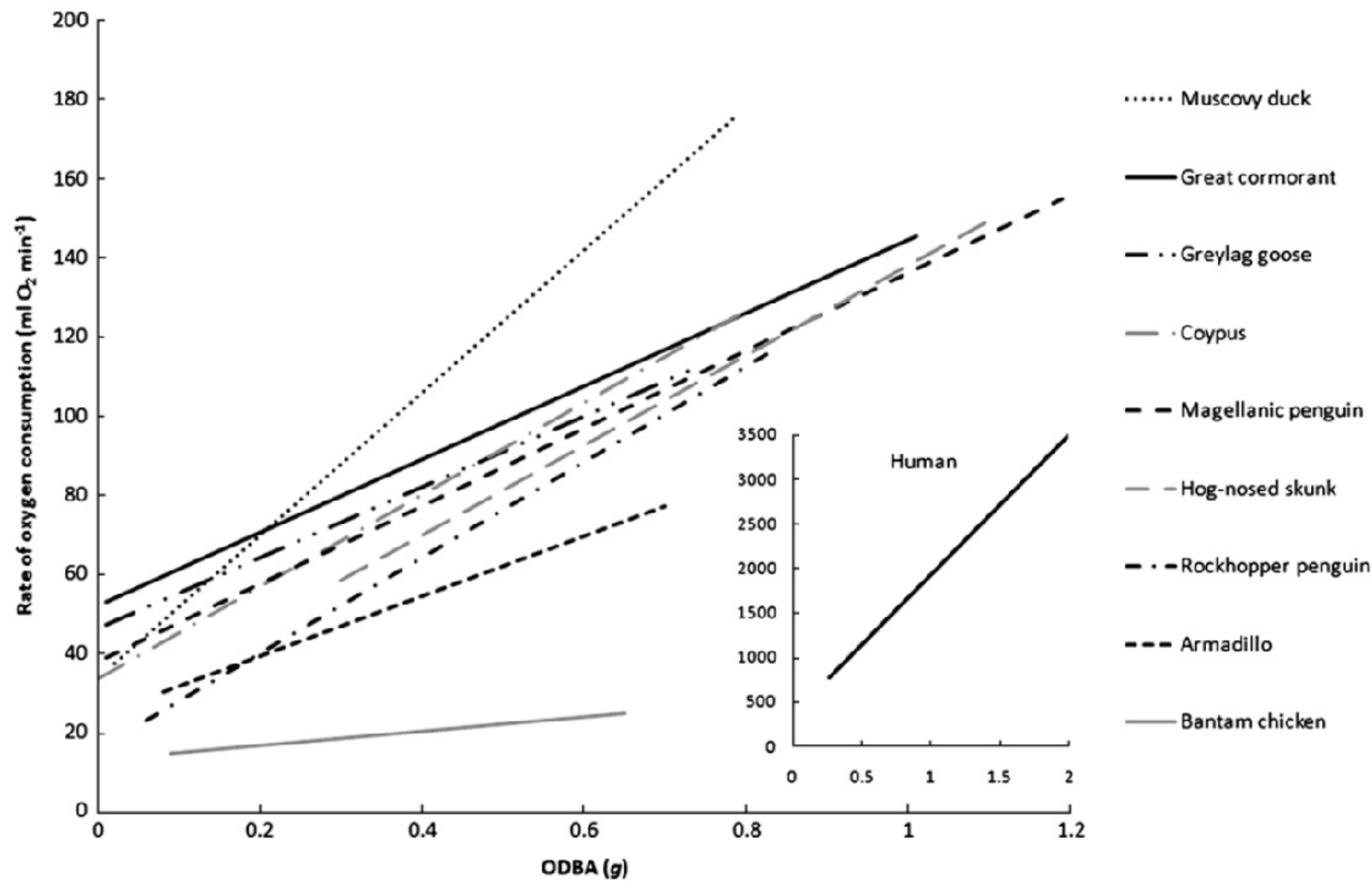


Fig. 1. Best fit linear relationships between rate of oxygen consumption and ODBA for a range of bipedal and quadrupedal species while resting and walking/running on a treadmill. Other behaviours were also displayed. Where data are available for multiple individuals of a species, a common slope is shown, derived from a linear mixed effects model. For clarity, the running order of species on the legend follows the order of slopes on the graph from top to bottom. Data for humans are included in an inset figure because values for rate of oxygen consumption are an order of magnitude greater than that of the other species.

Other species

measures



Muscovy Duck



Great Cormorant



Greylag Goose



Coypu



Magellanic Penguin



Hog-nosed skunk



Southern Rockhopper Penguin



Big hairy armadillo



Bantam chicken



Human

Other issues

measures

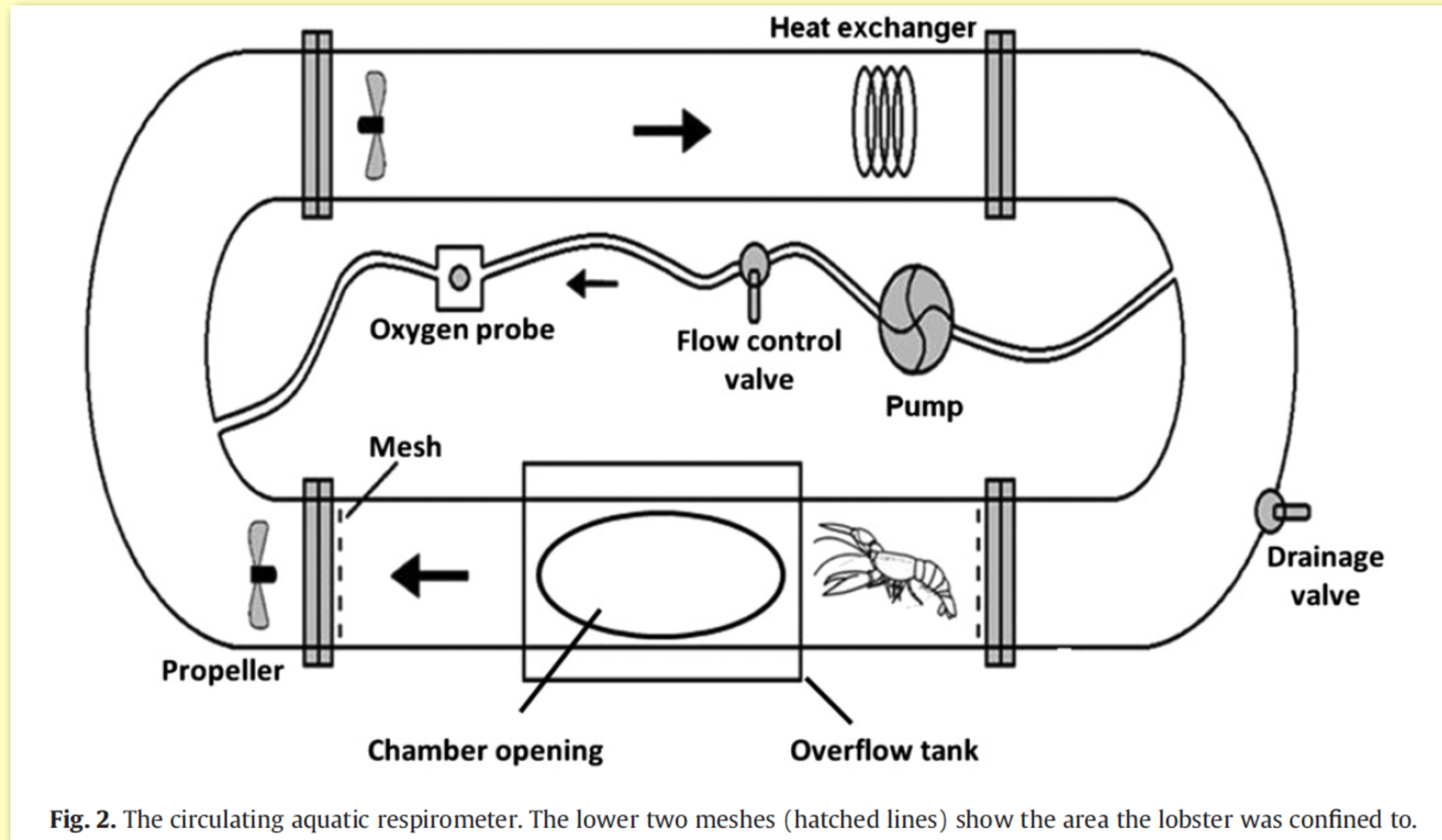


Fig. 1. Tri-axial accelerometer data logger attached directly to the dorsal carapace surface of a lobster using industrial strength Velcro® and adhesive.

Lobster

Lyons et al., 2013

Other issues



Lyons et al., 2013

Other issues

measures

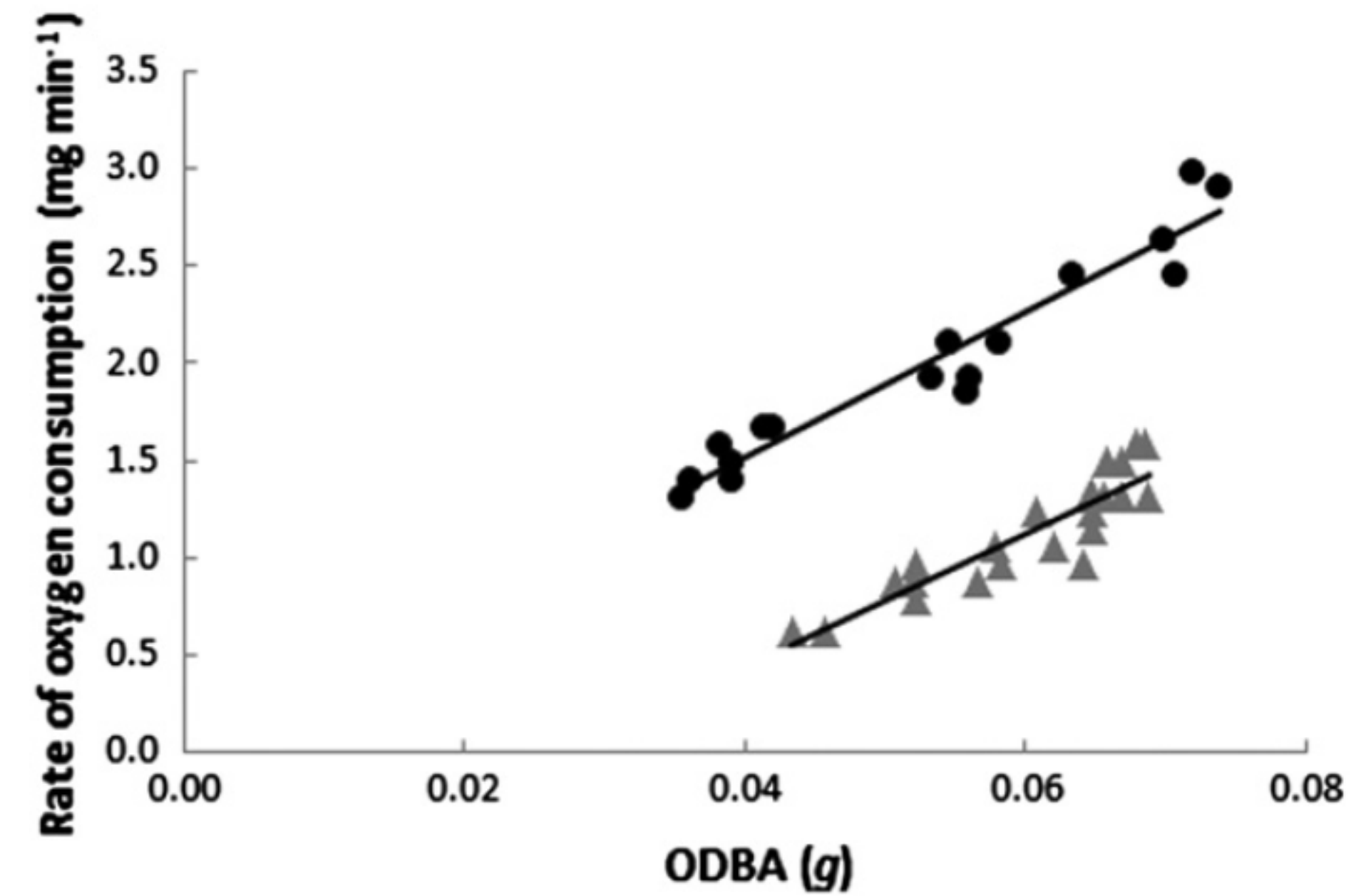


Fig. 4. The calibration data for two lobsters at 13 °C. Circles represent a lobster of 1017 g while triangles represent a lobster of 478 g.

Lyons et al., 2013

Other issues

measures



Other issues

measures



An example

measures

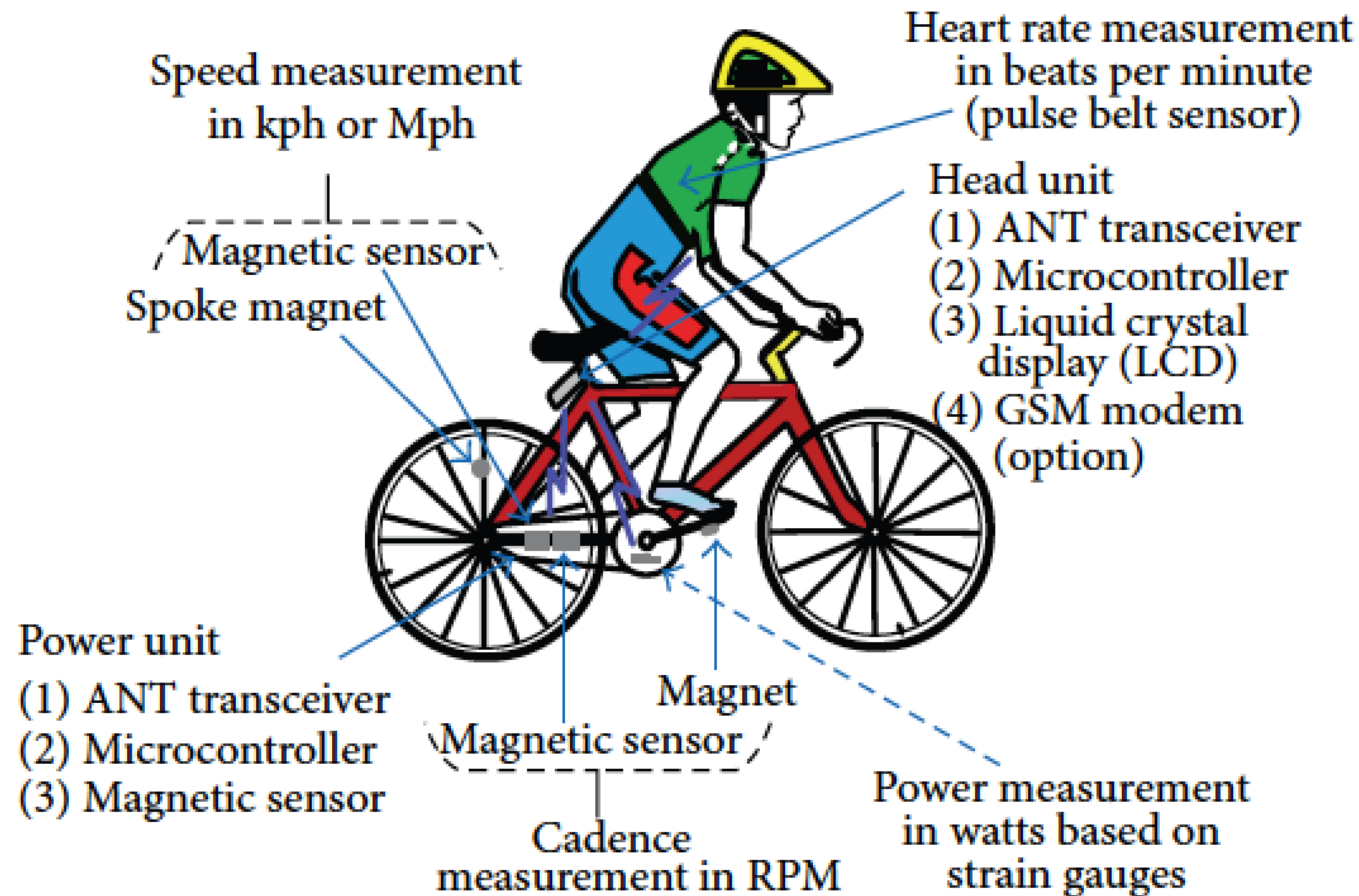
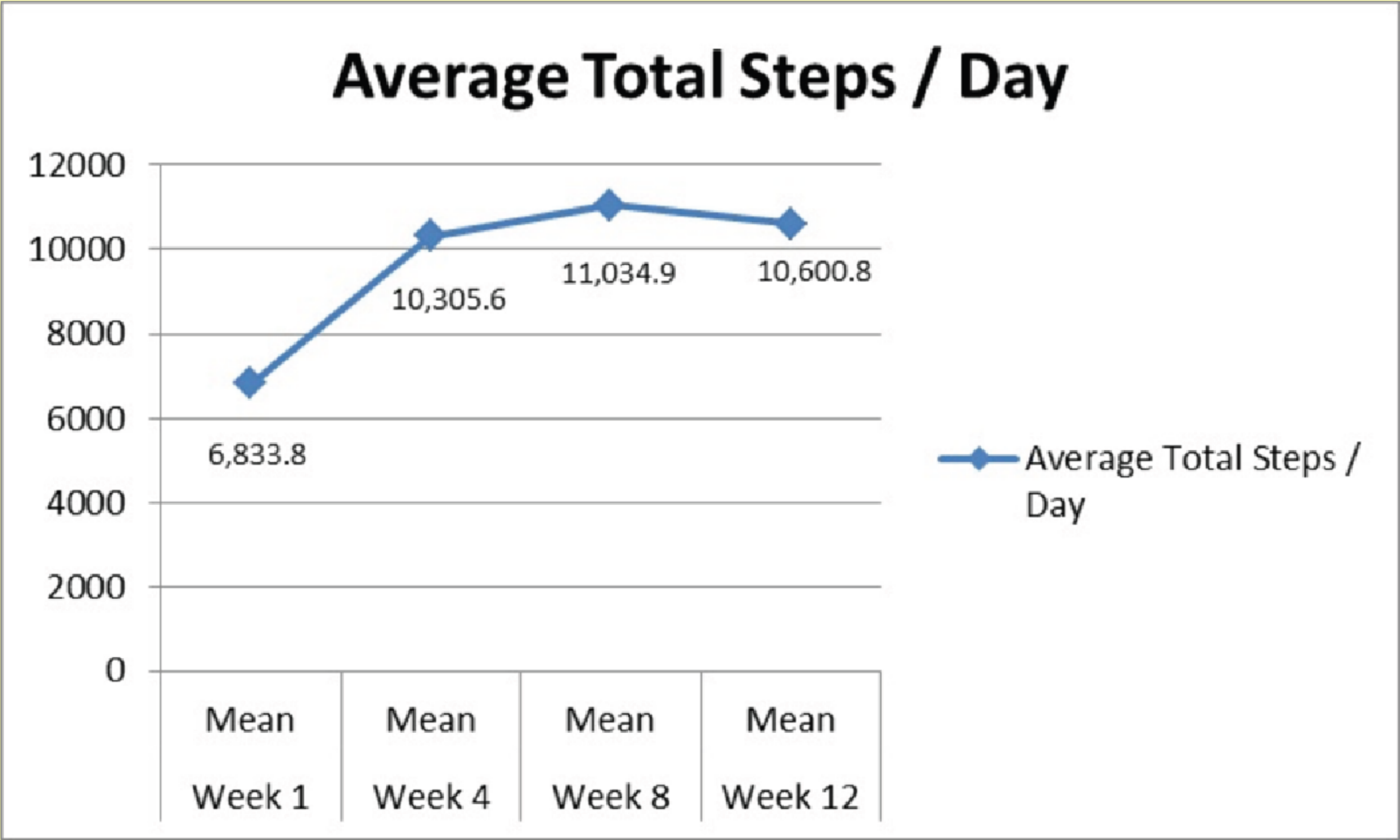


FIGURE 4: An overview of relevant wireless sensors and networks related to a bicycle and cyclist monitoring system.

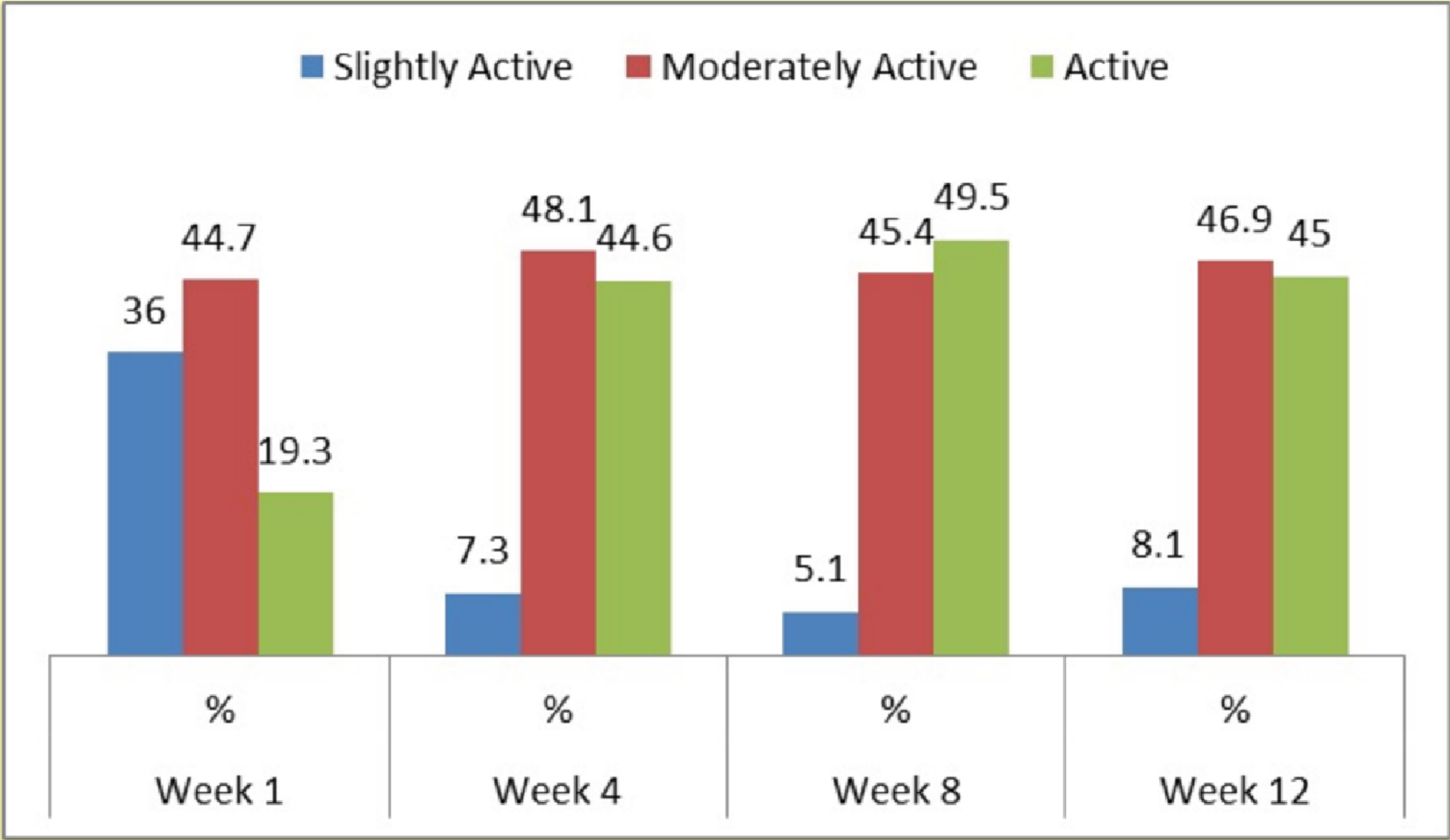
Specific measures

How many steps/day are enough?

- 10,000 (Hatano, 1993);
- Tudor-Locke et al., 2004:
 - <5,000 sedentary lifestyle;
 - 5,000 ÷ 7,499 typical daily activity that does not include exercise or sports and can be defined poorly active;
 - 7,500 ÷ 9,999 includes a bit of extra-work (and/or fatiguing work) and can be defined a little active;
- > 10,000 active lifestyle;
- > 12,500 very active lifestyle



Effect of online pedometer program on physical activity in Qatar



Pedometry

measures

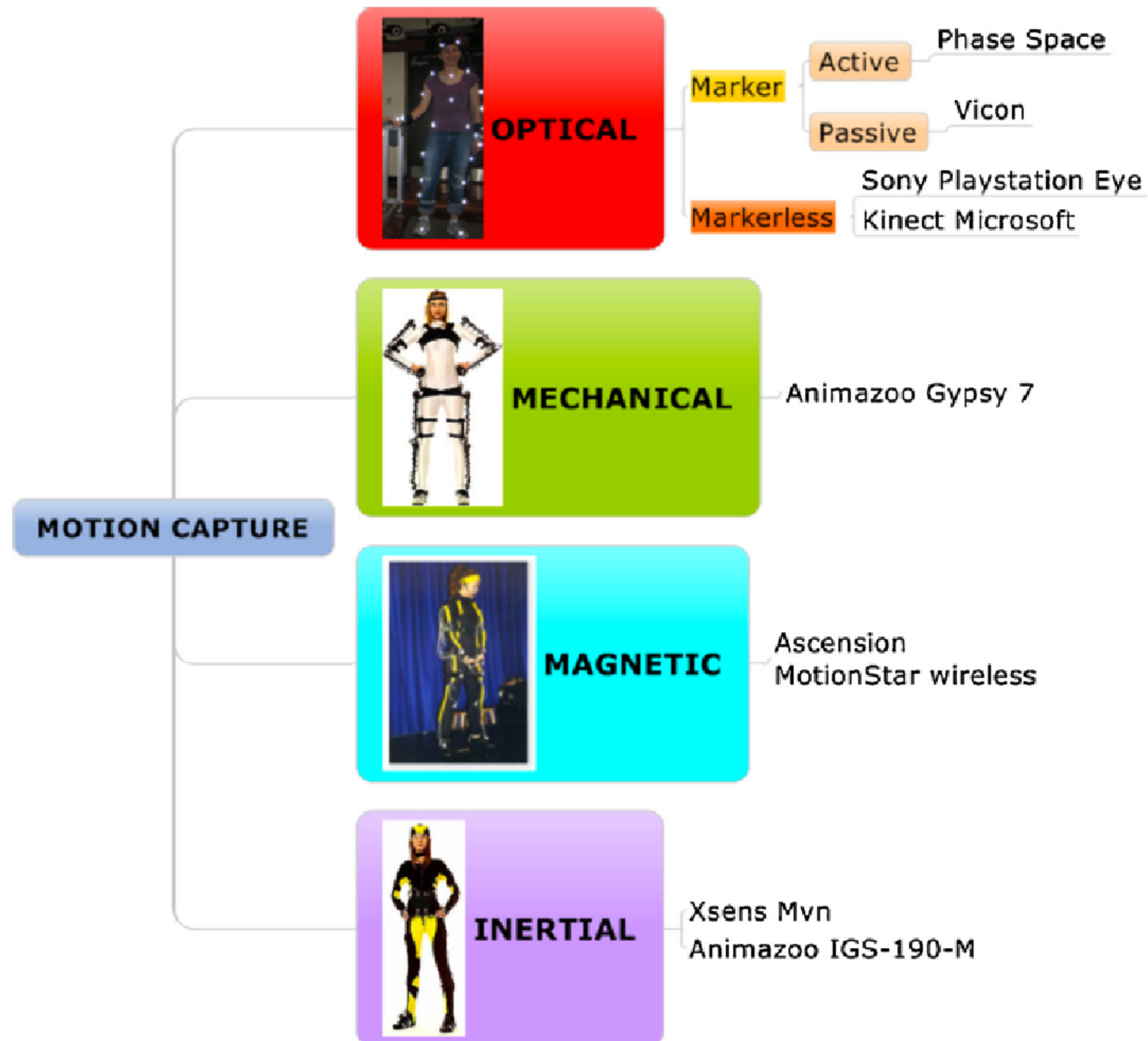
Specs



Vital sign: HR, HRV, temperature
Battery lifetime: Up to 10h (Rechargeable)
Charging time: Appr. 1h
Weight: 6,5g
Dimensions: 4,5 x 1,8 x 3,8 cm (H x D x W)
Radio frequency: 2,4 GHz
Compatibilty: Bluetooth 4.0 & ANT+
(certification coming soon)

cosinuss° One

Mocap options



measures

Regazzoni et al, 2015

Fig. 1. Mocap system classification depending on the technology used.

Fitness

Top twenty fitness trends for 2017

Human Kinetics on 30/11/2016 / 0 comments



The American College of Sports Medicine has announced its annual fitness trend forecast for the coming year. Now in its eleventh year, the survey was completed by over 1,800 health and fitness professionals worldwide.

Trends 11-20

- 11. Fitness Programmes for Older Adults
- 12. Functional Fitness
- 13. Outdoor Activities
- 14. Group Personal Training
- 15. Wellness Coaching
- 16. Worksite Health Promotion
- 17. Smartphone Exercise Apps
- 18. Outcome Measurements
- 19. Circuit Training
- 20. Flexibility and Mobility Rollers

10. Exercise and Weight Loss

In addition to nutrition, exercise is a key component of a proper weight loss programme. Health and fitness professionals who provide weight loss programmes are increasingly incorporating regular exercise and caloric restriction for better weight control in their clients.

9. Personal Training

Since the ACSM's first survey in 2006, personal training has reliably been included in the top 10. As more and more professional personal trainers are educated and become certified, they are increasingly becoming more accessible in all sectors of the health and fitness industry. Participants in the survey believe that personal trainers continue to be an important part of the professional staff in health and fitness centres.

8. Yoga

Moving higher up the list for 2017 is yoga, after occupying the number 10 spot last year. Yoga has a long history of making it into ACSM's top 20 trend survey. Its sustained popularity is thought to be down to its versatility. Yoga comes in a variety of forms and is continually being reinvented and refreshed, making it an attractive form of exercise.

7. Exercise is Medicine

Exercise is Medicine is a global health initiative that is focused on encouraging primary care physicians and other health care providers to include physical activity when designing treatment plans for patients. Back in May, we featured a [post detailing the worldwide initiative](#).

6. Group Training

Group training programmes are designed to be motivational and effective for people of different fitness levels. They cover a wide variety of workout preferences. Group exercise training programmes have been around for a long time and have appeared as a potential worldwide trend since this survey was originally constructed. However, this year is the first time group training has appeared in the top 20.

5. Strength Training

Strength training remains popular in all sectors of the health and fitness industry. Like many other trends in the top 10, strength training has been a consistent contender since the survey began. Most contemporary and innovative fitness professionals incorporate some form of strength training into exercise routines with their clients.

4. Educated, Certified and Experienced Professionals

More clients are demanding fitness professionals who have studied in their field and have been certified by third-party organisations. Educational programmes and accrediting bodies have seen sustained growth over the last few years. Regulation ensures a quality experience for clients and is a powerful way for fitness professionals to stand out in the crowded and competitive industry.

3. High-Intensity Interval Training

High-Intensity Interval Training (HIIT) blends short bursts of high-intensity exercise with short periods of rest or recovery. It typically takes less than 30 minutes to perform. HIIT failed to make the top 20 in surveys conducted before 2014, but the following year it placed in the number 1 spot. Some professionals have warned of the injury risks from HIIT, but that doesn't stop it being a firm favourite in gyms around the world.

2. Bodyweight Training

Bodyweight training first appeared in the trends survey in 2013 (at number 3) and has remained in the number 2 position for 2017. This trend didn't appear as an option before 2013 as it only became popular in gyms around the world over the last few years. However, its place at number 1 in the 2015 survey and number 2 last year have suggested bodyweight training is now a trend to look out for in the future.

1. Wearable Technology

Claiming the top spot for the second year in a row, wearable technology is still a slightly controversial entry. Although recent studies have suggested fitness trackers may not be as efficient as they seem, fitness professionals still think wearable technology will be big business for 2017. Most people are probably aware of gadgets like activity trackers, smart watches, heart rate monitors and GPS tracking devices. However, it's thought that 2017 could see an increase in the use of smart glasses, smart fabrics and interactive textiles.

2

Body weight training

It's not just push-ups and pull-ups. New packaging, particularly by commercial clubs, has now made it popular in all kinds of gyms.

[Discover more at Human Kinetics](#)

1

Wearable Technology

Includes fitness trackers, smartwatches, heart rate monitors and GPS tracking devices.

[Find out more at Human Kinetics](#)

Wearable technology



Wearable technology

FROM HEAD TO TOE WEARABLE TECHNOLOGY

SHIRT

Conductive thread means a computer is literally built into the fabric of the shirt, providing the processing power for all the other wearable gadgets.

WRISTBAND

A sensor that tracks movement to determine the number of steps taken through the day – 10,000 is ideal – and how much sleep the wearer gets at night.

TROUSERS

Also made with conductive thread, the trousers take the energy generated by movement and use it to power the other gadgets.

GLASSES

Overlays navigation directions and information about points of interest directly on to the wearer's field of vision.

WRISTWATCH

Vibrates when a message arrives and displays it on the watch face. Tells the time too.

HAND

Embedded under the skin is a chip containing medical records, passport data and credit records. Information is transferred by waving the hand over a suitable scanner.

SHOES

GPS chip provides directions using LED lights in each shoe: the left shoe indicates direction, while the right shows distance.

GRAPHIC: JOHN BRADLEY

Summary

measures

- PA & ME overview;
- PA & ME measures overview;
- pedometry;
- first generation accelerometry;
- portable HR measure;
- $\dot{V}O_2$ measure overview;
- DLW method overview;
- second generation accelerometry (purely physical sensors);
- second generation accelerometry (physical + physiological sensors);
- GPS;
- GIS overview;
- DGPS overview;

Summary

- multisensor portable devices/garments overview;
- IMUs overview;
- TurfTrax overview;
- RFID chip overview;
- ODBA overview

New methods for the evaluation of the energy expenditure in exercising humans in ecological conditions
A three class module

Thank you for your attention

Luca P. Ardigo Ph.D.

Senior Lecturer in Sport Science

School of Exercise and Sport Science

Department of Neurosciences, Biomedicine and Movement
Sciences

University of Verona

luca.ardigo@univr.it

