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Wearables –Forecast

Source: IDC 2018

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Wearables – Accuracy

- GPS and ECG-signals usually valid
- Critical: Physical activity from accelerometer data
  - Influence of position of sensor (wrist; Hasson et al., 2009)
  - Measures for improving accuracy may result in lower acceptance (Dannecker et al., 2013)
  - Underestimation of energy expenditure (Santos et al., 2014)
- Increased accuracy from additional measuring devices (e.g. ECG), improved algorithms (Crouter et al., 2005) or pattern recognition (recognition of type of sport performed)
- Wrist-worn devices (Shcherbina et al., 2017): None of 7 commercial available devices achieved error in energy expenditure <20%

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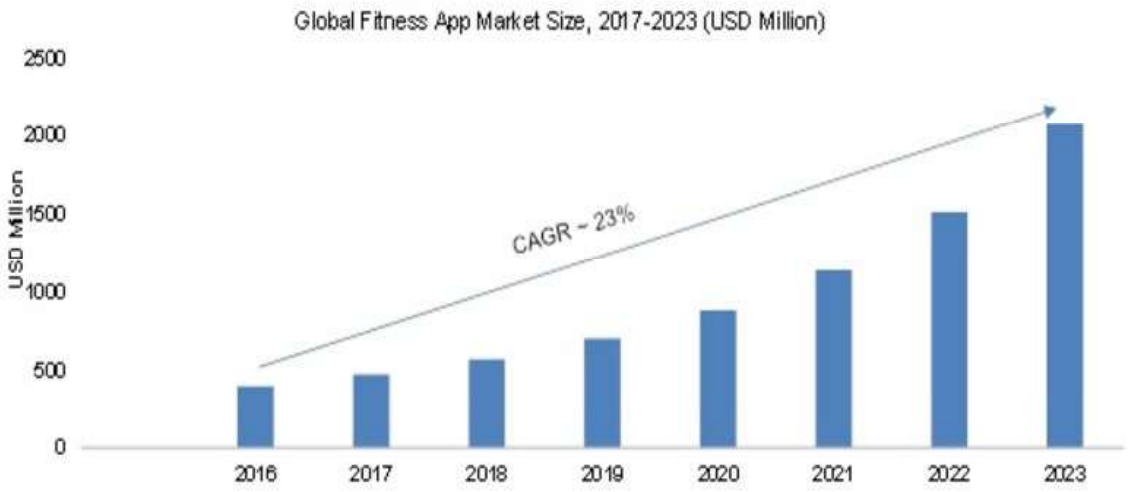
Apps – Market potential



Source: https://www.marketresearchfuture.com/reports/fitness-app-market-1405 (2019)

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Apps – Market potential

- 2020: 2,6 billion app users will have downloaded a mobile Health app at least once (551 million active users)

- Displayed apps in Health & Fitness and Medical categories:

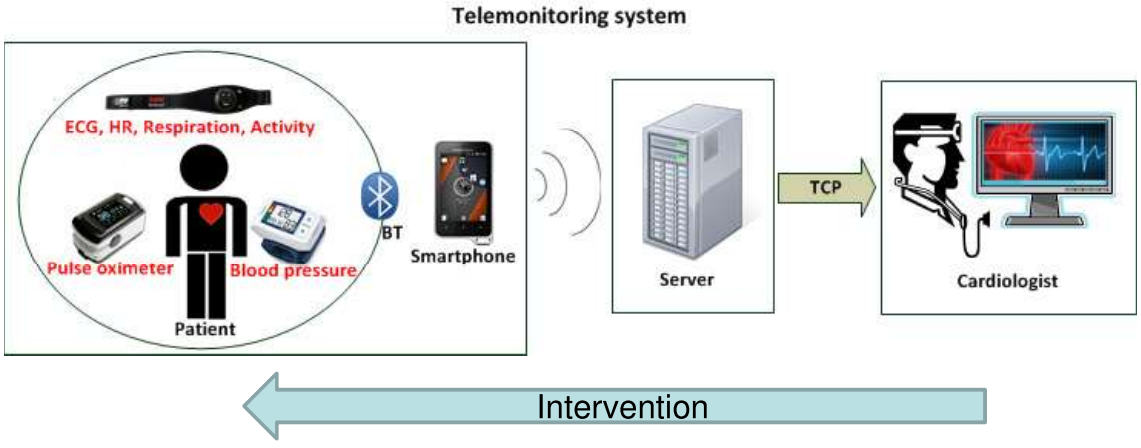
Android	105.000
iOS	126.000

Research2Guidance (2016)

Apps – Problems / Barriers

- „app-escape“; 80 - 90% of health related mobile apps are uninstalled after first usage (Mendiola et al., JMIR mHealth and uHealth, 2015)
- Overextension (mental overload)
- Lack of / few behavior change or gamification elements

Wearables – Example - Rehabilitation



cf. Patel et al., JNER, 2012; Baca et al., Proj. desc., 2013

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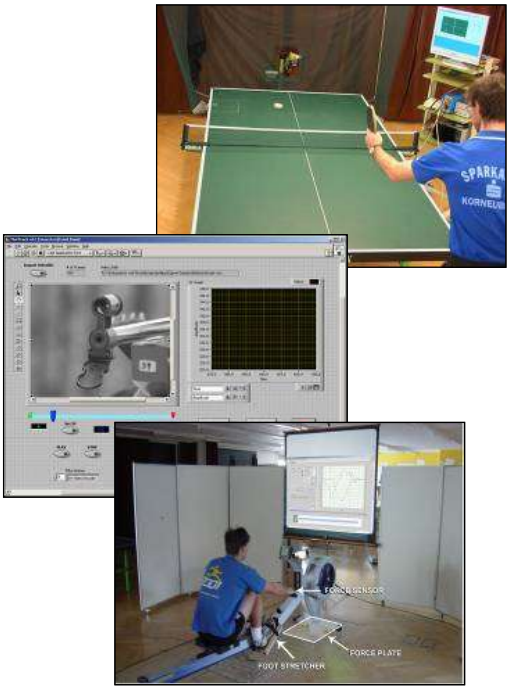
CONTENTS

- Pervasive Computing
- Wearables and Apps
- Intelligent Systems
- Example: MMA
- Perpectives & Conclusion



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Intelligent devices

- Perform operations guiding its behavior to some extent autonomously
- With respect to the surrounding environment (and its functionality)

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Intelligent devices/systems in sport

- Feedback provision on the quality of the motion just performed Baca, Int J Comp Sci Sport, 2003
- Recommendations on how to further proceed
- Automatically suggesting strategies and interventions
  Baca, Dabnichki, Heller and Kornfeind, J Sports Sci, 2009
- Adaptation of the sports equipment to the current needs of the athlete

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Intelligent devices/systems in sport

- Based on motion specific parameter values acquired by various sensors or sensor networks
- Possibility of miniaturizing sensors makes them perfectly suitable for acquisition of (biophysical, physiological, etc.) parameter values during regular sports activities
- Basis: Recognition of patterns characterizing the sports activity just performed and/or prediction of certain individual parameters (e. g. heart rate)

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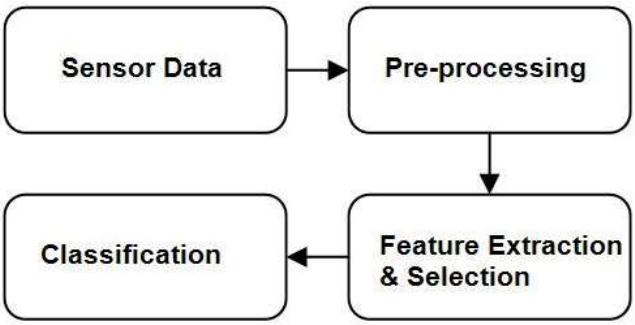
Methods for Classification

- **Statistical Classification**



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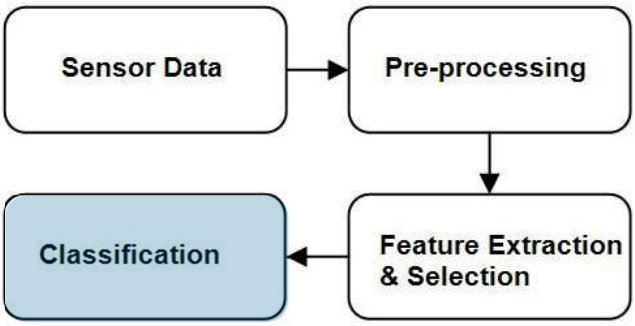
Methods

- **Statistical Decision**



- Identification of the corresponding class of motion
- Selection of the appropriate feedback or adaptation of the sports equipment

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Statistical decision

Binary classification trees

Decision engines

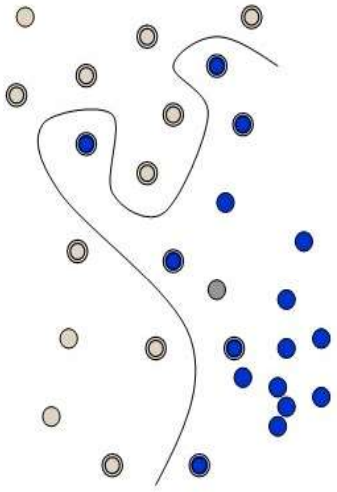
Bayes classifiers

K-Nearest Neighbour (k-NN)

Rule based approaches

Linear discriminant classifiers

Support Vector Machines



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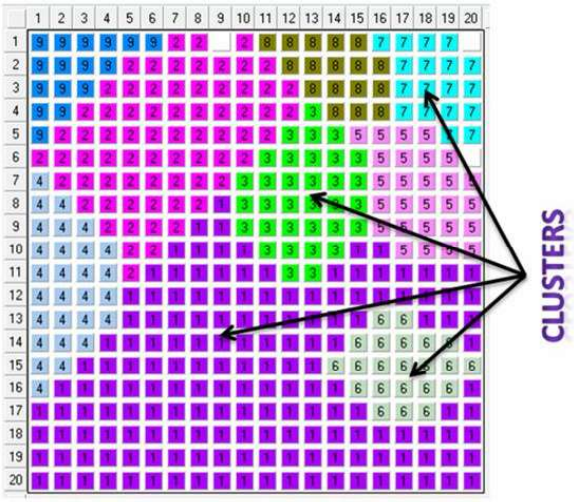
Unsupervised Neural Networks



Much consideration in sports and clinical biomechanics throughout the last years

(e.g. Bartlett, J Sports Sci Med, 2006)

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Specific Models

APPROACH:

Feedback instructions, recommendations, etc.
based on prediction of change of certain (e. g. physiological) parameters

Example: Prognosis of heart rate during running.
Recommendations for next track. Goal: Keeping heart rate in a target range, Method: Extrapolation (Vales-Alonso et al., Sensors, 2010)

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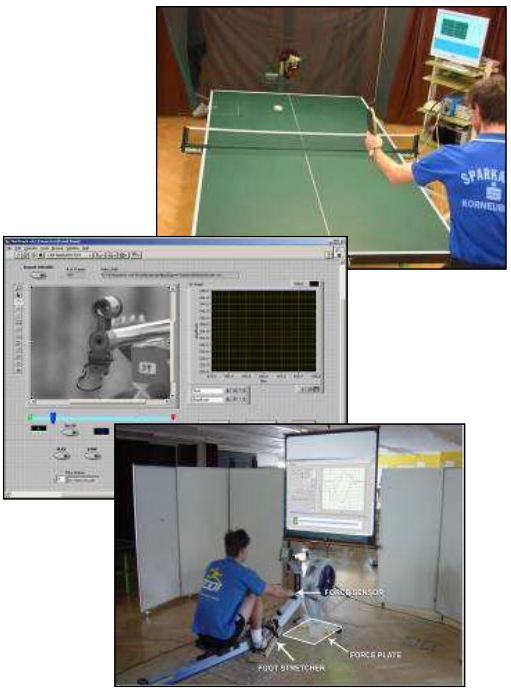

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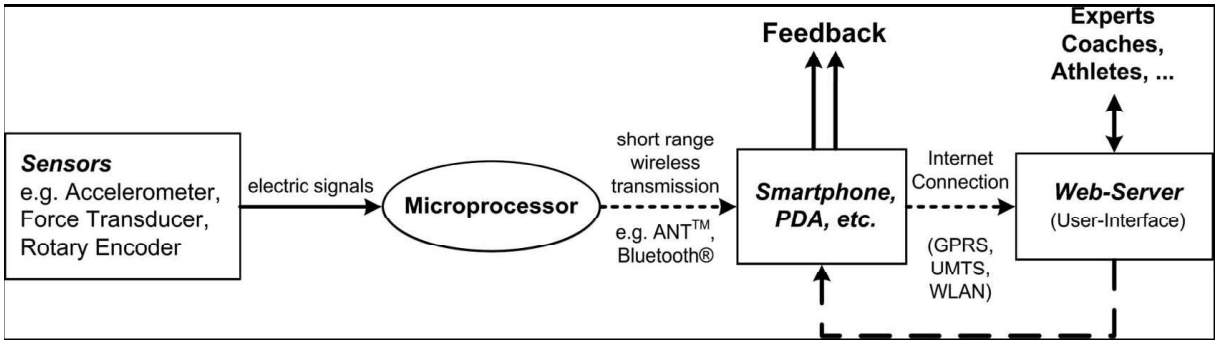
Wireless Monitoring & Feedback Systems



Baca et al. J Sports Sci. 2009 Sep 17:1-12

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→ **Training/exercising under natural, complex and ecological valid conditions**

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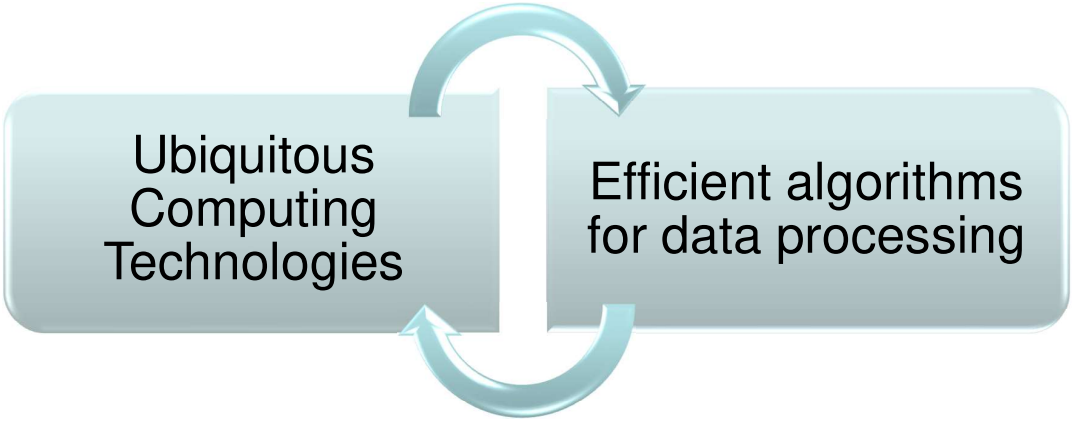
Mobile Coaching – Goals



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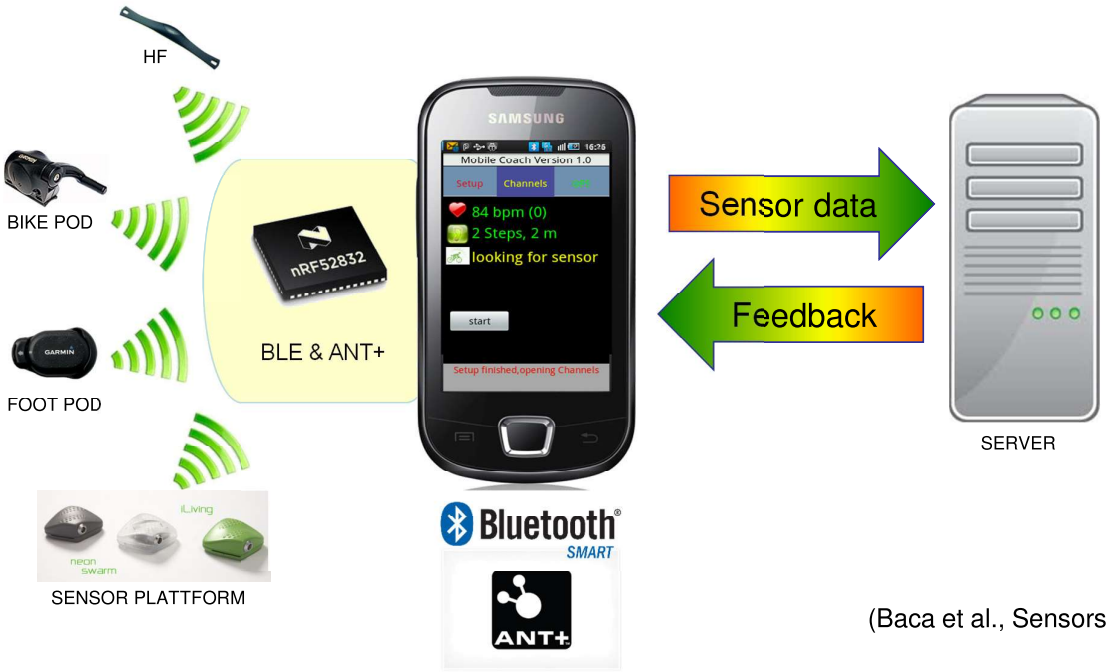
Mobile Motion Advisor (MMA)



(Baca et al., Sensors, 2010)

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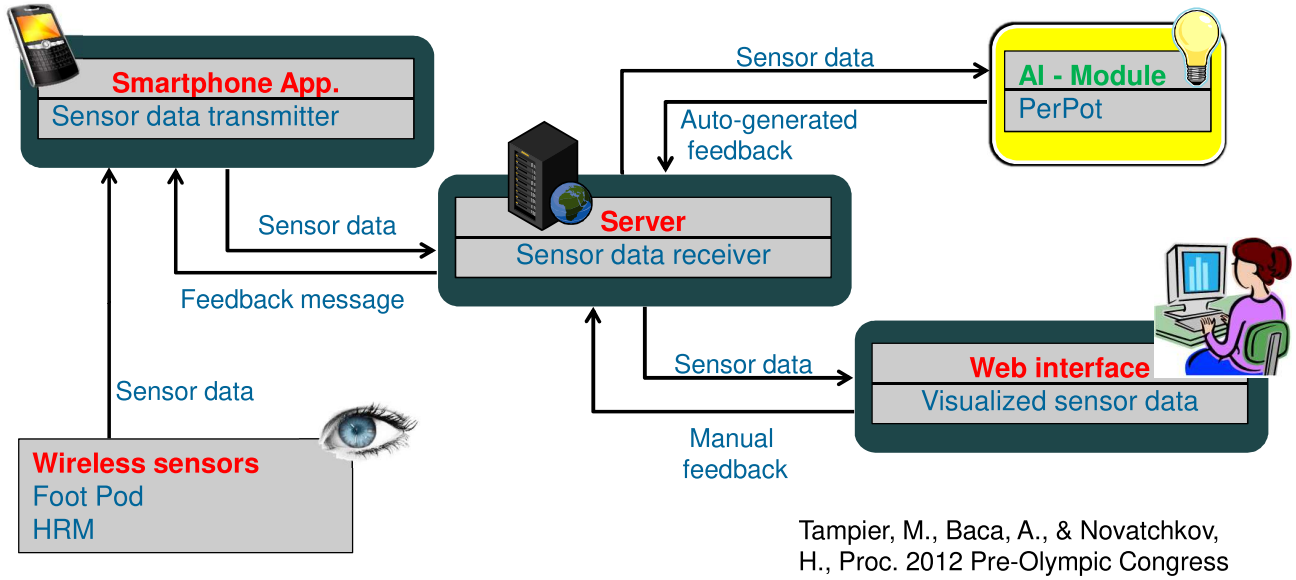
MMA: E-Coaching - Marathon



Tampier, M., Baca, A., & Novatchkov, H., Proc. 2012 Pre-Olympic Congress on Sports Science and Computer Science in Sport

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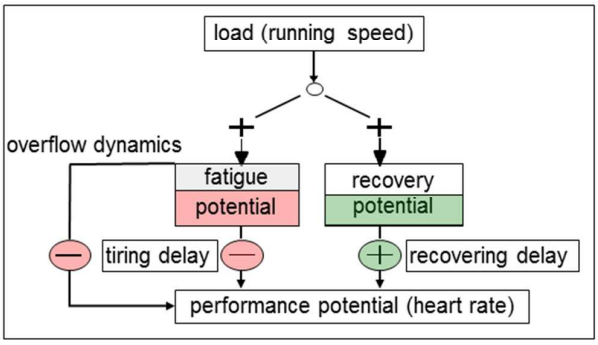
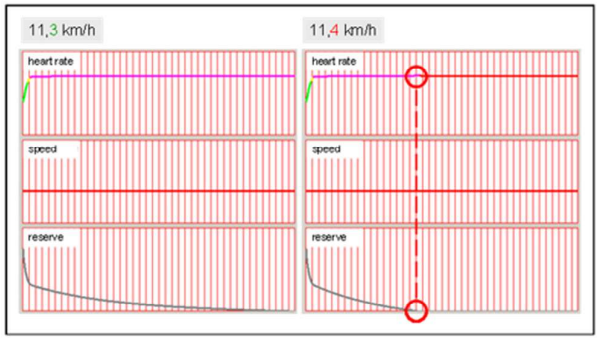
MMA: E-Coaching - Marathon

Meta-model PerPot

Physiological adaptation described as an antagonistic process



Prediction of load-based performance development



Optimization of current load management in order to avoid overload and underperforming

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MMA: E-Coaching – Marathon – Pilot Study

Subjects

- Runs on a flat track
- Runs completed within 2 weeks
- Comparable weather condititions
- No other physical sport activities
- Amateur athletes 18 - 25 years old
  (endurance sports like soccer, basketball, running…)

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Results / Experiences

Nr.	Distance	T1	T2	Diff.	PP
1	10.000 m	47:46 min	50:36 min	+2:50 min	49:29 min
2	8.000 m	46:46 min	45:08 min	- 1:38 min	44:45 min
3	9.250 m	44:40 min	43:35 min	- 1:05 min	45:00 min
4	8.400 m	40:00 min	39.19 min	- 0:41 min	34:03 min
5	9.600 m	54:45 min	54:11 min	- 0:34 min	48:38 min
6	9.400 m	49:26 min	41:36 min	- 7:50 min	42:44 min
7	9.200 m	50:19 min	47:02 min	- 3:17 min	46:47 min
8	7.200 m	47:30 min	46:06 min	- 1:24 min	45:57 min
9	6.700 m	42:35 min	33:48 min	- 8:47 min	35:16 min
10	5.500 m	40:56 min	37:55 min	- 3:01 min	33:40 min
11	6.300 m	43:57 min	42:52 min	- 1:05 min	45:33 min
12	7.950 m	45:55 min	44:32 min	- 1:23 min	41:07 min

…

T1: Time of free run
T2: Time of assisted run
PP: Estimated time of PerPot

27 of 34 (**79.4%**) participants could **improve** their performance
2 (5.9%) participants ran identical speed
5 (14.7%) participants performed better **without** the system

Endler, S., Tampier, M., Baca, A., & Perl, J., unpublished