

## Aim and Novelty

**Exercise Test** is worldwide recognized as valuable tool for investigating ST segment-based ischemia markers. Due to load-related risk, the test is reserved for office use, what causes inconvenience, limits patient participation rate and precludes screening for early ischemia stages. Transferring the diagnosis to patients' premises and using everyday activities as stimulus is an interesting alternative, but needs reliable recording of physical load.

**Usually:** Exercise test consists in exposing the patient to the controlled physical load, modulated accordingly to a given protocol and recording basic physiological parameters (heart rate, blood pressure and possible ischemia symptoms). Inconvenience related to regular exercise testing significantly decreases the participation of patients.

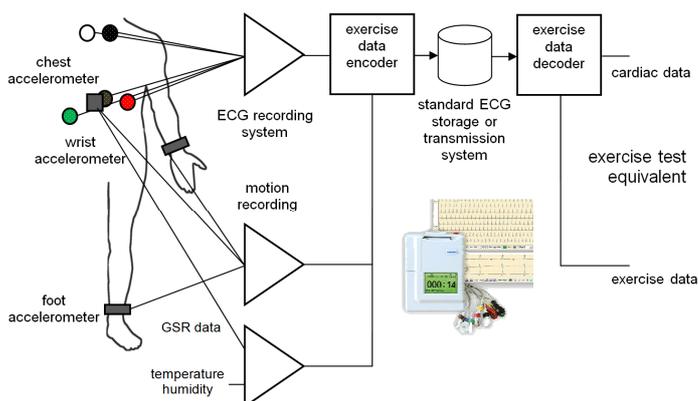


**Nowadays:** Designing a ubiquitous equivalent for exercise test requires to eliminate the risk of exceeding the load and complexity of the measurement. This may be achieved with reducing the load to everyday living activities and moving the test from the cardiologist's office to patient homes.

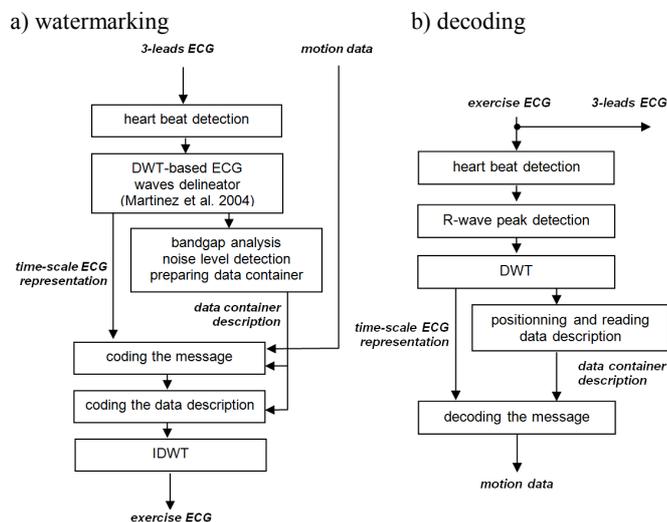


## Solution:

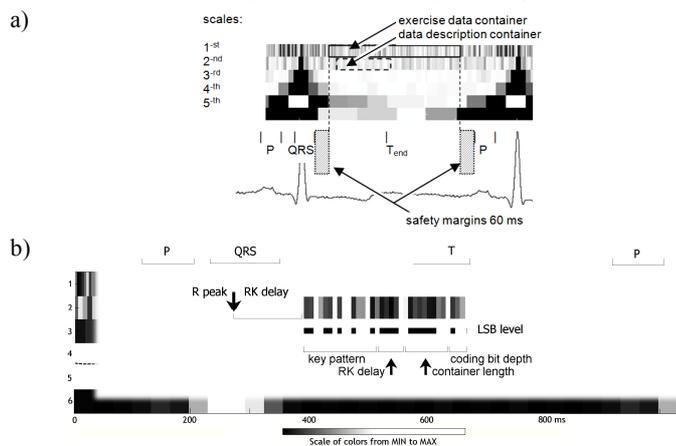
to embed the exercise and environmental data into the digital ECG structure to make the home exercise test feasible with a standard Holter recorder.



## Watermarking and decoding algorithms



## Details of exercise data containers



## Results

1) medical equivalence of the original and watermarked ECG host accordingly to EN60601-2-25:2015

ECG Section	Original Signal		Watermarked Signal		IEC Allowed Tolerance	
	mean	std	mean	std	mean	std
P	±4.3	3.3	±4.5	3.3	±10	15
QRS	±2.1	1.7	±2.1	2.4	±10	10
P-Q	±3.8	4.7	±4.0	5.1	±10	10
Q-T	±11.3	7.3	±11.8	10.8	±25	30

2) influence of watermarking on ST segment measurement accuracy and ischemia detection (17 volunteers)

S-T Parameter	Parameter Difference	
	mean	std
elevation/depression [ $\mu$ V]	±15.7	41.0
threshold mismatch cases	2	
slope coefficient	±0.157	0.203
slope sign mismatch cases	1	