Airbeat

The training assistive tool for athletes

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Which do you prefer for your kids?

Which do you prefer for yourself ?

Quick Survey

- **How many people in this actively engage in physical exercise more than 180 minutes in a week?**

Contents

- **Background**
  - **Motivation**
  - **Previous study**
- **Method**
  - **Idea**
- **Results**
  - **Hardware**
  - **Software**
  - **Algorithm**
- **Discussion**

Background

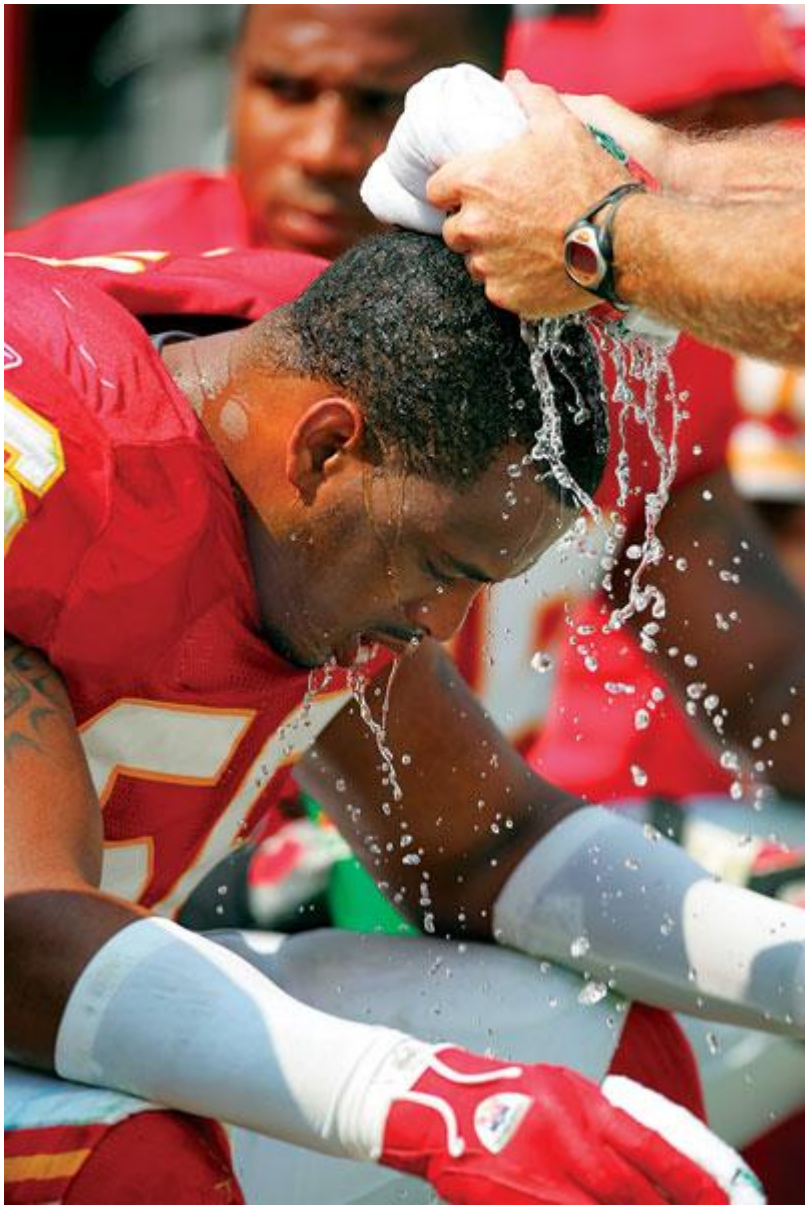
Why this study is required?

Motivation #1

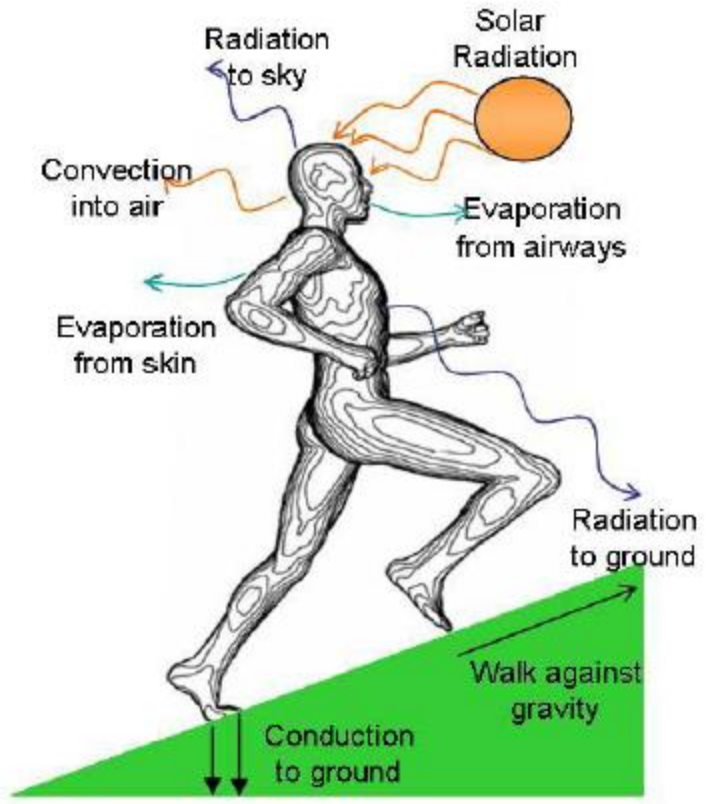
- The intrinsic trade-off between the strength and safety of athlete training

- Korey Stringer passed away at August 1, 2001 due to complications from heat stroke. Stringer completed the morning practice session and walked to an air conditioned shelter following practice. There he developed symptoms of heat stroke including weakness and rapid breathing.

- From 1995 through the 2000 football season there have been 14 high school heat stroke deaths in football.



Factors determining the Heat Stress



- Environmental factors
  - Temperature
  - Humidity
  - Air flow
  - Radiation
- Physical factors
  - Work load
  - Acclimatization

Previous Methods for Heat Stress

Table I. Screening Criteria for Heat Stress Exposure

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work 75% Rest	32.5	31	30	29.5	31	29	28	26.5

American conference of governmental industrial hygienist (ACGIH)

Motivation #2

- You can’t improve what you can’t measure.

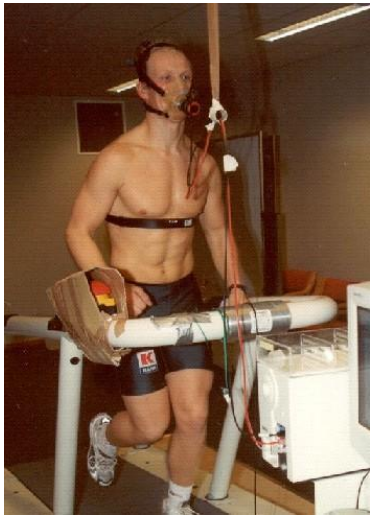
Agility

Endurance

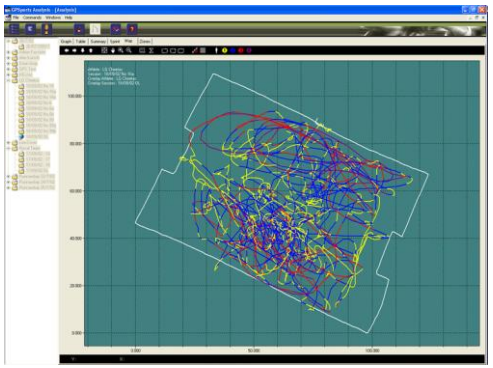
Previous Method for Assessment

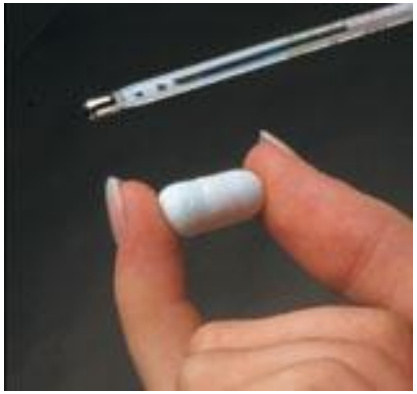
- Agility
  - Sidestep test
  - 10 m shuttle running
  - Reaction time
  - Zigzag running
  - Sargent jump

- Endurance
  - VO2 Max



Previous Study





Purpose of the research

- Innovative packaging
- Heat stress prevention
- Movement Assessment

Method

How Airbeat is designed?

Requirements for Packaging

- Minimal constriction
- Water-proof
- Light weight
- Easy and quick installation
- Low cost
- Adapt to various physical shape

Idea for Packaging

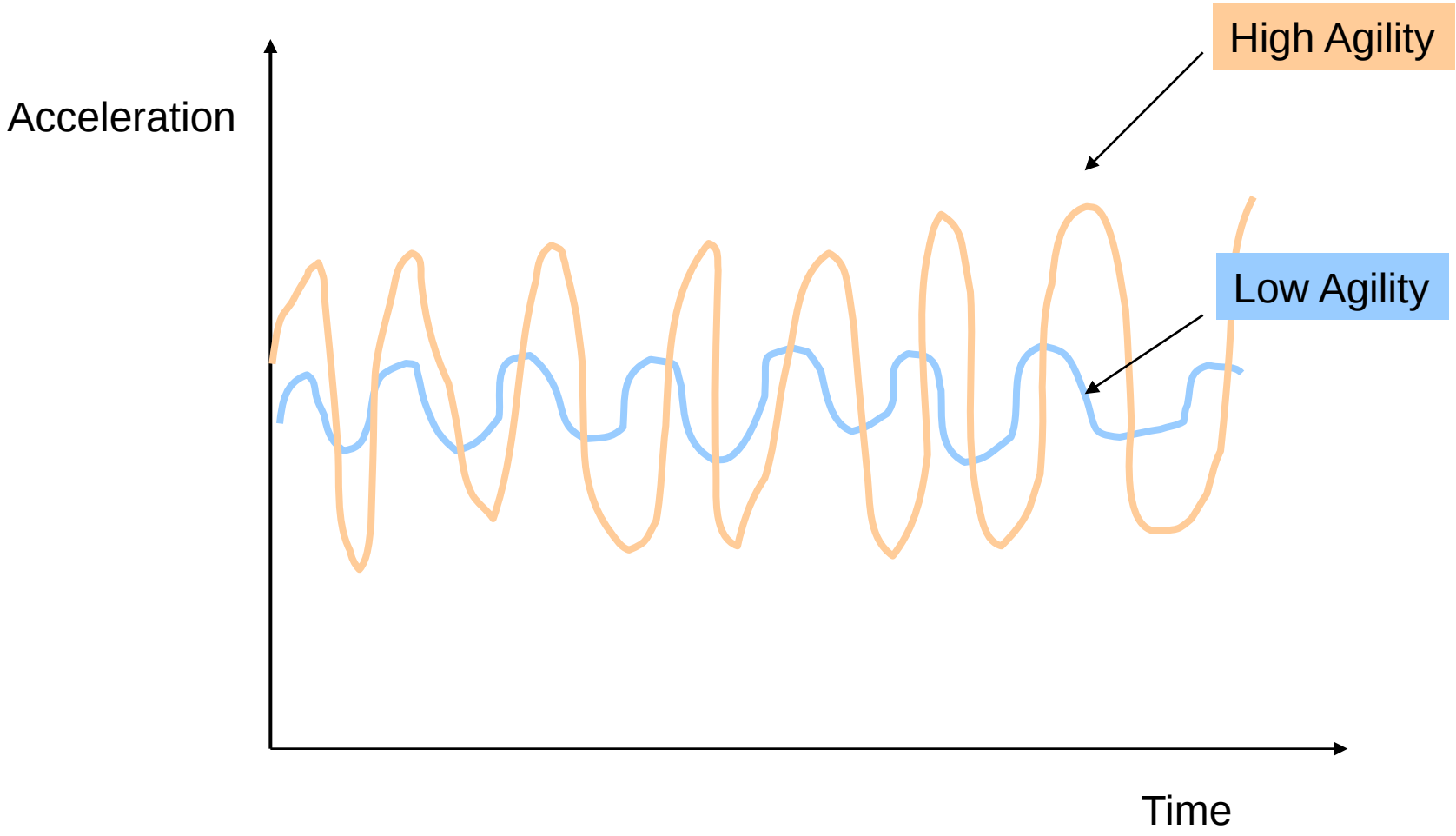
- Flexible printed circuit board
- Silicone rubber packaging
- Reusable Silicone rubber adhesive patch
- Personal inner suit sensing

Initial Idea for Heat Stress Management

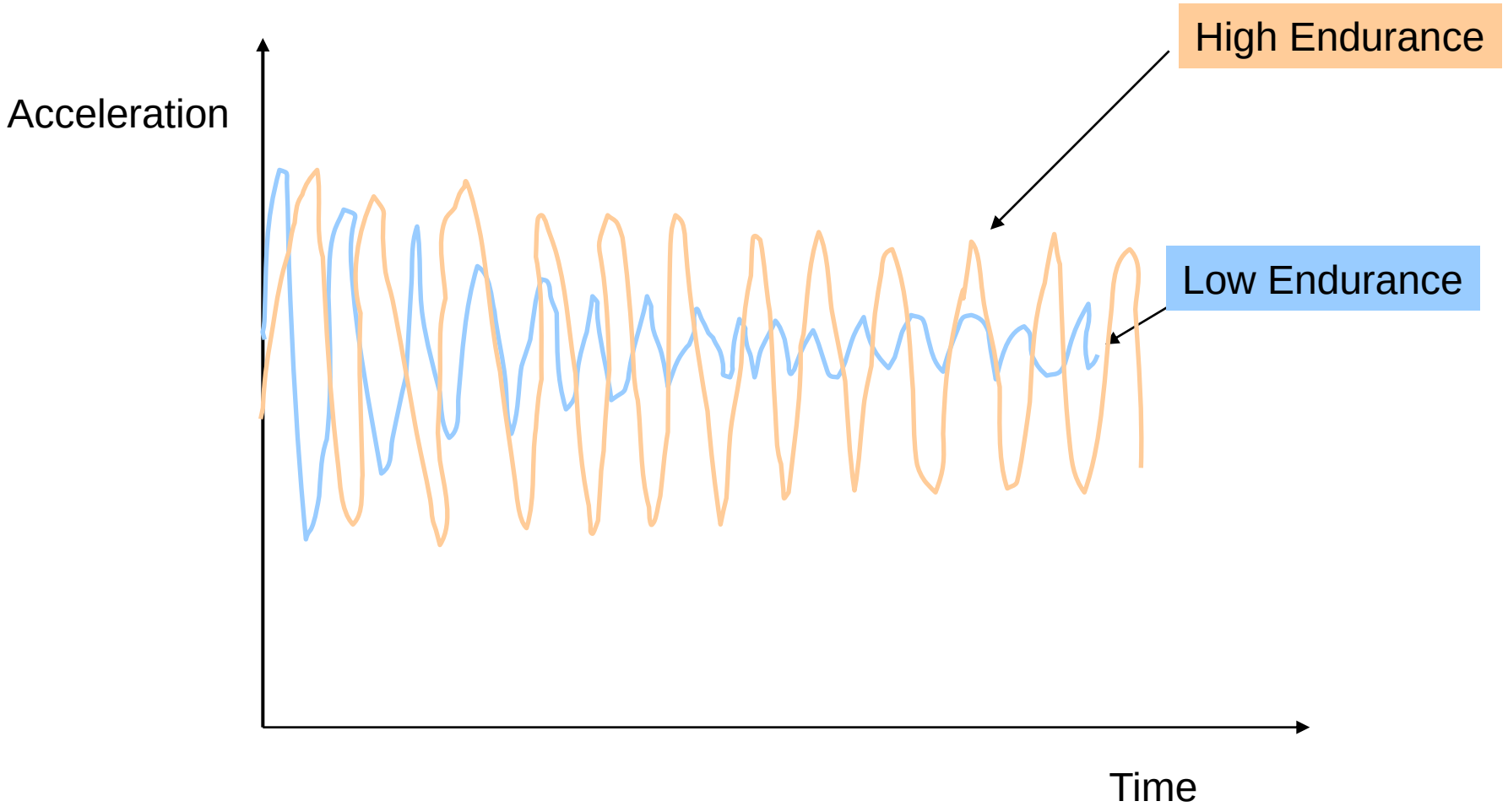
	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work 75% Rest	32.5	31	30	29.5	31	29	28	26.5

- Work Demands
  - Work load by Heart rate
- Work Hour
  - Motion Detect by Accelerometer
- Acclimatization
  - 3 week work record

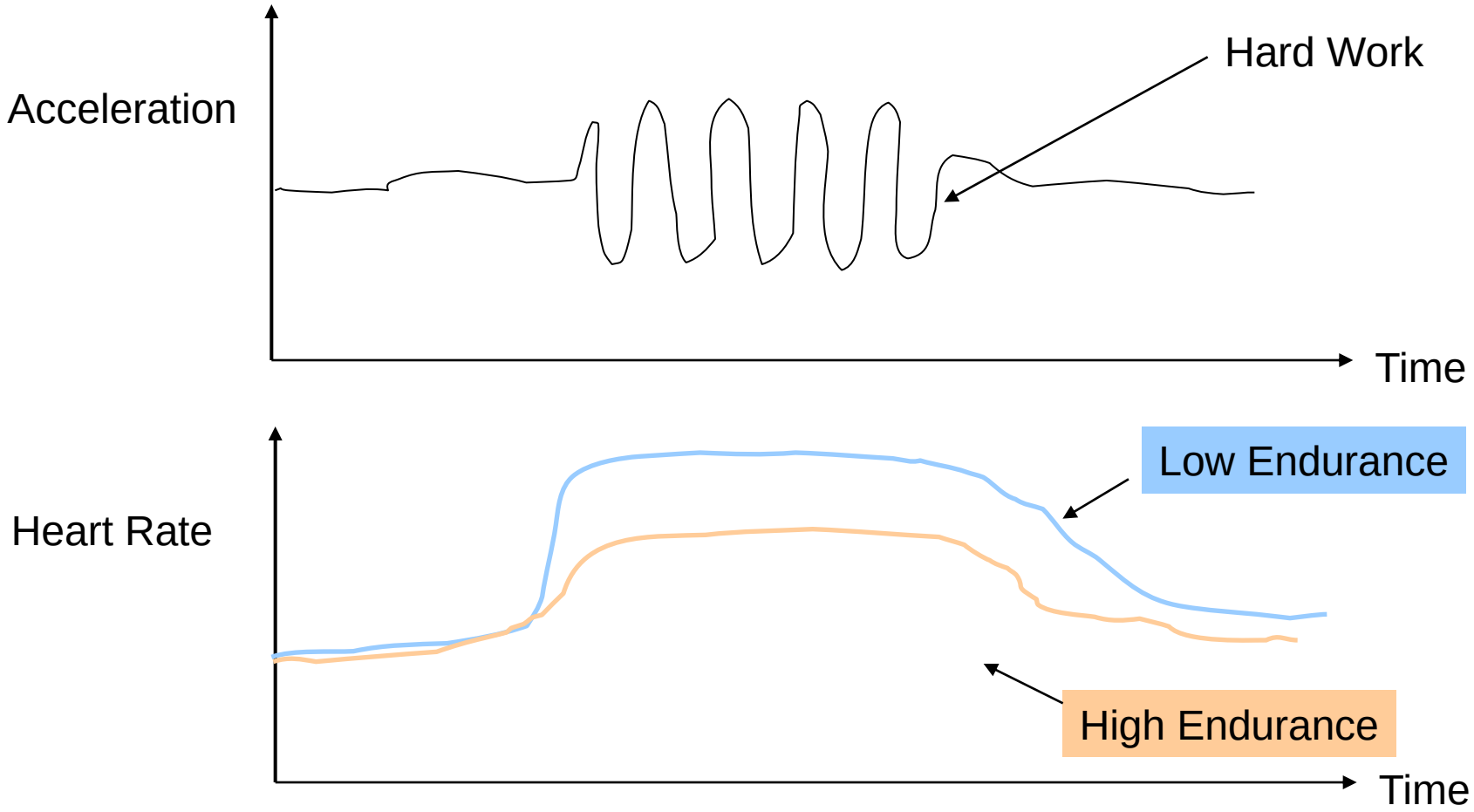
Initial Idea for Agility Algorithm



Initial Idea for Endurance Algorithm #1



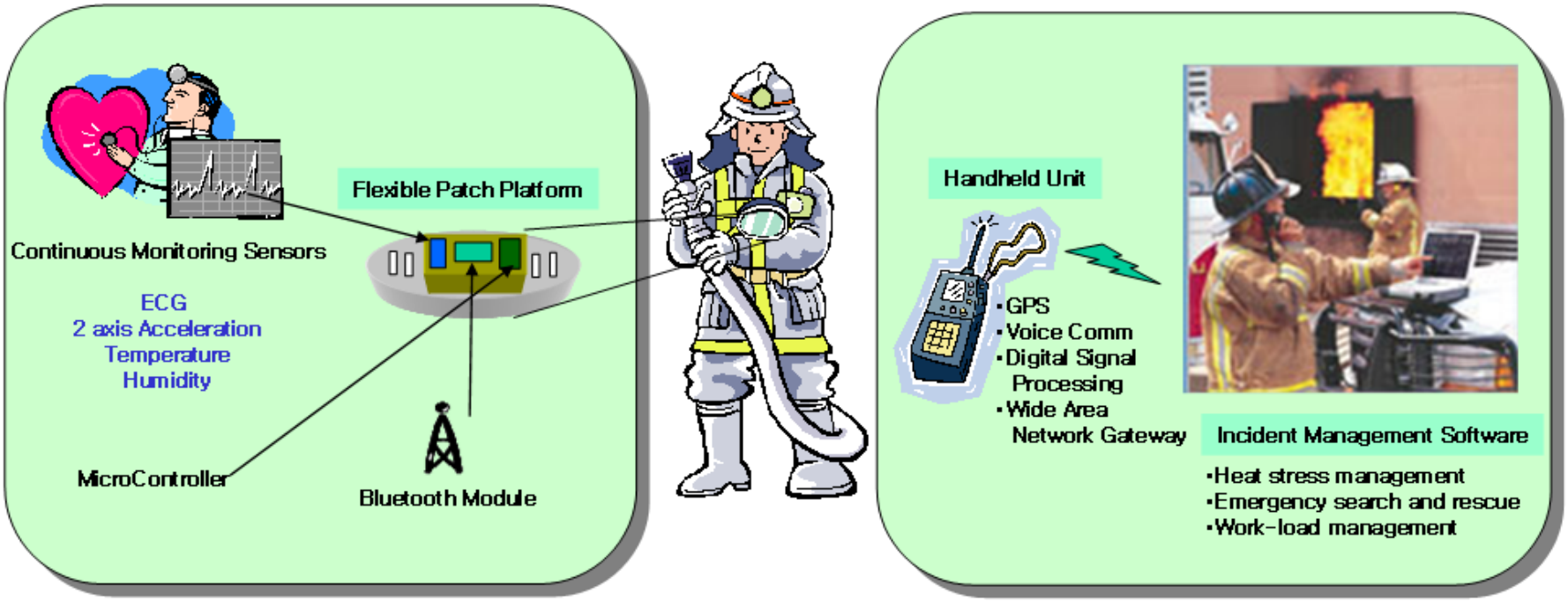
Initial Idea for Endurance Algorithm #2



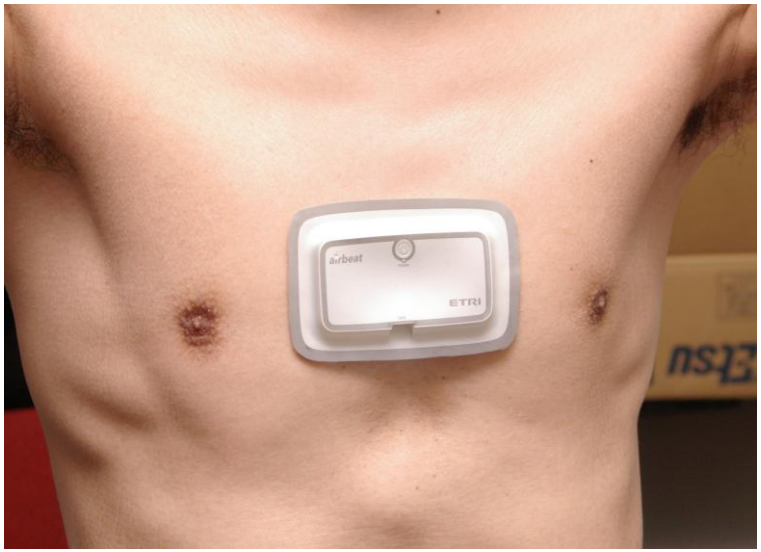
Results

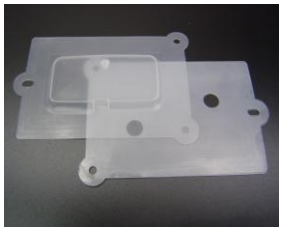
What is the results?

System Overview



Flexible Adhesive Packaging



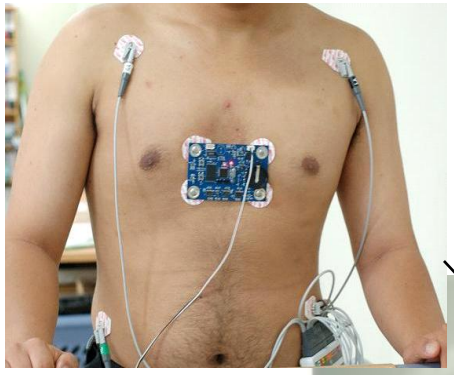


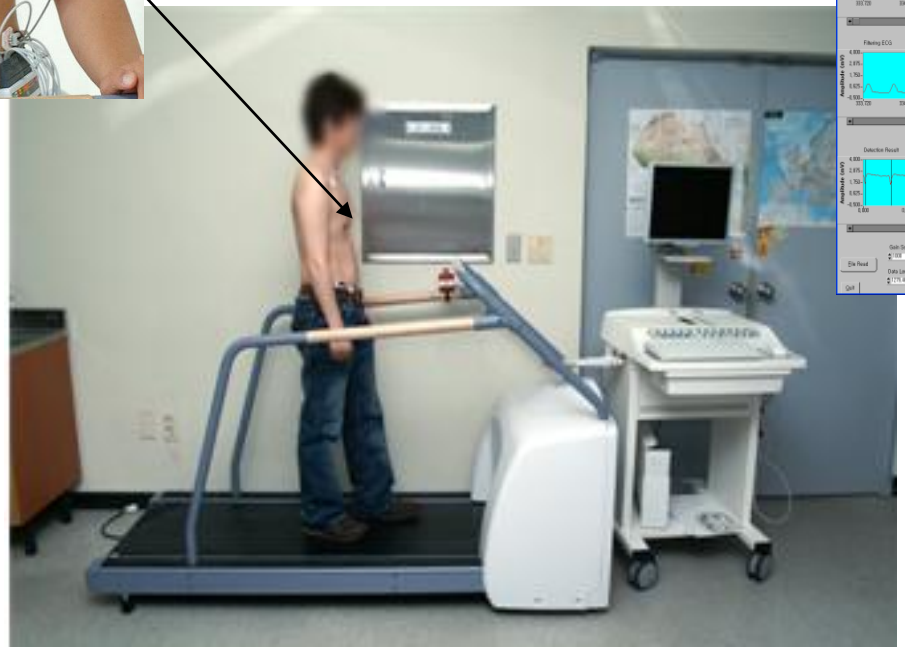
Flexible and Waterproof packaging using Silicone

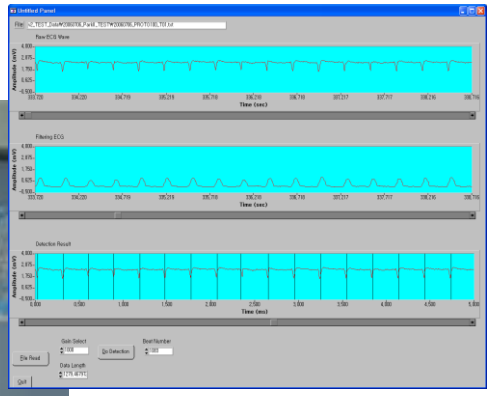
Flexible PCB with pattern antenna

Reusable Electrode Patch using Skin Adhesive

Heart Beat Detection



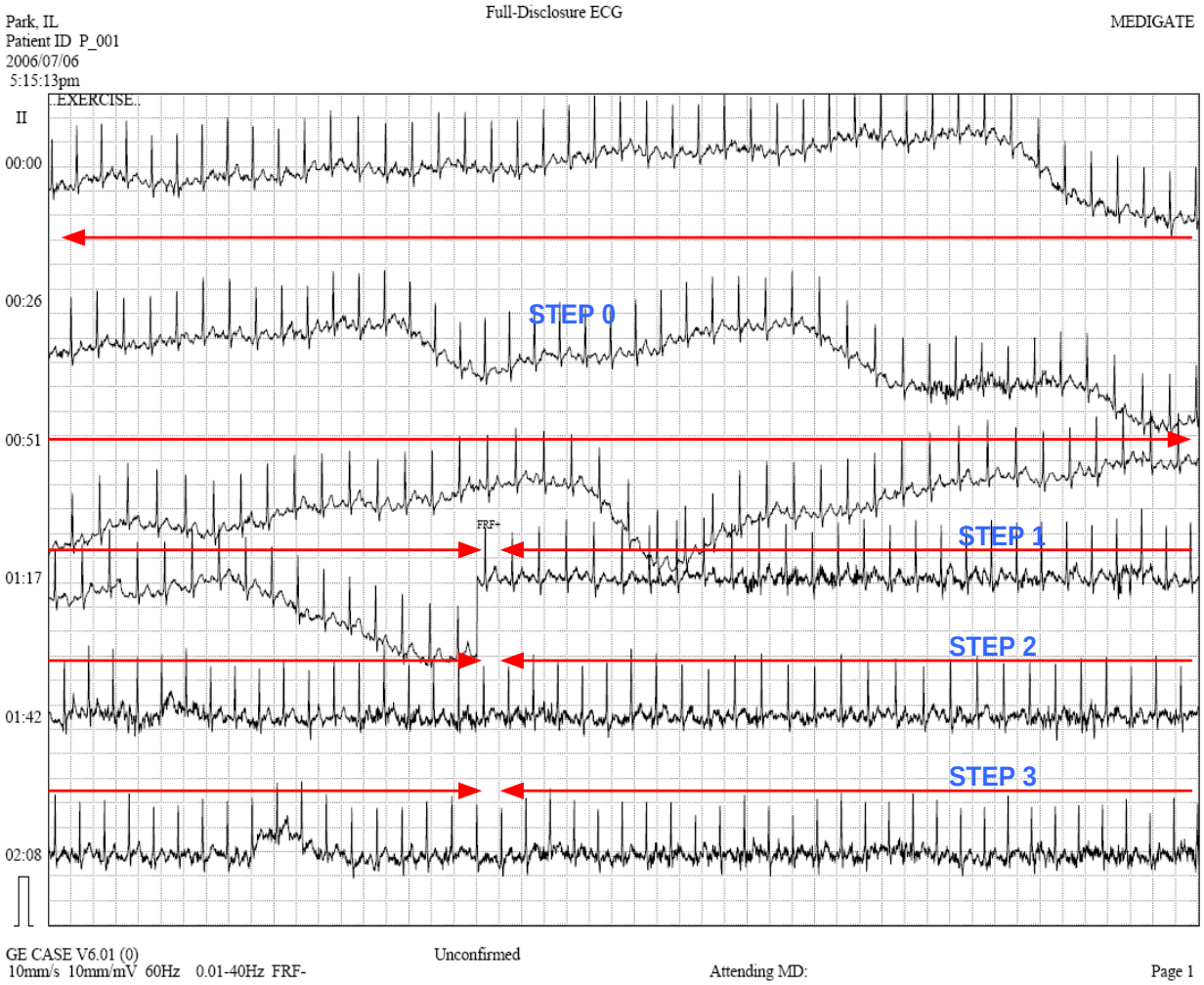




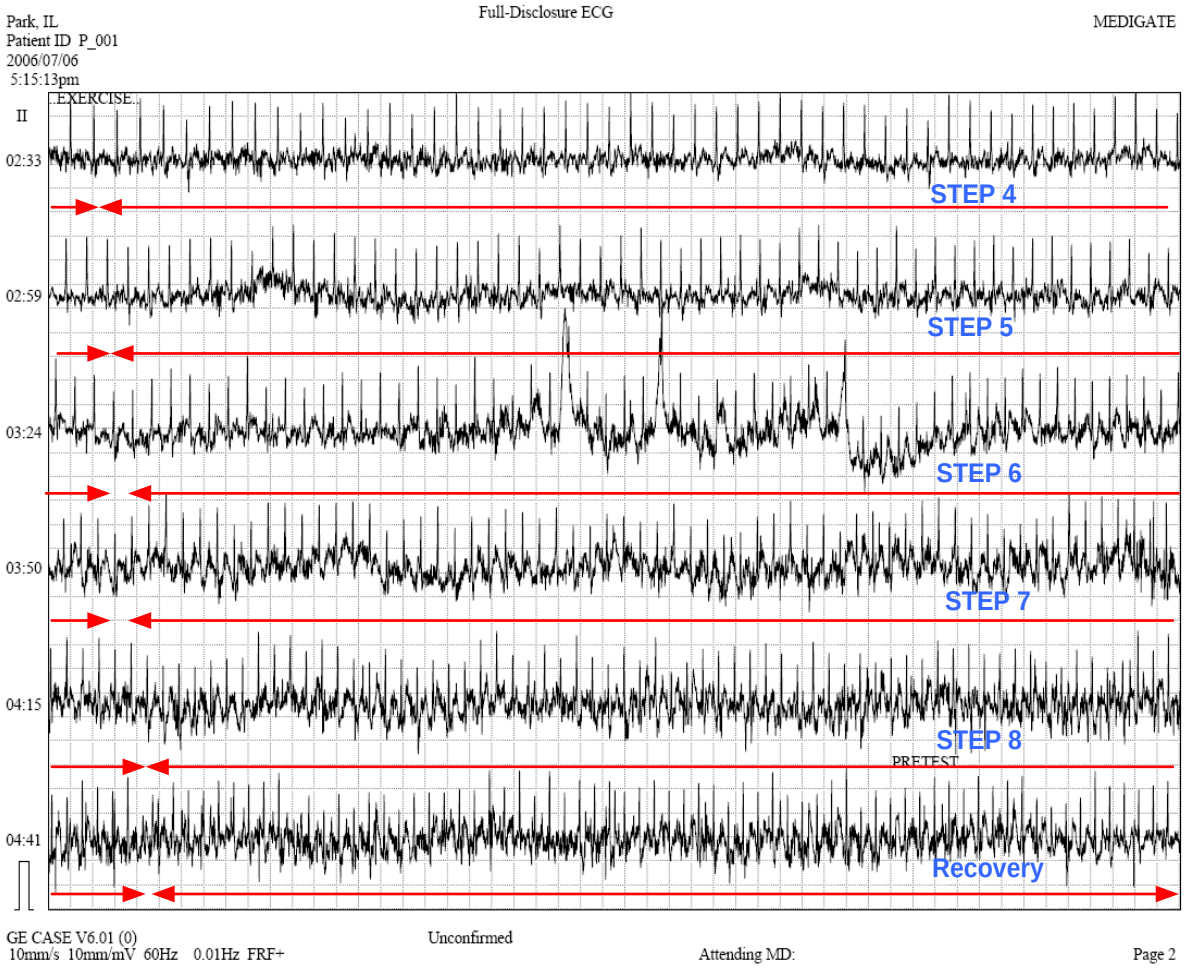
Experiment Protocol

Step	Duration	Speed	Accumulated Time
STEP P0	0:30	0Km/H	00:30 (30s)
STEP E0	00:30	2.7Km/H	01:00 (60s)
STEP E1	00:30	4 Km/H	01:30 (90s)
STEP E2	00:30	6 Km/H	02:00 (120s)
STEP E3	00:30	8 Km/H	02:30 (150s)
STEP E4	00:30	10 Km/H	03:00 (180s)
STEP E5	00:30	11 Km/H	03:30 (210s)
STEP E6	00:30	12 Km/H	04:00 (240s)
STEP E7	00:30	13 Km/H	04:30 (270s)
STEP E8	00:30	14 Km/H	05:00 (300s)
STEP E9	00:30	15 Km/H	05:30 (330s)
STEP R0	00:30	2.7 Km/H	06:00 (360s)

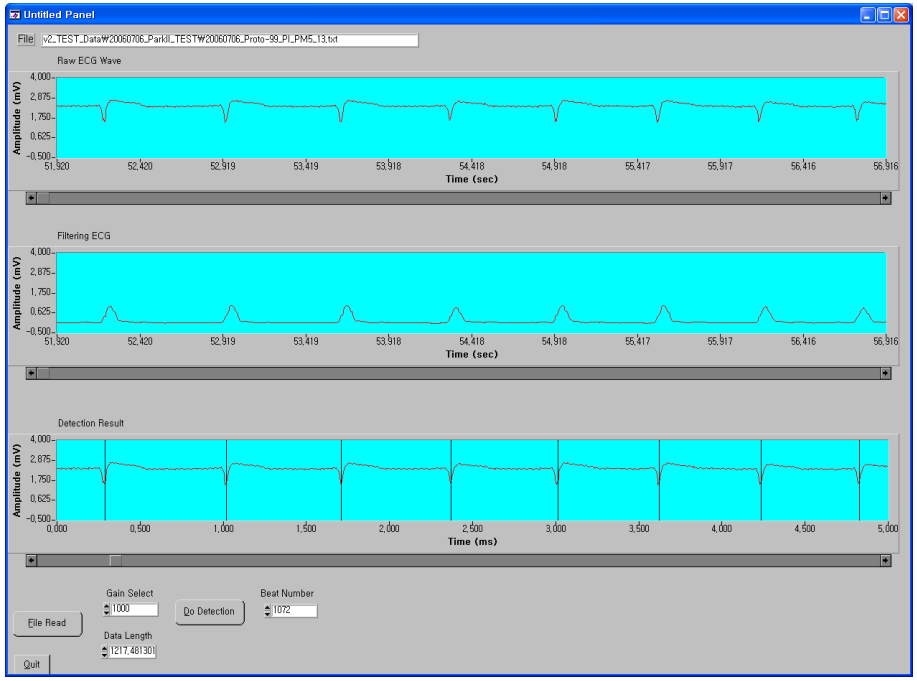
Comparison


Park, IL
Patient ID P_001
2006/07/06
5:15:13pm
Full-Disclosure ECG
MEDIGATE
EXERCISE
II
00:00
00:26
00:51
01:17
01:42
02:08
STEP 0
STEP 1
STEP 2
STEP 3
FRF-
GE CASE V6.01 (0)
10mm/s 10mm/mV 60Hz 0.01-40Hz FRF-
Unconfirmed
Attending MD:
Page 1

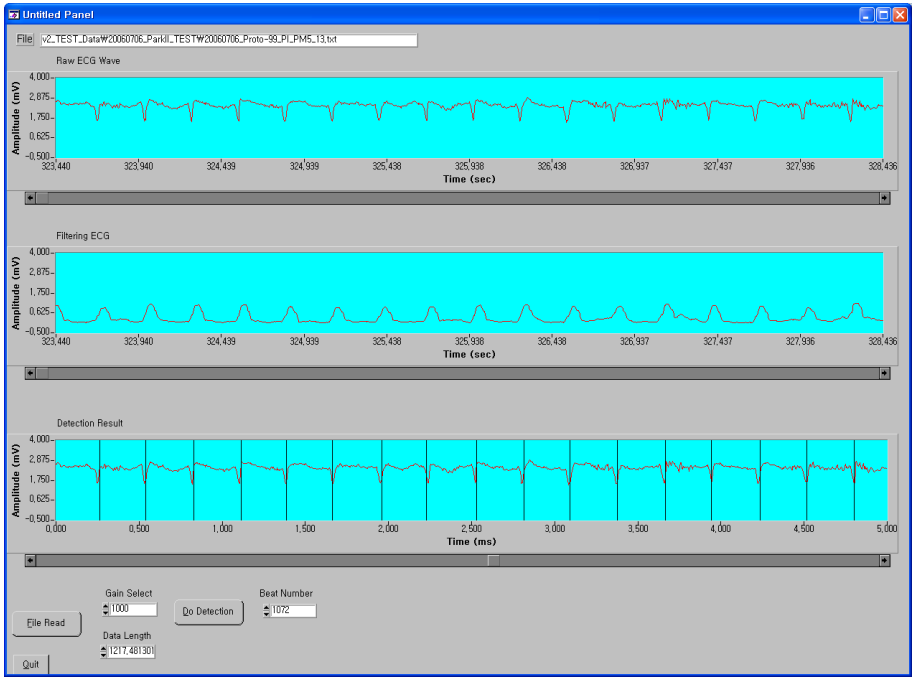
Comparison #2



Heart Beat Detection

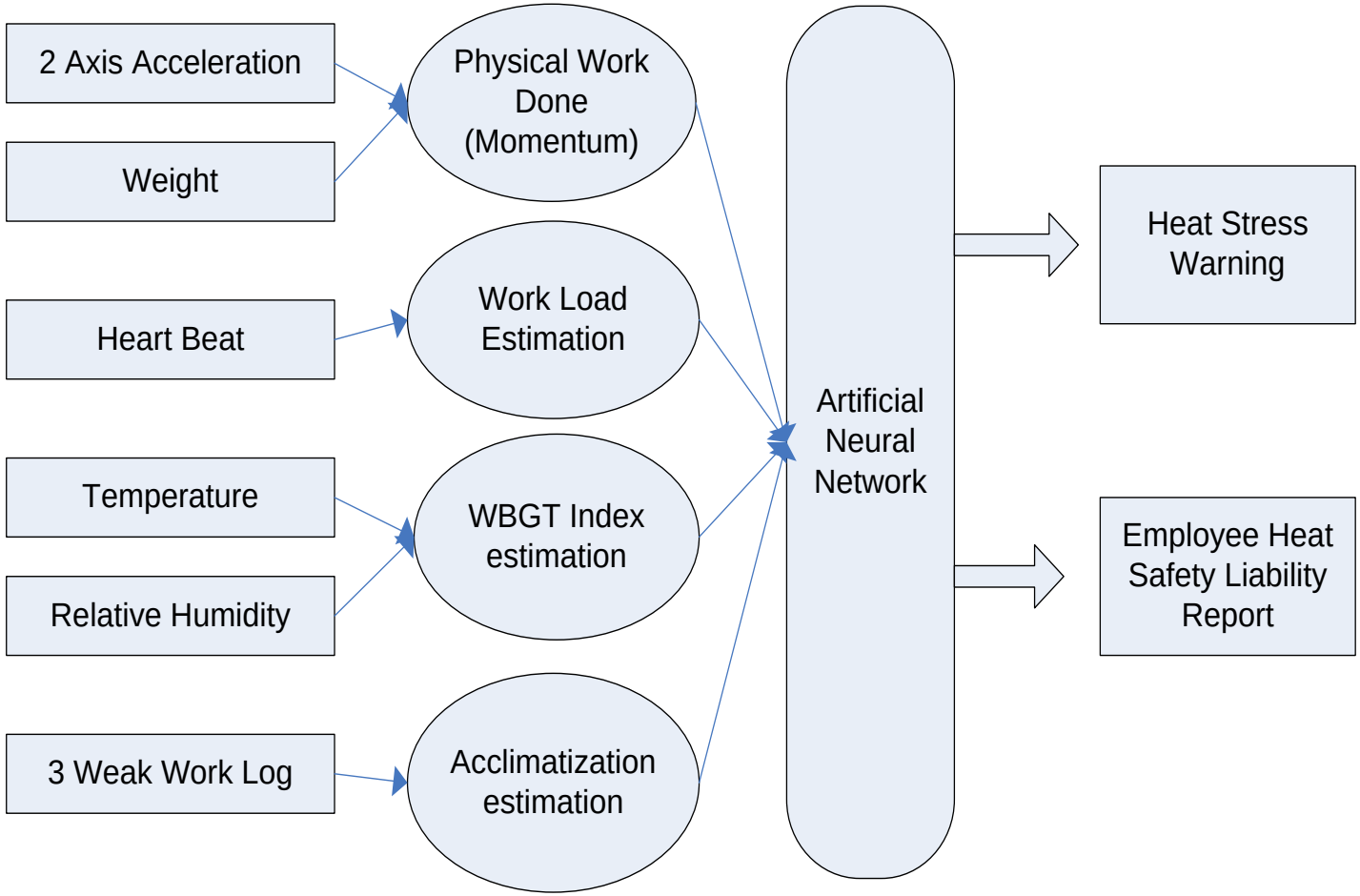


During Rest



During 15 km/H

Heat Stress Assessment Algorithm Flow

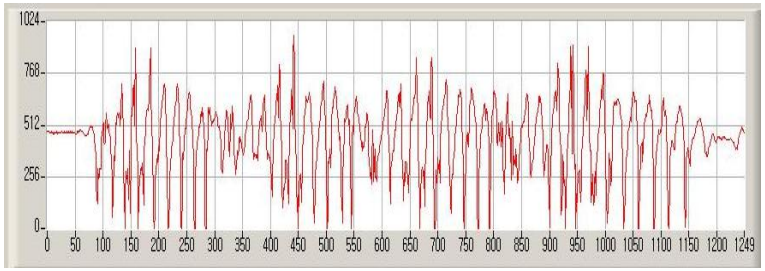
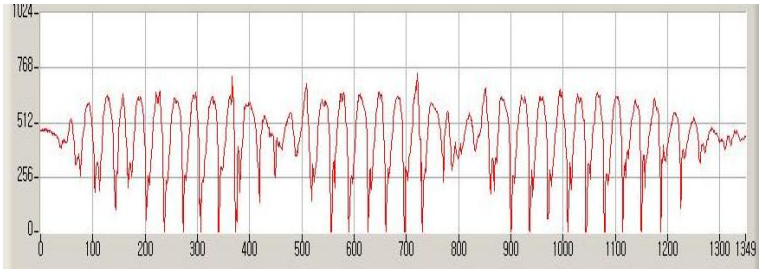
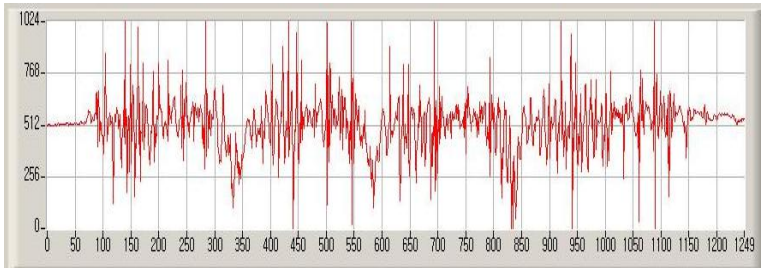
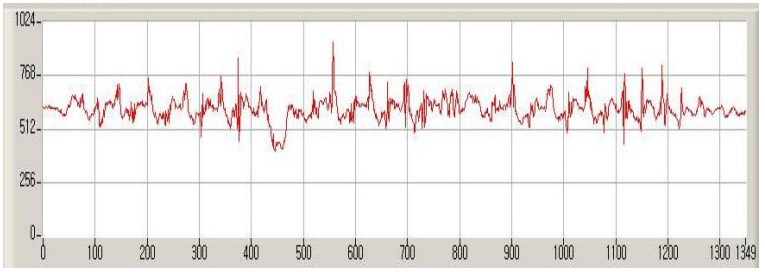
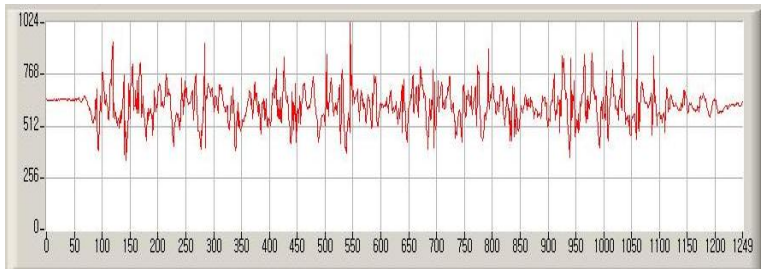
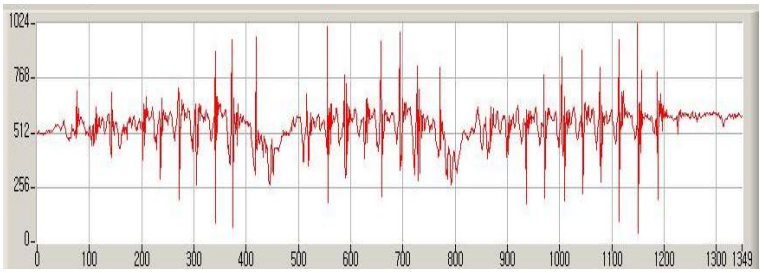


Algorithm detail

- Physical work done
  - $Time_{working}$ += Time (Acceleration > $Movement_{Threshold}$)
- Work load Estimation
  - WLE = (HB – RHB)/(RHB – MHB) ×100 (%)
    - WLE = Work Load Estimation
    - HB = Current Heart Beat Average Rate
    - RHB = Resting Heart Beat Rate
    - MHB = Maximum Heart Beat Rate
- WBGT Index estimation
  - WBGT = 0.567 × Ta + 0.393 × e + 3.94
  - e = rh / 100 × 6.105 × exp (17.27 × Ta / (237.7 + Ta))
    - Wet Bulb Glove Temperature (WBGT)
    - Ta = Temperature
    - e = Water vapor pressure
    - rh = Relative Humidity
- Acclimatization etimation
  - Was temperature record high during past 3 weeks?

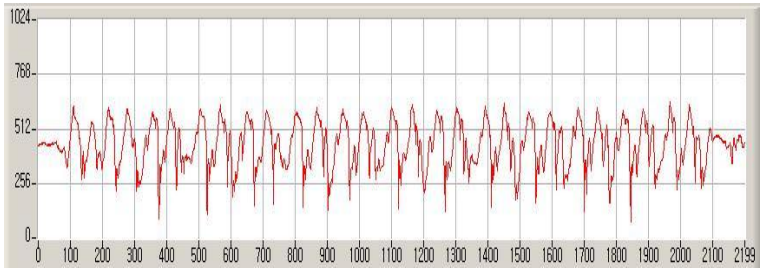
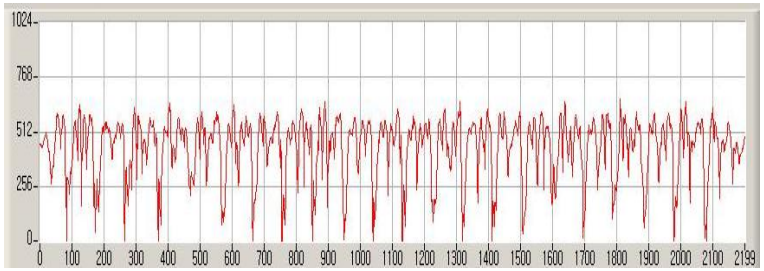
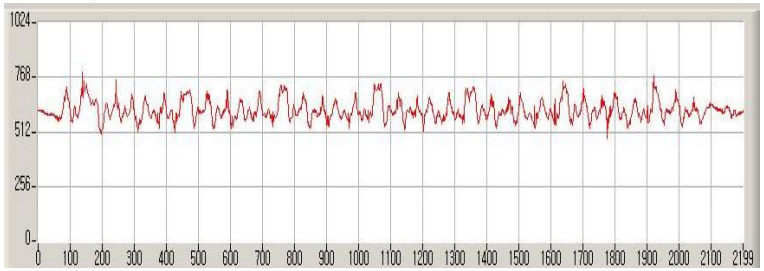
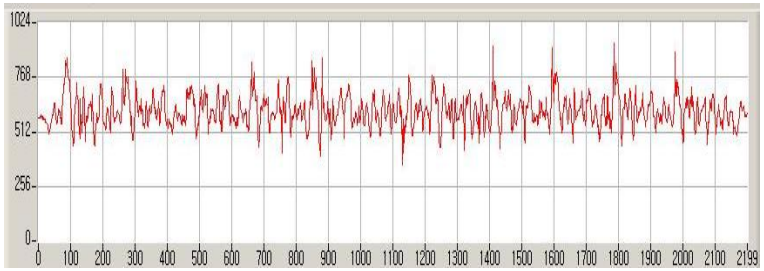
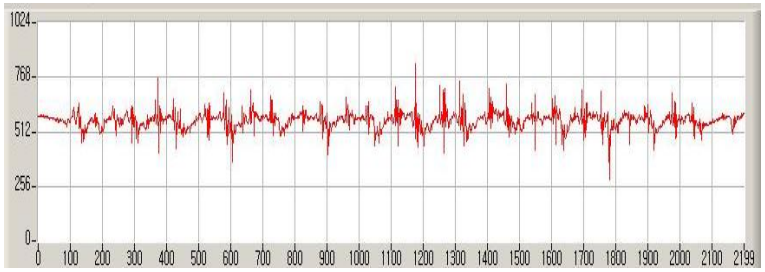
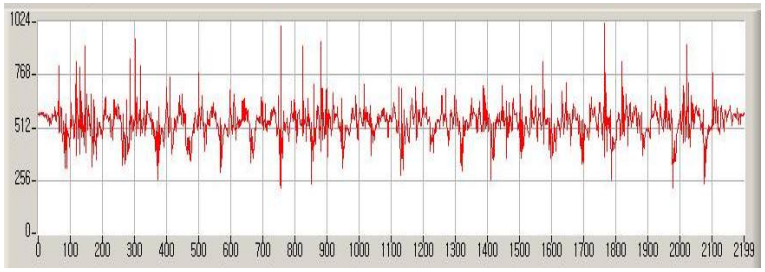
Movement Assessment

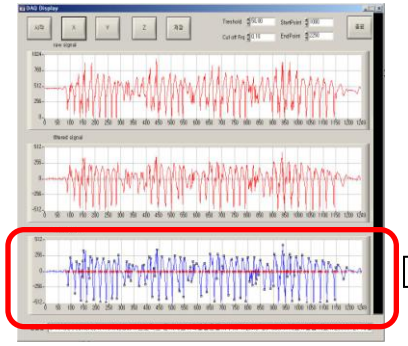
10m Shuttle Run (40m)

	Record Time = 10.5 sec	Record Time = 14.37 sec
X		
Y		
Z		

Movement Assessment

Side Step Test

	Record Step = 13	Record Step = 20
X		
Y		
Z		



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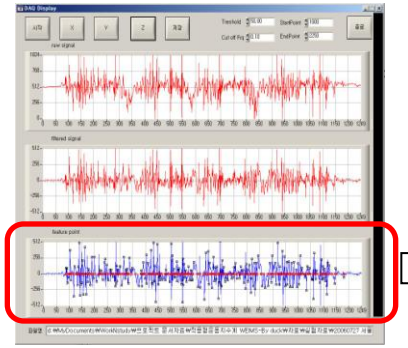
1092	0
1098	226
1110	0
1111	0
1117	–
363	
1119	0
1120	0
1123	162
1131	0
1131	0
1133	122
1135	0



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120	
1094	0
1095	0
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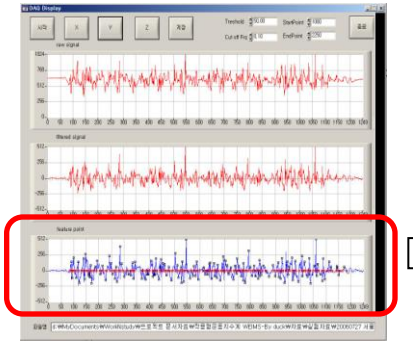
1103	0
1104	0



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1093	0
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1102	0
1103	0
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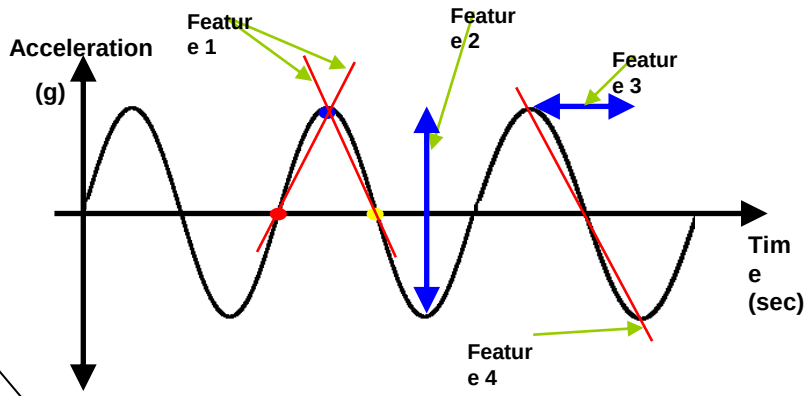


1. acceleration
2. Differential Acc
3. Peak to Peak Acc

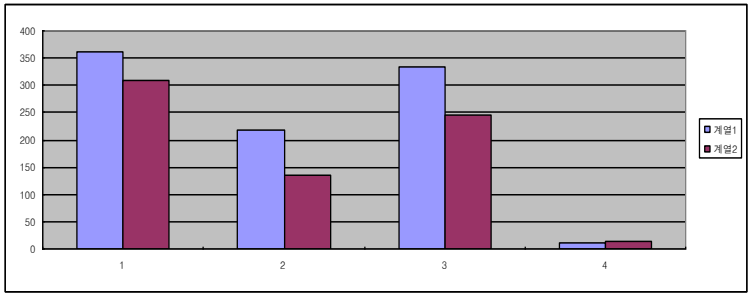
Feature point selection

feature calculation

Movement Assessment

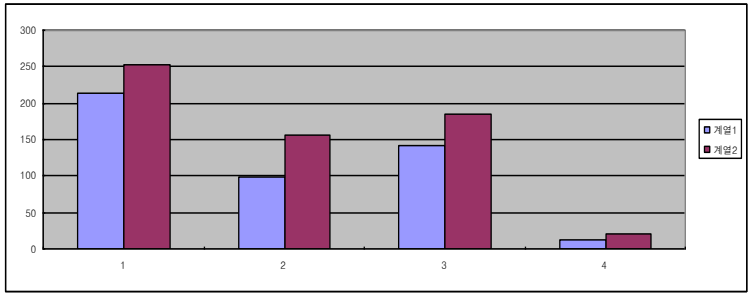
10m Shuttle Run (40m)

mean da/dt	mean a	mean peak da/dt	record
361.6	218.9	333.7	10.05
307.8	135.3	244.5	14.37

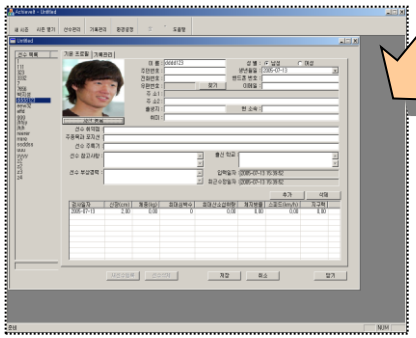


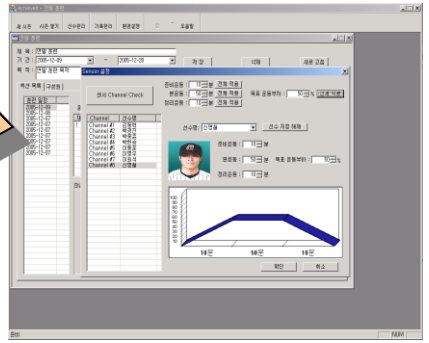
Side Step Counting

mean da/dt	mean a	mean peak da/dt	record
213.9	98.7	142.8	13
252.5	155.7	185.9	20



Training Assistive SW





Athlete Management

Planning Season

Creating Section

Athlete Tables

Achievement Tables

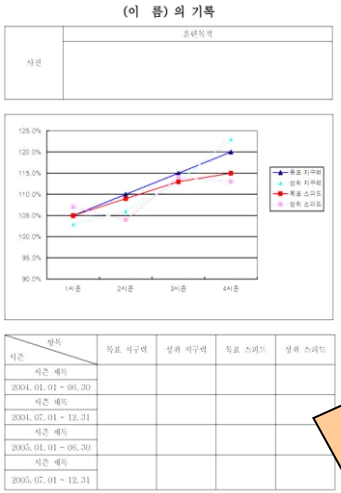
Section Tables

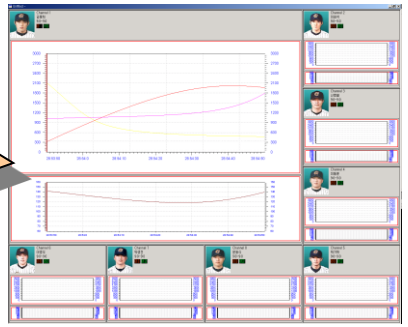
Data / Contents Tables

Generating Contents

COM Port

Sensor





Real time Monitoring

Section 종료시

Analyzing Contents

기록 분석 및 훈련성취도에 관한 정보 제공

선수별 기록 분석

Season별 기록 분석

Section별 기록 분석

Discussion

So what?

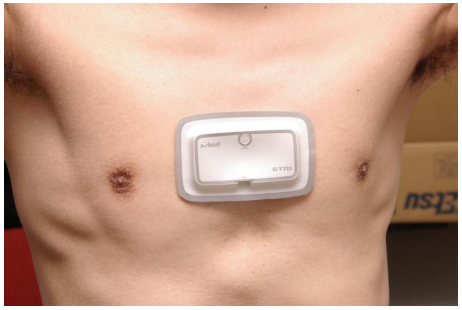
Target User

- Athlete
  - Football
  - Marathon
- Firefighter
- Soldier
- Policeman
- Workers in Hot Environment
- Normal People

California Fatality Assessment and Control Evaluation Program

- Title: “Firefighter dies of heat stroke while making a fire line during a wild land fire”
- The investigators concluded that in order to prevent future occurrences, fire agencies should
  - Require supervisors to regularly monitor firefighters, using generally accepted methods, during periods of high heat stress.
  - Assure firefighters workloads are appropriate for their level of acclimatization.
  - Assure firefighters are appropriate for ambient weather conditions and clothing
- Report No. 97CA01001

During Exercise



- Heart Beat
- 3 Axis Acceleration
- Humidity
- Temperature
- Rechargeable Battery
- Short Range RF

- MP3
- GPS
- Built in Speaker or sports headphone
- Rechargeable Battery
- Flash memory for recording
- Short Range RF

Ongoing Goal

- More Field Test
- Movement Indexing
- Adoption of CDMA
- Integration of GPS

Acknowledgement

- Kang Jae Min, Seoul National University
  - Algorithm
- Kim Hyo Jung, Joo Chang Hwa, Seoul National University
  - User Evaluation
- Kim Ki Jung, Seoul National University
  - Circuit and Firmware Development
- Kim Young Hoon, Flexis. inc
  - Silicone packaging
- Ryu Ki Hong, Hurev. inc
  - Silicone Adhesive Electrode
- Seo Kwang suk, Han Sang Hoon, Bae Ki Soo, Medicate .inc
  - ECG Circuit and Beat Detection Algorithm
- Kwak Jae Hyun, Jang Young Jun
  - Software Development
- Sung Bong Ju, PhD, Korean Institue of Sports Science
  - Sports science advisary
- Kwak Won il, Winizen
  - Antenna Development

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Question?

Specification

1. 재질: FPCB
2. 사이즈: 50 mm x 90 mm
3. 구성 및 성능
   (1) ECG 회로
      - 단일 채널 ECG 회로, Single Supply
      - 200 Hz Sampling
   (2) 온/습도 센서
      - 100 Hz Sampling
      - 습도 계산시 온도 보상
   (3) 3축 가속도 센서
      - 10 Hz Sampling
   (4) RF Module
      - 868 MHz 주파수(80 ch)
      - 4.8 kbps 전송 성능
      - fPCB Pattern Antenna
      - 300m 정도까지 데이터 전송 가능
   (5) Power Consumption
      - RF: 20 mA
      - 온/습도: 1 mA(max)
      - 3축 가속도 센서: 1.5 mA(max)
      - Microcontroller 및 기타 회로: 4-5 mA
      - 전체 회로: 약 30 mA 정도 소모

CDMA version